PROPOSED P393 BRIDGE WIDENING
UMHLATHUZE LOCAL MUNICIPALITY, KWAZULU-NATAL

Freshwater Wetland and Aquatic Habitat Impact Assessment Report




Version 1.1

Date: 28th August 2017

Eco-Pulse Environmental Consulting Services

Report No: EP291-01

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Suggested report citation:

Eco-Pulse Consulting, 2017. Proposed P393 Bridge Widening: ***Freshwater Wetland and Aquatic Habitat Impact Assessment Report***. Unpublished specialist report prepared by Eco-Pulse Environmental Consulting Services for Royal HaskoningDHV. Version 1.1. 28 August 2017.

SPECIALIST ASSESSMENT REPORT DETAILS AND DECLARATION OF INDEPENDENCE

This is to certify that the following report has been prepared as per the requirements of Section 32 (3) of the NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (Act No. 107 OF 1998) ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS 2014 as per Government Notice No. 38282 GOVERNMENT GAZETTE, 4 DECEMBER 2014.

Document Title:	***Frehwater Wetland and Aquatic Habitat Impact Assessment Report*** *for the Proposed P393 Bridge Widening, uMhlathuze Municipality, KZN.*
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Date:	30th June 2017
Version Number:	1.0
Report No.	EP291-01
Client:	Royal HaskoningDHV

Details of Project Team (Eco-Pulse)

The relevant experience of specialist team members from Eco-Pulse Consulting involved in the assessment and compilation of this report are briefly summarized below. *Curriculum Vitae's* of the specialist team are available on request.

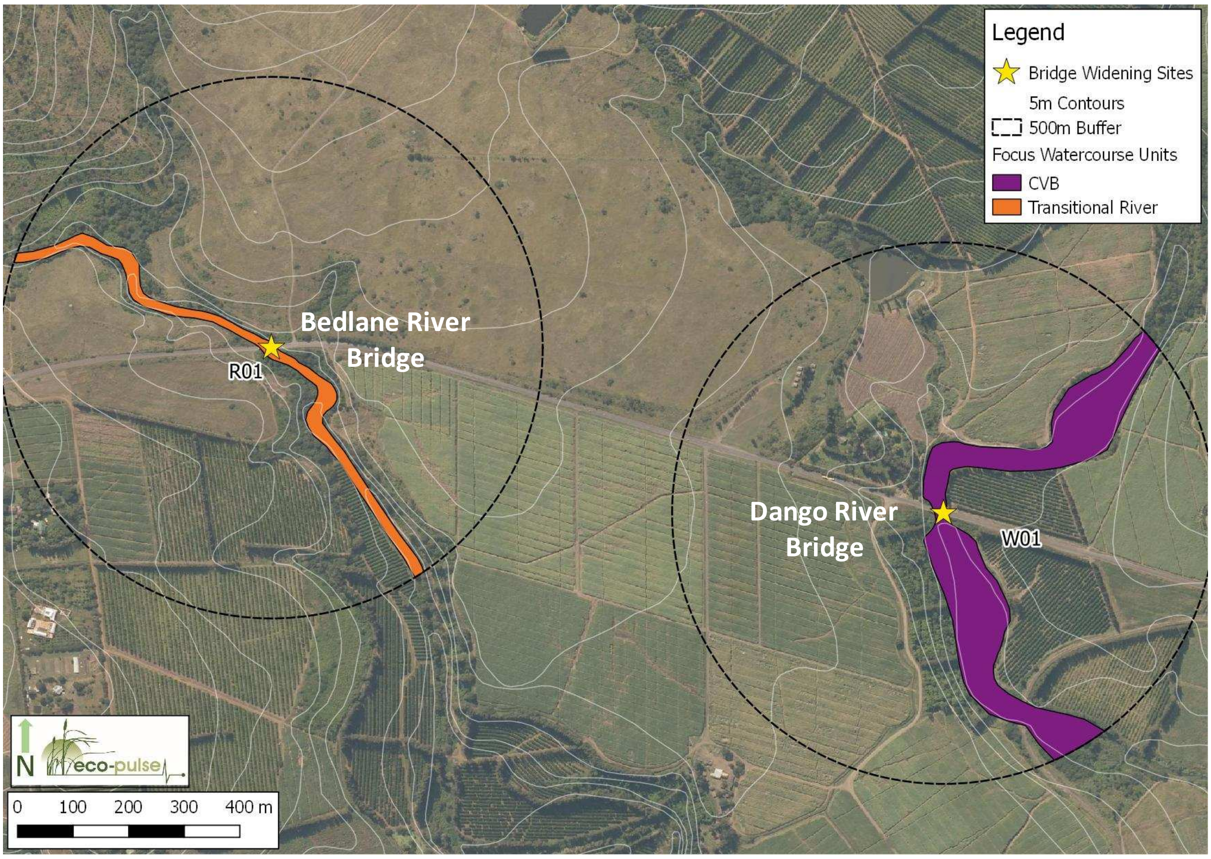
Specialist	Role	Details
Adam Teixeira-Leite *Pr. Sci. Nat.* Senior Scientist	Project manager, lead author	Adam is a Senior Scientist at Eco-Pulse with a BSc Honours degree in *Environmental Science: Earth Sciences*. He is a registered Professional Natural Scientist (Pr. Sci. Nat.) in the Ecological Sciences field with 10 years' experience, having worked extensively on numerous wetland and river assessment projects requiring the delineation of wetlands and riparian areas; and assessment of wetland functional importance and sensitivity both in KwaZulu-Natal, the Western and Eastern Cape, Orange Free State and Gauteng. He is also experienced in wetland and river rehabilitation and biomonitoring. Adam lead the project, fieldwork and reporting.
Andrew Briggs *Cand. Nat. Sci.* Junior Environmental Scientist	Undertaking fieldwork and co-author	Andrew is a Junior Environmental Scientist at Eco-Pulse with an MSc. Degree in Conservation Ecology. His thesis focused primarily on invertebrate and plant diversity in KZN watercourses. Andrew is currently involved in wetland delineation, riparian delineation, background research and undertaking wetland assessments.

EXECUTIVE SUMMARY

The KwaZulu-Natal Department of Transport (KZN DoT) is planning to widen two existing bridges on the P393 (R24) road between Eshowe and Melmoth towns, in the uMhlathuze Local Municipality, KwaZulu-Natal. The two bridges are located on the Bedlane and Dango Rivers, respectively, with the activity considered both a listed activity in terms of the NEMA: EIA Regulations (2014, as amended) and a water use as contemplated in terms of Chapter 4 and Section 21 of the National Water Act No. 36 of 1998. Eco-Pulse Environmental Consulting Services ('Eco-Pulse') was appointed by Royal HaskoningDHV ('RHDHV') to undertake a Freshwater Wetland & Aquatic Habitat Impact Assessment to inform the Basic Assessment (BA) and Water Use Licence Application (WULA) processes for the two (2) road bridge upgrades. The main findings of the specialist wetland/aquatic assessment report are summarized below:

- The P393 bridges widening project is located within the Usutu to Mhlatuze Water Management Area (WMA) in DWS quaternary catchment W12D. Both bridges to be upgraded (widened) are situated at the footslope of a steep mountainous area where a dense network of drainage lines converge to form the perennial Bedlane and Dango Rivers, which are tributaries of the perennial Mhlatuze River, located roughly 1-1.5km south of the bridge crossings.
- Several watercourses (includes wetlands and rivers) were identified within the DWS regulated area for wetland water use (i.e. 500m radius of the two existing bridges) through analysis of available desktop GIS information and further field verification, including the field delineation and assessment of wetlands PES and EIS. These watercourses were screened in terms of the potential risk of being impacted and requiring a water use license for associated water uses identified. Wetlands and rivers assessed as being at moderate to high risk (i.e. that stand to be negatively affected by the development project and potentially qualify as water uses and require a Water Use License) were subject to further detailed delineation and baseline assessment in the field, and included the following two (2) watercourses:

Water Resource Unit	HGM Type	Extent	PES	EIS	Location
Bedlane River R01	Transitional River	N/A	C: fair	Low	Associated with the Bedlane River at the existing bridge site
Wetland W01	Channelled valley bottom (CVB) wetland	~7.8 ha	D: poor	Moderate	Associated with the Dango River at the existing bridge site



- Future management of the freshwater wetlands associated with the study area and bridge widening project should be informed by the recommended management objectives for the water resource which, in the absence of classification, is generally based on the current status of the water resource or PES and the EIS for the resources (DWAF, 2007). The recommended management objective (based on a combined PES and EIS rating) should be to ***maintain the current status quo of aquatic ecosystems without any further loss of integrity/functioning (PES/EIS).*** This is also supported by Ezemvelo KZN Wildlife (EKZNW) whose guiding principle with regards to biodiversity conservation and sustainable development is one of ***no net loss of biodiversity and ecosystem processes.***

- Sensitive, vulnerable, highly dynamic or stressed ecosystems such as wetlands require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. Possible activities, aspects (or stressors) and potential ecological risks identified for the P393 bridge widening project that could potentially manifest in impacts to the four drivers of wetland or river condition/functioning as defined by the DWS are likely to include the following (regarded as low risk activities in general):
    - Permanent destruction/modification of aquatic habitat and vegetation due to bridge widening;
    - General habitat disturbance leading to the colonisation of adjacent wetland /riparian habitat by alien plants, weeds and other undesirable plant species (post-construction);

- o The risk of reduced water quality and the knock-on effects on aquatic ecology (flora and fauna/biota) as a result of 'accidental' pollution during the construction-phase.

- Identified potential direct and indirect negative impacts linked with the construction and operation of the bridges widening project on the local freshwater wetland/riverine environment include:

POTENTIAL IMPACTS	IMPACT SIGNIFICANCE		KEY MITIGATION CONSIDERED
	'Poor' mitigation	Recommended Scenario: 'Good' mitigation	
CONSTRUCTION PHASE			
1 Physical destruction and/or modification of aquatic habitat	Moderately-Low	Moderately-Low	• Appropriate design • Access control • Onsite BMPs (sediment and pollution control s) • Post-construction rehabilitation
2 Flow modification and erosion/sedimentation impacts	Moderately-Low	Low	
3 Water quality impacts	Low	Low	
OPERATION PHASE			
1 Physical destruction and/or modification of aquatic habitat	Moderately-Low	Low	• Appropriate design • IAP control • Ecological monitoring • Long-term bridge maintenance
2 Flow modification and erosion/sedimentation impacts	Low	Low	
3 Water quality impacts	Low	Low	

The most significant ecological impact is likely to be associated with bridge widening during the construction phase, during which piers and abutments will be lengthened in both an upstream and downstream direction, resulting in the destruction of potential aquatic habitat beyond the existing bridge footprint. However, due to the small extent of the planned bridge widening and the already disturbed/degraded nature of the watercourses and associated aquatic habitat at each bridge crossing, impact significance is likely to be moderately-low and generally acceptable from an aquatic environmental perspective. Other more indirect impacts are likely to be of low significance and can be easily mitigated on-site through a range of practical measures recommended in Section 8 of this report, with the principal recommendations including:

- o Bridge design recommendations;
- o Construction-phase impact mitigation measures;
- o Operation-phase impact mitigation measures;
- o Post-construction aquatic habitat rehabilitation guidelines; and
- o Ecological monitoring recommendations.

Based on the assessment then, there are unlikely to be any potential 'fatal flaws' associated with the proposed bridge widening project from an aquatic ecosystems perspective, granted that mitigation measures are applied to best practise standards and in accordance with the recommendations made in Section 8 of this specialist aquatic assessment report.

- The widening of the bridges across the Dango and Bedlane Rivers associated with the P393 road upgrade are associated with two principle "non-consumptive" water uses as contemplated under Chapter 4 and Section 21 of the National Water Act No. 36 of 1998, for which a water use license is required**.** Applicable water uses are summarised below as follows:
    - **21 (c):** *Impeding or diverting the flow of water in a watercourse:* Associated with temporary impoundment/diversion of flows may be necessary to allow for construction to take place within the watercourse during bridge widening.
    - **21 (i):** *Altering the bed, banks, course or characteristics of a watercourse:* Associated with widening of bridge piers and abutments will result in the alteration of channel banks upstream and downstream of the existing structure.

Due to the risk of activities and related stressors considered to be low, the project would essentially qualify for licensing under a General Authorisation (GA). The recent GA also includes a number of activities that are generally authorized for State Owned Companies (SOC's) and institutions that are then subject only to compliance with the conditions of the GA, which includes Provincial Department of Transport engaging in the "*maintenance of bridges over rivers, streams and wetlands and the new construction of bridges done according to the SANRAL Drainage Manual or similar norms and standards*."

CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITION OF TERMS

Biodiversity	The wide variety of plant and animal species occurring in their natural environment (habitats). The term encompasses different ecosystems, landscapes, communities, populations and genes as well as the ecological and evolutionary processes that allow these elements of biodiversity to persist over time.
Catchment	A catchment is an area where water is collected by the natural landscape. In a catchment, all rain and run-off water eventually flows to a river, wetland, lake or ocean, or into the groundwater system.
Conservation	The safeguarding of biodiversity and its processes (often referred to as Biodiversity Conservation).
Delineation	Refers to the technique of establishing the boundary of a resource such as a wetland or riparian area.
Ecosystem	An ecosystem is essentially a working natural system, maintained by internal ecological processes, relationships and interactions between the biotic (plants & animals) and the non-living or abiotic environment (e.g. soil, atmosphere). Ecosystems can operate at different scales, from very small (e.g. a small wetland pan) to large landscapes (e.g. an entire water catchment area).
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 (gulley)	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.
Ezemvelo KZN Wildlife	Ezemvelo KwaZulu-Natal Wildlife, the local conservation authority for the Province of KwaZulu-Natal.
Endemic	Refers to a plant, animal species or a specific vegetation type which is naturally restricted to a particular defined region (not to be confused with indigenous). A species of animal may, for example, be endemic to South Africa in which case it occurs naturally anywhere in the country, or endemic only to a specific geographical area within the country, which means it is restricted to this area and grows naturally nowhere else in the country.
Function/functioning/ functional	Used here to describe natural systems working or operating in a healthy way, opposed to dysfunctional, which means working poorly or in an unhealthy way.
Habitat	The general features of an area inhabited by animal or plant which are essential to its survival (i.e. the natural "home" of a plant or animal species).
Hydric status	A classification of plants according to occurrence in wetlands and can be useful in determining whether the habitat at a site is wetland/riparian based on the hydric status of dominant species occurring.
Indigenous	Naturally occurring or "native" to a broad area, such as South Africa in this context.
Intact	Used here to describe natural environment that is not badly damaged, and is still operating healthily.
Invasive alien plants	Alien invasive species (IAPs) 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.
Mitigate/Mitigation	Mitigating impacts refers to reactive practical actions that minimize or reduce in situ impacts. Examples of mitigation include "changes to the scale, design, location, siting, process, sequencing, phasing, and management and/or monitoring of the proposed activity, as well as restoration or rehabilitation of sites". Mitigation actions can take place anywhere, as long as their effect is to reduce the effect on the site where change in ecological character is likely, or the values of the site are affected by those changes (Ramsar Convention, 2012).
Riparian habitat / Riparian area / Riparian zone	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 (National Water Act).
Risk	A prediction of the likelihood and impact of an outcome; usually referring to the likelihood

	of a variation from the intended outcome.
Soil Mottles/ Mottling	Soil mottling is a feature of hydromorphic (wet) soils and common to wetland areas. Mottles refer to secondary soil colours not associated with soil compositional properties that usually develop when soils are frequently wet for long periods of time. In water-logged soils, anaerobic (oxygen deficient) conditions generally causes redoximorphic soil features such as red mottles to develop. Lithochromic mottles on the other hand are a type of mottling associated with variations of colour due to weathering of parent materials.
Systematic conservation plan	An approach to conservation that prioritises actions by setting quantitative targets for biodiversity features such as broad habitat units or vegetation types. It is premised on conserving a representative sample of biodiversity pattern, including species and habitats (the principle of representation), as well as the ecological and evolutionary processes that maintain biodiversity over time (the principle of persistence).
Threatened ecosystem	In the context of this document, refers to Critically Endangered, Endangered and Vulnerable ecosystems.
Threat Status	Threat status (of a species or community type) is a simple but highly integrated indicator of vulnerability. It contains information about past loss (of numbers and / or habitat), the number and intensity of threats, and current prospects as indicated by recent population growth or decline. Any one of these metrics could be used to measure vulnerability. One much used example of a threat status classification system is the IUCN Red List of Threatened Species (BBOP, 2009).
Transformation (habitat loss)	Refers to the destruction and clearing an area of its indigenous vegetation, resulting in loss of natural habitat. In many instances, this can and has led to the partial or complete breakdown of natural ecological processes.
Water course	Means a river or spring; a natural channel in which water flows regularly or intermittently: a wetland, lake or dam into which, or from which, water flows: und 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 (National Water Act, 1998).
Wetland	Refers to land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (National Water Act, 1998).
Wetland Type	This is a combination between wetland vegetation group and Level 4 of the National Wetland Classification System, which describes the Landform of the wetland.
Wetland Vegetation Group	Broad wetland vegetation groupings reflect differences in regional context such as geology, soils and climate, which in turn affect the ecological characteristics and functionality of wetlands.

ABBREVIATIONS/ACRONYMS USED

CBA	Critical Biodiversity Area
CR	Critically Endangered (threat status)
DEA	Department of Environmental Affairs (formerly DEAT)
DWS	Department of Water and Sanitation (formerly DWA/F)
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment: EIA regulations promulgated under section 24(5) of NEMA and published in Government Notice R.543 in Government Gazette 33306 of 18 June 2010
EI	Ecological Infrastructure
EIS	Ecological Importance and Sensitivity
EKZNW	Ezemvelo KwaZulu-Natal Wildlife: as defined in Act 9 of 1997 as KZN Nature Conservation Service
EMPr	Environmental Management Programme
EN	Endangered (threat status)
ESA	Ecological Support Area
FEPA	Freshwater Ecosystem Priority Area
FW	Facultative wetland species - usually grow in wetlands (67-99% occurrence) but occasionally found

	in non-wetland areas
GIS	Geographical Information Systems
GPS	Global Positioning System
HGM	Hydro-Geomorphic (unit)
IAPs	Invasive Alien Plants
IHI	Index of Habitat Integrity
LT	Least Threatened (threat status)
NEMA	National Environmental Management Act No.107 of 1998
NEM:BA	National Environmental Management: Biodiversity Act No.10 of 2004
NFEPA	National Freshwater Ecosystem Priority Areas, identified to meet national freshwater conservation targets (CSIR, 2011)
NT	Near Threatened (threat status)
NWA	National Water Act No.36 of 1998
Ow	Obligate wetland species
PES	Present Ecological State, referring to the current state or condition of an environmental resource in terms of its characteristics and reflecting change from its reference condition.
SANBI	South African National Biodiversity Institute
VU	Vulnerable (threat status)
WULA	Water Use License Application

1 INTRODUCTION

1.1 Project Background and Locality

The KwaZulu-Natal Department of Transport (KZN DoT) is planning to widen two existing bridges on the P393 (R24) road between Eshowe and Melmoth towns, in the uMhlathuze Local Municipality, uThungulu District, KwaZulu-Natal (Figure 1, below). The bridges are located on the Bedlane and Dango Rivers, which are tributaries of the large Mhlathuze River:

- **Bedlane River bridge**: 28° 43' 17.30" S | 31° 33' 18.44" E
- **Dango River bridge**: 28° 43' 28.49" S | 31° 34' 3.61" E

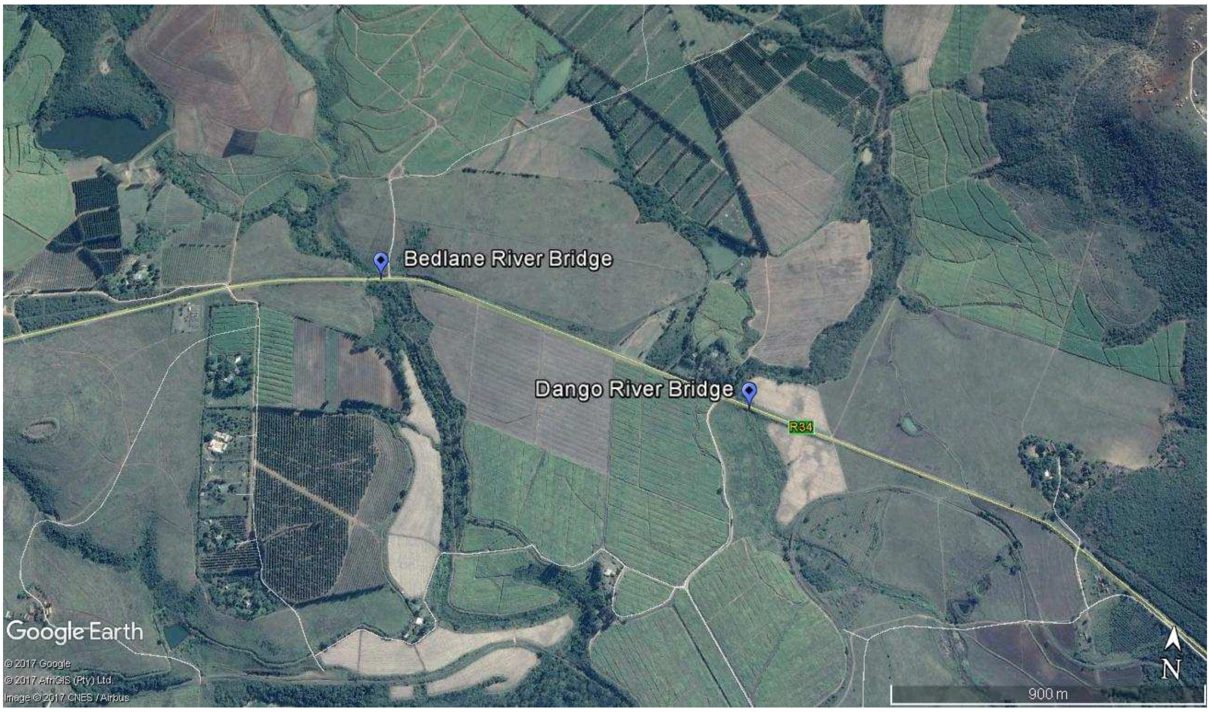


Figure 1 Google Earth™ map showing the two (2) bridges to be upgraded/widened on the Bedlane and Dango Rivers, P393/R34 road, KZN.

The proposed road bridge upgrade constitutes a listed activity in terms of Listing Notices 1 and 3 of the National Environmental Management Act (NEMA): Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) and requires Environmental Authorisation (EA) subject to a Basic Assessment (BA) process before construction can commence. Eco-Pulse Environmental Consulting Services ('Eco-Pulse') was appointed by Royal HaskoningDHV ('RHDHV') to undertake a **Freshwater Wetland & Aquatic Habitat Impact Assessment** to inform the Basic Assessment (BA) and Water Use Licence Application (WULA) processes for the two (2) road bridge upgrades along the P393/R34 road.

1.2 Project Description

The following serves as a description of activities and necessary additional components for the widening of the bridge over the **Bedlane & Dango Rivers,** based on information extracted from the bridges design report (RHDHV, 2016):

1.2.1 Proposed Bedlane River Bridge Widening (B1330: Bedlane)

Deck: The deck is to be widened by 2.825m upstream and 1.225m downstream. The deck widening will consist of simply supported solid concrete slabs approximately 600mm deep spanning onto the extended pier and abutments. A 600mm strip along either side of the existing deck is to be demolished to expose the existing reinforcement and will be lapped with the new deck reinforcement. The new deck will then be cast and after a minimum of 28 days, the 600mm strip between the new and old deck will be cast. An F-Shape New Jersey and sidewalk will be installed. Finally a Thorma joint will be installed across the old and the new decks as detailed in the relevant bridge report (RHDHV, 2016).

Abutments: The top of the abutments will be demolished 600mm deep and 1800mm length at both ends. Existing wing walls will be retained in order to support the existing road fill. The extended front walls will be dowelled into the existing wall and footing. The new spread footing extension will be dowelled into the existing using Y20 bars at 400mm centres. The existing concrete face will be scabbled to expose the aggregates before casting. Dowel bars of Y20 and 600 centres will be installed at the top of the wall to connect into the new deck concrete.

Pier: The pier is to be extended by 3.84m upstream and 1.12m downstream. The 800mm strip along the height on either side of the existing pier will be demolished to expose the existing reinforcement to be lapped with the new pier reinforcement. The new pier concrete extension is cast to bond with the existing concrete. Two layers of 3ply malthoid roofing felt will be placed over the pier top surface before casting the deck. The new spread footing extension is dowelled to the existing by means of Y20 bars at 400mm centres. The existing concrete face will be scabbled in order expose the aggregates before casting.

The following ancillary components are also proposed for the Bedlane bridge upgrade;

- Asphatic Plug type expansion joints,
- Scupper drainage pipes,
- 3 Ply malthoid bearings,
- Double drip moulds (30mm half round) to the full length of the deck cantilevers, and
- F Shape New Jersey barriers

1.2.2 Proposed Dango River Bridge Widening (B1272: Dango)

Deck: The deck is to be widened by 3.129m upstream and 1.329m downstream. The deck widening will consist of simply supported concrete deck approximately 900mm deep spanning onto the piers and abutments. A 1600mm wide x 200mm deep top strip and 200mm wide x 750m deep bottom strip along either side of the existing deck will be demolished to expose the existing reinforcement which will be lapped with the new deck reinforcement. The new deck will then be cast and, after a minimum of 28 days, the 300mm strip between the new and old deck will be cast. Standard parapets and sidewalk will be installed and a Thorma joint will be installed across the old and the new decks as detailed in the relevant bridge report (RHDHV, 2016).

Abutments: The east abutment wall and footing will be extended by 4.425m upstream and 1.880m downstream. The new wall will then be dowelled into existing using Y20 bars at 400mm centres.

The west abutment top will be demolished and modified to provide a deck extension seating. The existing wingwalls will be demolished to a depth of 1000mm from the top and raised to match the new deck. The fill behind the raised wingwalls will be soil reinforced in order not to exert earth pressure on the raised wingwalls.

The approach embankments will be stabilised by means of gabion boxes.

Pier: Pier heads 1.5m deep x 1.0m wide will be added to the piers for the new deck seating. The concrete surface will be scabbled and roughened for the new concrete to bond with the old. Three rows of holes at 500mm centres will be drilled through and epoxied Y12 bars are to be placed adequately to hang the pier head reinforcement. The pier head will then be tied to the pier by means of four rows of 25mm DYWIDAG treaded bars which will be torqued with flanged anchor nuts.

The ancillary components proposed for the Dango bridge upgrade are identical to the components proposed for the Bedlane bridge upgrade.

1.3 Scope of Work

The scope of work associated with the freshwater habitat impact assessment was as follows:

- Contextualization of the study area in terms of important biophysical characteristics and aquatic conservation planning information available at the time of the study.
- Desktop mapping, delineation, classification and screening of all watercourses (including wetland and riparian habitat) within a 500m radius of the proposed development using available imagery, contour information and spatial datasets in a Geographical Information System (GIS).
- Undertaking a rapid aquatic screening and risk assessment to determine which of the desktop delineated/mapped watercourses is likely to be measurably affected by the proposed development activity and are likely to trigger Section 21 (c) or (i) water use. This was used to flag watercourses for further focal assessment whilst identifying areas that will not be affected by the project and will therefore not require further assessment (i.e. wetlands/rivers within adjacent catchments or upstream/significantly downstream of the predicted impact zone).
- Detailed infield delineation of river/stream channels, riparian habitat and wetland habitat on the property according to the techniques and methods contained in '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005).
- Sub-division and classification of the delineated riverine and wetland areas using the latest *National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa* (Ollis *et al.*, 2013).

- Description of the biophysical characteristics of the delineated freshwater habitats based on onsite observations and sampling – hydrology, soils, vegetation, etc.
- Site visit to gather field data necessary to assess wetland/riverine integrity and functioning (PES/EIS) including brief descriptions of the wetland vegetation communities.
- Functional assessment of freshwater wetland and aquatic ecosystems and associated habitats based on field investigations, involving:
    - WET-Health level 1 rapid assessment (Macfarlane *et al.*, 2008) to establish the Present Ecological State (PES) of wetlands delineated;
    - Application of the rapid Index of Habitat Integrity (IHI) (Kleynhans, 1996) assessment tool for instream and riparian habitats to establish the PES of riverine units delineated;
    - Assessment of the functional importance of the wetland in providing ecosystem goods and services according to the WET-Ecoservices assessment tool (Kotze *et al.*, 2009);
    - Assessment of the Ecological Importance and Sensitivity (EIS) of the delineated wetland/riparian units.
- Application of the "Risk Assessment Matrix" for each watercourse likely to be impacted by the bridge upgrading, as detailed in the General Authorisation in terms of Section 39 of the National Water Act No. 36 of 1998 for Water Uses as defined in Section 21 (C) and/or Section 21 (I), as contained in Government Gazette No. 40229, 26 August 2016 and contained within the DWS document titled '*Section 21(c) and (i) Risk-based assessment and authorization, October 2014, Edition 2*'.
- Identification, description and assessment of the construction and operational phase impacts to wetlands/rivers/streams and associated riparian habitat through the utilisation of a qualitative significance assessment tool developed by Eco-Pulse (2015).
- Provision of planning, design, construction and operational phase mitigation measures to avoid, minimise and remediate potential impacts.
- Outline any possible environmental licensing/permitting requirements triggered by the development, including the need for a Water Use License in terms of Section 21 of the NWA.
- Reporting: compilation and submission of a single *Specialist Freshwater Aquatic and Wetland Habitat Impact Assessment Report*.

1.4 The Conservation Importance of Freshwater Resources

Freshwater ecosystems are a subset of the Earth's aquatic ecosystems and include all inland freshwater rivers, streams, wetlands, lakes, ponds and springs. South Africa's freshwater ecosystems are diverse, are vital for supplying freshwater and are amongst the most scare natural resources and foundation for social-economic growth, as well as providing for a range of other important ecosystem goods and services. They are also particularly vulnerable to anthropogenic or human activities, which can often lead to irreversible damage or longer term, gradual/cumulative changes. Since wetlands and rivers are generally located at the lowest point in the landscape; they are often the "receivers" of wastes, sediment and pollutants transported via surface water runoff as well as subsurface water movement (Driver *et al.*, 2011). This combined with the strong connectivity of freshwater ecosystems, means that they are highly susceptible to upstream, downstream and upland impacts, including changes to water quality and quantity as well as changes to aquatic habitat & biota (Driver *et al.*, 2011).

South Africa's freshwater ecosystems have been mapped and classified into National Freshwater Ecosystem Priority Areas (NFEPAs). This work shows that 60% of our river ecosystems are threatened and 23% are critically endangered. The situation for wetlands is even worse: 65% of our wetland types are threatened, and 48% are critically endangered (Driver *et al*., 2011). Recent studies reveal that less than one third of South Africa's main rivers are considered to be in an ecologically 'natural' state, with the principal threat to freshwater systems being human activities, including river regulation, followed by catchment transformation (Rivers-Moore & Goodman, 2009). South Africa's freshwater fauna also display high levels of threat: at least one third of freshwater fish indigenous to South Africa are reported as threatened, and a recent southern African study on the conservation status of major freshwater-dependent taxonomic groups (fish, molluscs, dragonflies, crabs and vascular plants) reported far higher levels of threat in South Africa than in the rest of the region (Darwall *et al*., 2009). Clearly, urgent attention is required to ensure that representative natural examples of the different ecosystems that make up the natural heritage of this country for current and future generations to come. The degradation of South African rivers and wetlands s is a concern now recognized by Government as requiring urgent action and the protection of freshwater resources, including rivers and wetlands, is considered fundamental to the sustainable management of South Africa's water resources in the context of the development of the country.

1.5 Relevant Environmental Legislation

The link between ecological integrity of freshwater resources and their continued provision of valuable ecosystem goods and services to burgeoning populations is well-recognised, both globally and nationally (Rivers-Moore *et al*., 2007). In response to the importance of freshwater aquatic resources, protection of wetlands and rivers has been campaigned at national and international levels. A strong legislative framework which backs up South Africa's obligations to numerous international conservation agreements creates the necessary enabling legal framework for the protection of freshwater resources in the country. Relevant environmental legislation pertaining to the protection and use of aquatic ecosystems (i.e. wetlands and rivers) in South Africa includes the following:

- South African Constitution 108 of 1996
- National Environmental Management Act No. 107 of 1998 (NEMA)
- NEMA Environmental Impact Assessment (EIA) Regulations (2014, as amended)
- National Water Act No. 36 of 1998 (NWA)
- National Environmental Management: Biodiversity Act No. 10 of 2004
- Conservation of Agricultural Resources Act 43 of 1967

Any development with a potential impact to the environment therefore typically needs to be assessed to ensure that impacts are adequately minimized. Authorisations may also be required before planned activities can commence.

Detailed information on applicable legislation can be found in **Annexure B** at the back of this report.

2 APPROACH AND METHODS

2.1 Approach to the Assessment

The general approach to the freshwater wetland and aquatic assessment was based on the proposed framework for wetland assessment proposed in the Water Research Commission's (WRC) report titled: '*Development of a decision-support framework for wetland assessment in South Africa and a Decision-Support Protocol for the rapid assessment of wetland ecological condition*' (Ollis *et al.*, 2014). This is shown graphically in Figure 2, below.

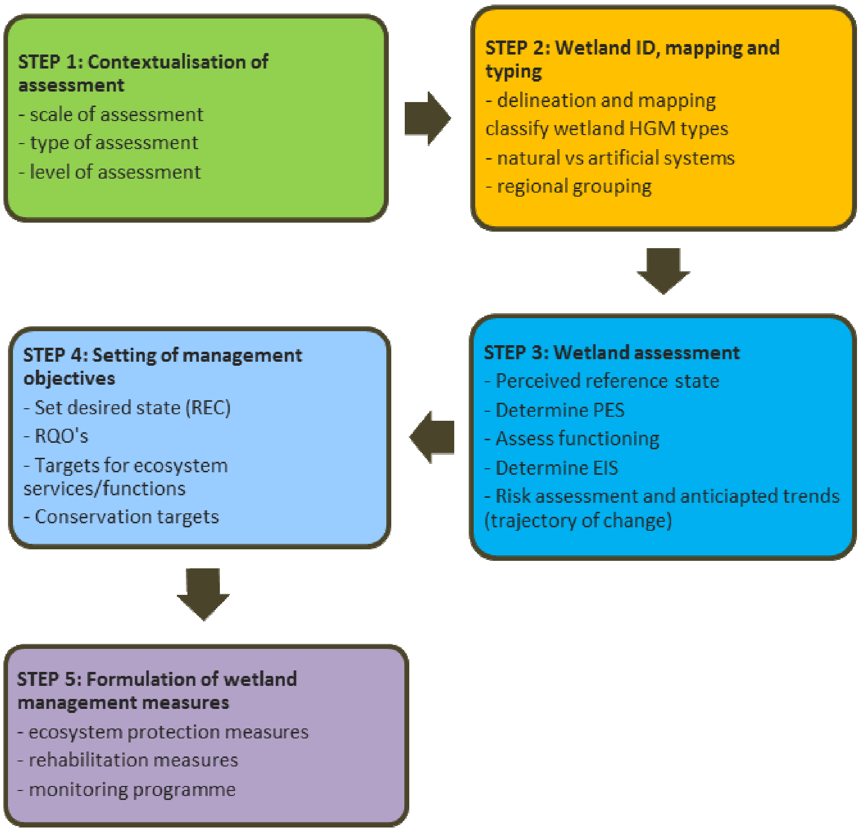


Figure 2 Proposed decision-support framework for wetland assessment in SA (after Ollis *et al.*, 2014).

Note that the freshwater assessment report has been developed in line with the requirements of the Department of Water & Sanitation (DWS) for Water Use Licensing, as outlined in the '*Regulations Regarding the Procedural Requirements for Water Use License Applications and Appeals*' contained in the Government Gazette No. 40713 of 24 March 2017.

2.2 Data Sources Consulted

The following data sources and GIS spatial information provided listed in Table 1 (below) was consulted to inform the specialist freshwater habitat assessment. The data type, relevance to the project and source of the information has been provided.

Table 1. Data sources and GIS information consulted to inform the wetland/aquatic assessment.

	Data/Coverage Type	Relevance	Source
Biophysical Context	**Quaternary catchment MAP, MAT, MAR and PET**	*Determination of climatic factors that drive freshwater hydrology.*	Schulze (1998)
	KZN Rivers (GIS Coverage)	*Highlight potential onsite and local rivers and map local drainage network*	Surveyor General (2006)
	KZN Geology (GIS Coverage)	*Understand regional geology and factors controlling wetland formation and subsurface hydrological processes*	Surveyor General (2006)
	5m Elevation Contours (GIS Coverage)	*Desktop mapping of drainage network and freshwater habitats*	Surveyor General (2006)
	National Geomorphic Provinces	*Understand regional geomorphology controlling the physical environment*	Partridge *et al*., 2010
	DWA Eco-regions (GIS Coverage)	*Understand the regional biophysical context in which water resources within the study area occur*	DWA (2005)
	South African Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference vegetation*	Mucina & Rutherford (2006)
	KwaZulu-Natal Vegetation Map (GIS Coverage)	*Classify vegetation types and determination of reference vegetation*	Scott-Shaw and Escott (2011)
Conservation Context	**National Freshwater Ecosystem Priority Areas (NFEPA)** (GIS Coverage)	*Shows location of national aquatic ecosystems conservation priorities*	CSIR (2011)
	National Biodiversity Assessment - Threatened Ecosystems (GIS Coverage)	*Freshwater ecosystem / vegetation type threat status*	SANBI (2011)
	KwaZulu-Natal Provincial Pre-Transformation Vegetation Type Map (GIS Coverage)	*Classify vegetation types and determination of reference primary vegetation and its provincial threat status*	Scott-Shaw and Escott (2011)
	KZN Terrestrial Conservation Plan (GIS Coverage)	*Provincial conservation planning importance.*	EKZNW (2016)
	KZN Aquatic Systematic Conservation Plan (GIS Coverage)	*Provincial conservation planning importance.*	EKZNW (2007)

2.3 Methods Used

Table 2 below summarises the methods that were used as part of the specialist aquatic assessment. For additional details on the individual assessment methods applied in this study, refer to **Annexure A** at the back of this report.

Table 2. Summary of methods used in the assessment of delineated water resource units.

METHOD/TECHNIQUE	REFERENCE FOR METHODS/TOOLS USED	ANNEXURE
Wetland/riparian areas delineation	*'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas'* (DWAF, 2005).	**A1**
Classification of wetlands & rivers	National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013).	**A2**
Wetland condition/Present Ecological State (PES)	WET-Health assessment tool (Macfarlane *et al*., 2008).	**A3**
River Present Ecological State (PES)	*Qualitative Index of Habitat Integrity tool (Kleynhans, 1996)*	**A4**
Wetland Functional Importance	WET-EcoServices assessment tool adapted from Kotze (2009).	**A5**

METHOD/TECHNIQUE	REFERENCE FOR METHODS/TOOLS USED	ANNEXURE
Wetland Ecological Importance & Sensitivity (EIS)	Wetland EIS tool (Eco-Pulse, 2015) adapted from Wetland EIS tool (Duthie, 1999).	**A6**
River Ecological Importance and Sensitivity (EIS)	EIS tool developed by Eco-Pulse adapted from the DWAF River EIS tool (Kleynhans, 1999)	**A7**
Impact Significance Assessment	Impact assessment method (Eco-Pulse, 2015).	**A8**
Risk Assessment: Section 21 c & i water use	DWS Risk Matrix/Assessment Tool (based on the DWS 2015 publication: 'Section 21 c and i water use Risk Assessment Protocol')	-

2.4 Assumptions and Limitations

The following limitations and assumptions apply to the wetland assessment undertaken:

2.4.1 General assumptions & limitations

- This report deals exclusively with a defined area and the extent and nature of river and wetland ecosystems in that area.
- Additional information used to inform the assessment was limited to data and GIS coverage's available for the Province at the time of the assessment.
- All field assessments were limited to day-time assessments.

2.4.2 Sampling limitations & assumptions

- Sampling by its nature, means that generally not all aspects of ecosystems can be assessed and identified.
- With ecology being dynamic and complex, there is the likelihood that some aspects (some of which may be important) may have been overlooked.
- Not all wetlands and rivers within the 500m DWS regulated area were assessed/delineated in the field. Focal areas at risk of being impacted or triggering Section 21 water use were flagged during the desktop risk/screening exercise to be assessed in detail in the field. Thus, finer habitat type details of the systems not formally assessed were not acquired.
- The wetland boundary was identified and classified along a transitional gradient from saturated through to terrestrial soils which makes it difficult to identify the exact boundary of the wetland. The boundaries mapped in this specialist report therefore represent the approximate boundary of wetlands as evaluated by an assessor familiar and well-practiced in the delineation technique.
- Mapped boundaries are based largely on the GPS locations of soil sampling points. GPS accuracy will therefore affect the accuracy rating of mapped sampling points and therefore wetland/riparian boundaries. Soil sampling points were recorded using a GarminTM Oregon Global Positioning System (GPS) with an accuracy of 3-5m.
- Infield soil and vegetation sampling was only undertaken within a specific focal area in the vicinity of the proposed development, while the remaining water resource/HGM units were delineated at a desktop level with limited accuracy.

- It is important to note that delineation of wetlands on this site was difficult in some areas due to the extent of soil disturbance, infilling, removal of indigenous wetland vegetation and replacement of the native vegetation community with invader exotic/alien plants.
- Inferences made about the ecological integrity/river health of the rivers/stream assessed was based on selected variables, sampled on selected occasions at selected geographic locations. This limits the degree to which this information can be extrapolated spatially (within or across river systems) and temporally (i.e. over seasons). Rivers by nature are highly variable ecosystems and can display fine and large scales changes in the structure, composition and quality of the habitat over short periods of time.
- Note that a risk-based approach was followed in selecting the most appropriate assessment tools for the assessment, with the choice of tools selected with due consideration of expected project risks and costs for collecting and reporting on the assessments.
- It is acknowledged that whilst the river Index of habitat Integrity (IHI) assessment tool is a rapid assessment tool and is not designed to monitor short-term changes in aquatic conditions, it does however provide a useful framework for assessing existing impacts and documenting the PES of rivers and streams where a rapid assessment is appropriate. Eco-Pulse therefore apply the IHI tool routinely to river assessments undertaken for developments that we regard as "low risk", such as the case of minor road upgrades, re-alignments and culvert/bridge upgrades (as per this project).
- Whilst the South African Scoring System (SASS) (and the use of other more detailed assessments) can be a useful tool for assessing baseline water q1uality conditions, it adds cost to the assessment and we therefore apply this approach selectively to projects where we believe it would add significantly to the assessment and/or is likely to be recommended as an approach for monitoring project impacts. We would therefore typically apply SASS to moderate to high risk activities, and particularly in instances where planned activities pose a real risk to water quality.
- It is also worth noting that SASS is not an appropriate tool for assessing wetlands and ephemeral river systems.
- It should be noted that while WET-Health (Macfarlane *et al*., 2008) is the most appropriate technique currently available to undertake assessments of wetland condition/integrity, it is nonetheless a rapid assessment tool that relies on qualitative information and expert judgment. While the tool has been subjected to an initial peer review process, the methodology is still being tested and will be refined in subsequent versions. For the purposes of this assessment, the assessment was undertaken at a rapid level with limited field verification. It therefore provides an indication of the PES of the system rather than providing a definitive measure.
- The Ecological Importance and Sensitivity assessment did not specifically address the finer-scale biological aspects of the rivers such as fauna (amphibians and invertebrates) occurring. No detailed assessment of aquatic fauna/biota was undertaken. Fauna documented in this report are based on site observations during site visits and are therefore not intended to reflect the overall faunal composition of the habitats assessed.
- The vegetation information provided is based on observation points, not formal vegetation plots. As such species documented in this report should be considered as a list of dominant

and/or indicator wetland/riparian species and only provide a very general indication of the composition of the wetland/riverine vegetation communities.

2.4.3 Assumptions with respect to the assessment of impacts

- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar road/bridge upgrade projects in KZN.
- Evaluation of the significance of impacts with mitigation takes into account mitigation measures and best management practice, as provided in this report.

3 BACKGROUND TO THE STUDY AREA

3.1 Regional / Local Biophysical Setting

A summary of key biophysical setting details of the study area and surrounds are presented in Table 3, below.

Table 3. Key biophysical setting details of the study area.

Biophysical Aspects	Desktop Biophysical Details	Source
Elevation	Approx. 120-150 m a.m.s.l.	Google Earth™
Mean annual precipitation (MAP)	848.4 mm	Schulze, 1997
Rainfall seasonality	Early to late summer	DWAF, 2007
Average temperature range	21.8°C in winter (July) to 27.5°C in summer (February)	http://saexplorer.co.za/south-africa/climate/eshowe_climate.asp
Potential Evaporation (mm) Mean Annual A-pan Equivalent	1792.8 mm/annum	Schulze, 1997
Median Annual Simulated Runoff (mm)	77.9 mm/annum	Schulze, 1997
Geomorphic Province	Southeastern Coastal Hinterland	Partridge *et al*., 2010
Geology	Shale	RSA 1:1000 0000 Geological Map (SA Geological Society)
Water management area	Usutu to Mhlatuze	DWS
Quaternary catchment	W12F	DWS
Main collecting river(s) in the catchment	Mhlatuze River	CSIR, 2011
Geomorphic zone of the reach assessed	Transitional River	CSIR, 2011
DWS Ecoregion	North Eastern Uplands (14.01)	DWA, 2005

3.2 Local Surface Water Drainage Setting

The P393 bridges widening project is located within the Usutu to Mhlatuze Water Management Area (WMA) in DWS quaternary catchment W12D (Figure 3, below). Both bridges to be upgraded are situated at the footslope of a steep mountainous area where a dense network of drainage lines converge to form the perennial Bedlane and Dango rivers. Both rivers form left-bank tributaries of the perennial Mhlatuze River which flows in an easterly direction and is located roughly 1-1.5km south of the Bedlane and Dango bridge crossings. Figure 3, below shows the regional and local drainage network in relation to the study area.

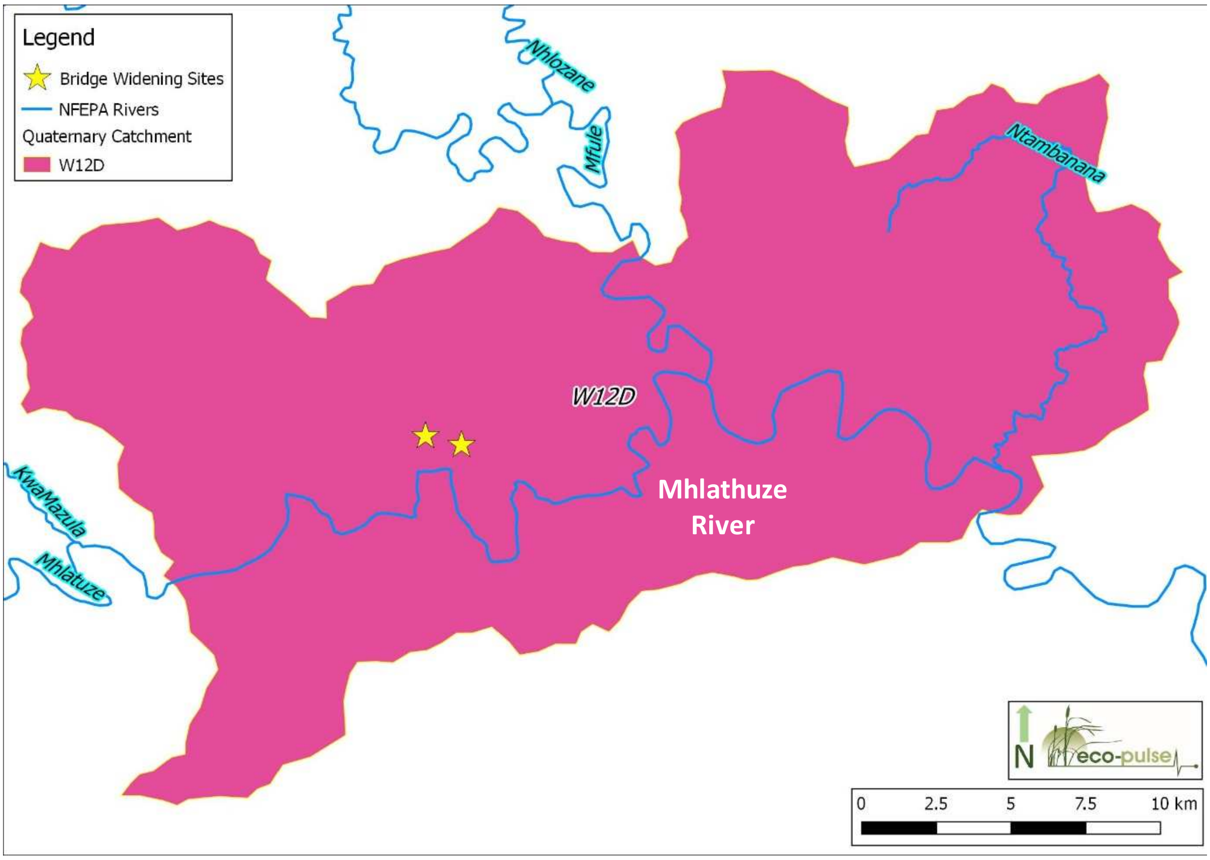


Figure 3 Map showing the location of the proposed P393 bridge widening sites within DWS Quaternary Catchment W12D, drained by the large perennial Mhlatuze River.

3.3 Conservation Context

Understanding the conservation context and importance of the study area and surrounds is important to inform decision making regarding the management of the aquatic resources in the area. In this regard, national, provincial and regional conservation planning information available and was used to obtain an overview of the study site. Key conservation context details of the project site and surrounds have been summarised in Table 4, below.

Table 4. Key conservation context details for the study area.

NATIONAL LEVEL CONSERVATION PLANNING CONTEXT			
Conservation Planning Dataset	**Relevant Conservation Feature**	**Location in Relation to Project Site**	**Conservation Planning Status**
National Vegetation Map (Mucina & Rutherford, 2006) Ecosystem Threat Status NBA 2011	Eastern Valley Bushveld (SVs 6)	Remaining intact terrestrial vegetation within the entire study area and surrounds	Least Threatened
The National Freshwater Ecosystem Priority Area (NFEPA) Assessment (CSIR, 2011)	Wetlands	Wetlands on and adjacent to the site	Wetland vegetation group: **Sub-escarpment Savanna (Endangered)**

NATIONAL LEVEL CONSERVATION PLANNING CONTEXT			
Conservation Planning Dataset	**Relevant Conservation Feature**	**Location in Relation to Project Site**	**Conservation Planning Status**
PROVINCIAL AND REGIONAL LEVEL CONSERVATION PLANNING CONTEXT			
Conservation Planning Dataset	**Relevant Conservation Feature**	**Location in Relation to Project Site**	**Conservation Planning Status**
KZN Vegetation Map (EKZNW, 2012)	Eastern Valley Bushveld	Untransformed terrestrial bushveld surrounding project sites	Least Threatened
KZN Aquatic Conservation Plan (EKZNW, 2007)	Freshwater Planning Units No. 2117 (Bedlane River Bridge) and 1955 (Dango River Bridge)	Relevant study area and catchment	Broader catchments 'available'
KZN Terrestrial Conservation Plan (EKZNW, 2010)	Terrestrial Planning Units No. 142041 and 142087	Areas surrounding Dango River	100% Transformed
KZN Terrestrial Systematic Conservation Assessment (EKZNW, 2016)	Bushveld/savannah (remaining untransformed)	N/A	None

Aquatic conservation concerns and features of particular importance to the study area are summarised below as follows:

3.3.1 National Level Aquatic Conservation Priorities

The National Freshwater Ecosystem Priority Area (NFEPA) project (Nel *et al*., 2011), is the first formally adopted national freshwater conservation plan that provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting the sustainable use of water resource units that includes rivers, wetlands and estuaries. The importance of water resources in meeting national freshwater conservation targets is provided in the National Freshwater Ecosystems Priority Areas (NFEPA) outputs and coverage's (CSIR, 2011). This coverage reveals that **wetlands identified within a 500m radius of the proposed development property have not been identified or classified at a national level of important Freshwater Ecosystem Priority Areas or FEPAs.** The wetland vegetation group within which mapped wetlands occur is "**Sub-escarpment Savanna**", which is regarded as being '***Endangered'*** in terms of ecosystem threat status and poorly protected (CSIR, 2011).

3.3.2 Provincial Level Aquatic Conservation Priorities

The study area falls within a sub-catchment classified as 'Available' according to the freshwater CPLAN (EKZNW, 2007), which suggests that the catchment has not specifically been identified as a provincial priority area aquatic conservation priority. Despite not being prioritized nationally or provincially, this should not undermine the importance of wetlands and riverine ecosystems in general in terms of their habitat value and being important sources of valuable ecosystem services both to society and the environment in general.

In terms of the 2010 KZN Terrestrial Systematic Conservation Plan (CPLAN), the sites of the two bridges crossing the Dango and Bedlane Rivers have not been flagged as being important in terms of potential terrestrial biodiversity priorities.

3.3.3 Regional & Local Level Aquatic Conservation Priorities

Additional conservation planning information is also available in terms of the Biodiversity Sector Plan (BSP) for the uThungulu District Municipality (Elliott & Escott, 2013), which was interrogated in terms of the location, extent and relevance of local conservation priorities identified for the project site and immediate surrounding areas. The BSP is "…*intended to assist and guide land use planners and managers within the uThungulu District and its respective local municipalities, to account for biodiversity conservation priorities in all land use planning and management decisions, thereby promoting sustainable development and the protection of biodiversity, and in turn the protection of ecological infrastructure and associated ecosystem services*" (Elliott & Escott, 2013).

The 'Local Conservation Priorities' spatial output as identified in the Biodiversity Sector Plan (BSP) for the uThungulu District Municipality was reviewed from an aquatic ecosystems conservation perspective, with no local conservation priorities identified.

4 INITIAL AQUATIC SCREENING

Initially, a desktop wetland identification and mapping exercise was undertaken in GIS (Geographical Information Systems) based on available imagery (Google Earth™), elevation contours and existing wetland coverage's for the region (e.g. KZN wetland map, NFEPA wetland coverage). This allowed for the identification of watercourses which were later ground-truthed and delineated in the field using various indicators (discussed under Section 5 of this report). The wetland & river delineation map shown below in Figure 4 below identifies and maps the location, extent and spatial distribution of two (2) wetland units, one (1) artificially created wetland unit and two (2) riverine units within the DWS regulated area for wetland 'water use' (i.e. within a 500m radius of the proposed bridge widening sites). The two wetlands which occur within the DWS regulated area of the Dango River Bridge were classified as channelled valley bottom (CVB) wetlands, with one artificial wetland noted approximately 450m upstream, while the riverine units occurring within the DWS regulated area of the Bedlane River Bridge were classified as transitional rivers (Figure 4, below).

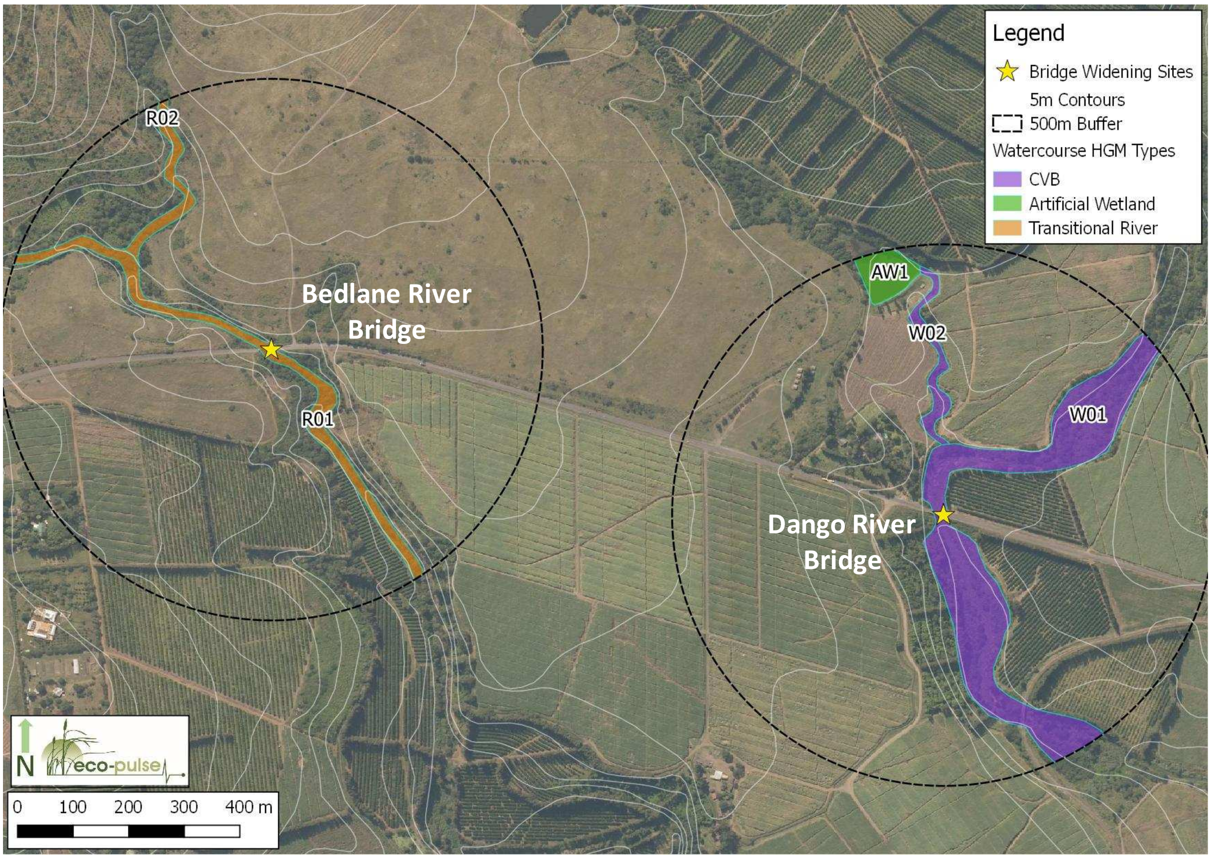


Figure 4 Wetland delineation map and HGM unit classification for wetlands within the 500m regulated area of the proposed bridge widening sites.

An initial desktop screening of 'impact potential' for identified wetlands within a 500m radius of the development (which corresponds to the DWS regulated area for wetlands water use) was undertaken in GIS and then verified in the field. Based on the position of the identified water resources in the landscape and in relation to the bridge widening sites, the probability of the proposed upgrades impacting or constituting a water use for each watercourse was determined based on professional opinion and through the interpretation of the criteria/rationale presented in Table 5. This resulted in the identification of two (2) key watercourses that have already been directly impacted or are likely to be impacted by the activities associated with the upgrading of bridges and which will require a water use license in some form (Figure 5, below). This is essentially the channelled riverine ecosystem associated with the Bedlane River and a channelled valley bottom wetland associated with the Dango River at the existing bridge crossings. Other wetlands identified within the 500 regulated area for water use licensing included an artificially created wetland and an additional channelled valley bottom wetland, however due to these features being located a considerable distance upstream from the bridge sites, these watercourses are unlikely to have sustain direct nor indirect impacts from the facility in any way, shape or form, and thus will not require a water use license in terms of Section 21 of the National Water Act No. 36 of 1998.

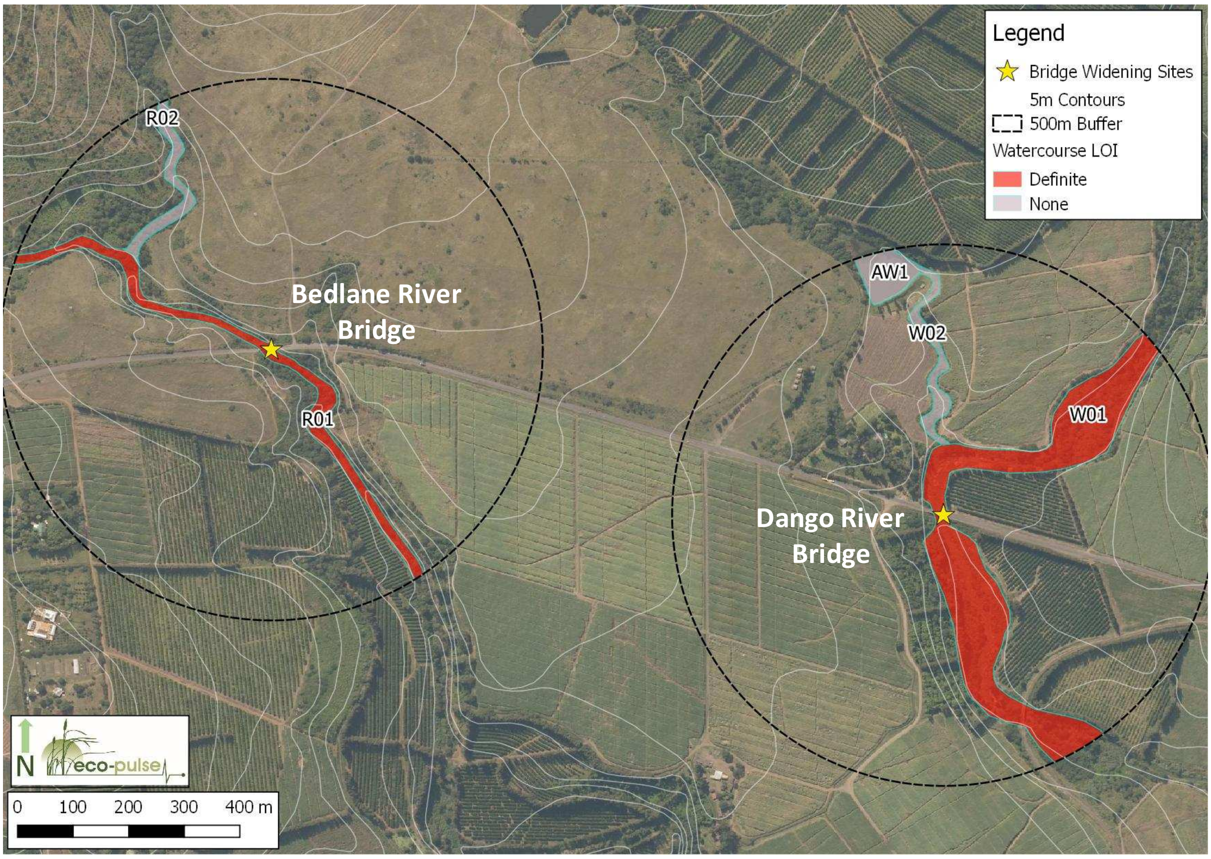


Figure 5 Desktop mapping and preliminary 'impact potential rating' to screen initial water use licensing requirements for the site and study area within 500m of the two bridge widening sites. Watercourses shaded in "Red" are likely to require a water use license in some form, whilst those shaded in "Purple" will not require a water use license as contemplated in terms of Section 21 (c) and/or (i) of the National Water Act.

Table 5. Qualitative 'impact potential' rating guidelines (Eco-Pulse Consulting, 2017).

Impact Potential	Description and Rating Guidelines
Definite	These resources will require an assessment of aquatic impacts and a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are located **within the footprint of the proposed development** and will be directly impacted; and/or ➢ resources are located **within 15m upstream or upslope** of the development and trigger requirements for Environmental Authorisation according to the latest NEMA: EIA regulations; and/or ➢ resources are located **downstream or downslope** of the development and trigger requirements for Environmental Authorisation according to the latest NEMA: EIA regulations under the following development scenarios: o within **15m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o within **50m downstream/downslope of a moderate risk development** (e.g. housing estates) o within **100m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. large dams and water abstraction projects, mining, large industrial sites, WWTW, etc.)
	Assessment guidelines for watercourses where impact potential is regarded as 'definite/probable': **1. Detailed onsite delineation** **2. HGM unit classification** **3. Habitat assessment** **4. PES/functioning/EIS assessment at moderate or high level of detail** **5. Risk assessment*** **6. Detailed impact assessment with/without pre and post change to PES/functioning** **7. Detailed impact mitigation in line with the mitigation hierarchy: *possibly including the need to consider offset requirements***
Probably / Likely	These resources are likely to require an assessment of aquatic impacts and a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are located **within 32m but greater than 15m from** the proposed development activity/activities, with a high likelihood of incurring direct impacts as a result; and/or ➢ resources are **located within a range at which they are likely to incur indirect impacts** (e.g. water pollution, erosion and sedimentation) associated with development activities and usually downstream of the development within the following guiding thresholds: o within **32m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o within **100m downstream/downslope of a moderate risk development** (e.g. housing estates) o within **500m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. dams, water abstraction, mining, large industrial sites, WWTW, etc.)
	Assessment guidelines for watercourses where impact potential is regarded as 'possible': **1. Desktop delineation with onsite verification of boundaries** **2. HGM unit classification** **3. Habitat assessment** **4. PES/functioning/EIS assessment at low level of detail** **5. Risk assessment*** **6. Impact assessment** **7. Impact mitigation in line with the mitigation hierarchy: *including buffer zones***
Unlikely	These resources are unlikely to require an assessment of aquatic impacts or a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) for the following reasons: ➢ resources are **located a moderate distance upstream or upslope (>32m)** of the proposed

Impact Potential	Description and Rating Guidelines
	development and are unlikely to be directly impacted by the development activities; and/or ➢ the location of resources and nature of the development activity is **not considered a 'Listed Activity'** according to the latest NEMA: EIA regulations[1] **;** and/or ➢ resources are **located downstream but well beyond the range at which they are likely to incur indirect impacts** (e.g. water pollution, erosion and sedimentation) associated with the development and usually downstream of the development within the following guiding thresholds: o >**32m downstream/downslope of a low-risk development** (e.g. for linear activities such as roads and water pipeline development projects) o >**100m downstream/downslope of a moderate risk development** (e.g. housing estates) o >**500m downstream/downslope of high risk developments and activities associated with large water quality/flow related impacts** (e.g. dams, water abstraction, mining, large industrial sites, WWTW, etc.)
	Assessment guidelines for watercourses where impact potential is regarded as 'unlikely': **1. Desktop mapping of watercourses within 500m of the development site** **2. Desktop HGM unit classification** **3. Risk assessment***
None	These resources will not require impact assessment or a Water Use License in terms of NEMA and Section 21 (c) & (i) of the National Water Act (No. 36 of 1998) as resources are: (i) situated **a large distance (>100m) upstream of the impact causing activity**, or (ii) **located within another adjacent sub-catchment**, such that the drivers and characteristics of the watercourse will not be modified or impacted in any way, shape or form.
	Assessment guidelines for watercourses where impact potential is regarded as 'None': **1. Desktop mapping of watercourses within 500m of the development site**

[1] Note that the latest EIA Regulations and Listed Activities should be referred to on a case-by-case basis when considering the need for impact assessment in terms of NEMA.

5 BASELINE WETLAND & AQUATIC ASSESSMENT FINDINGS

This section of the report presents the findings of the wetland/riparian areas delineation study and baseline condition and functionality assessment undertaken for the freshwater aquatic resources (wetlands and rivers/streams) identified as requiring further assessment to inform the Basic (Environmental) Assessment and Water Use Licensing requirements for the proposed bridge widening on the Dango and Bedlane Rivers.

5.1 Location, extent, classification and description of aquatic ecosystems and habitats

Freshwater aquatic resources and associated habitat requiring further assessment to inform water use licensing (as an outcome of the initial water use license screening exercise undertaken as per Section 4 of this report) included a large channelled valley bottom wetland system (W01) associated with the Dango River at the existing bridge crossing to be upgraded, and a semi-perennial transitional river (R01) associated with the Bedlane River at the bridge crossing (see Figure 6). These watercourses will likely be directly or indirectly impacted by the proposed bridge upgrading (widening) and will require some form of a water use license (*see licensing requirements in Section 9 of this report*). Summary details of these watercourses and their locations are included below in Table 6, with the watercourses shown mapped in Figure 6.

Table 6. Summary and locations of watercourses assessed in detail for the proposed P393 bridge upgrades.

Water Resource Unit	HGM Type	Location	GPS Coordinates
Bedlane River R01	Transitional River	Associated with the Bedlane River at the existing bridge site	28◦ 43' 17.30" S | 31◦ 33' 18.44" E
Wetland W01	Channelled valley bottom (CVB) wetland	Associated with the Dango River at the existing bridge site	28◦ 43' 28.49" S | 31◦ 34' 3.61" E

These two watercourses (wetlands W01 and river R01 and associated riparian habitat) were subject to further detailed field delineation and a baseline aquatic ecological assessment to inform the assessment of potential impacts and recommendation of impact mitigation/management measures, ecological monitoring requirements and water use licensing requirements.

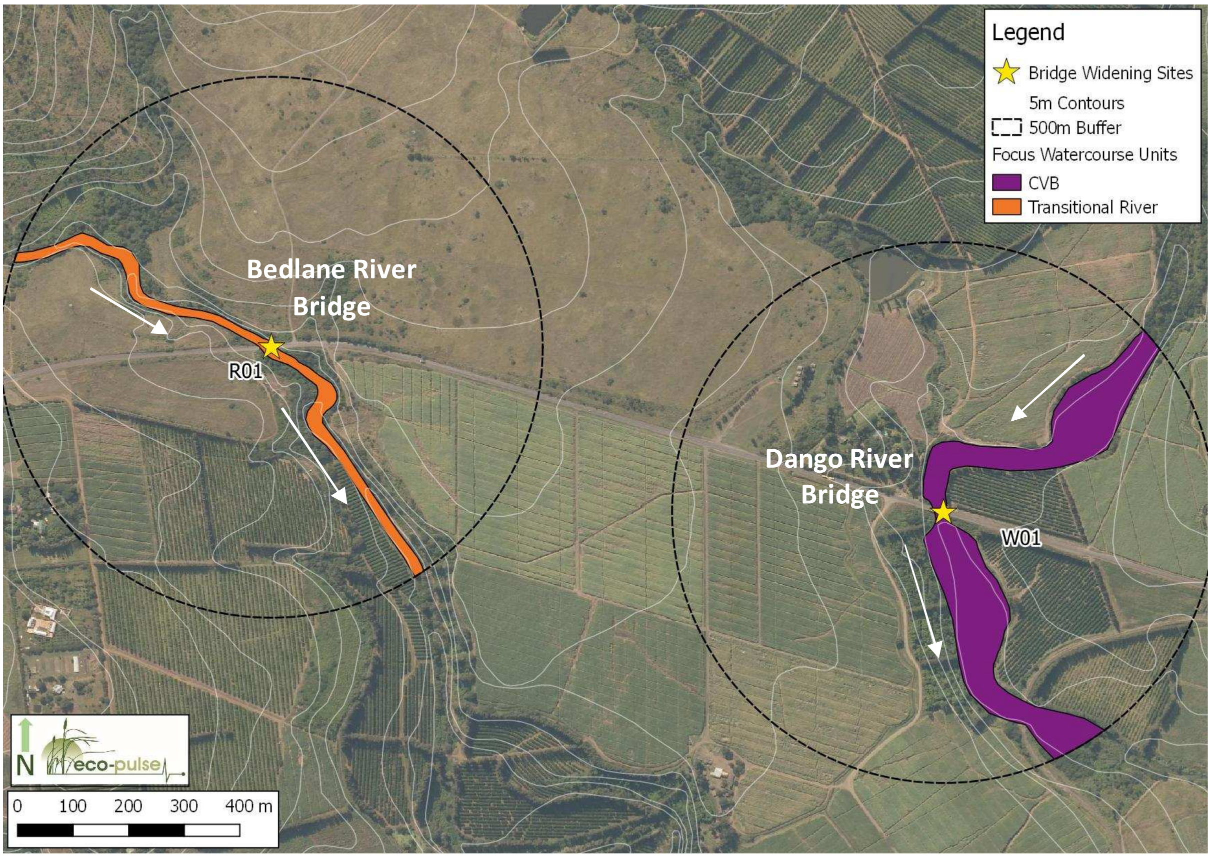


Figure 6 Map showing the two delineated and classified watercourses identified at the proposed bridge widening sites and surrounding areas within the 500m DWS regulated buffer as being at risk of impact and triggering Section 21 c and/or i water use, which were the focus of the detailed baseline aquatic and wetland assessment. The 'White' arrows show direction of flow.

5.1.1 Delineation of wetlands and riparian areas

Wetland W01 associated with the Dango River (shown in Figure 6, above) was identified as requiring further detailed assessment to inform the WULA and was therefore subject to detailed in-field sampling and delineation according to the methods and techniques found in the Department of Water Affairs wetland delineation manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005). Three specific wetland indicators were used in the detailed field delineation of wetlands, which included: topography, vegetation and soil morphology. In most cases, the soils provided a good indication of the level of wetness of the soils (permanent, seasonal and temporary), with low matrix chroma and soil mottling present. However, due to the largely transformed nature of the vegetation at the site as well as the extensive soil disturbance in some areas, delineation was challenging. In these instances, topography and to a lesser extent, soil morphology, were key in determining the outer boundary of wetlands (i.e. the boundary between the temporary wetness zone and adjacent terrestrial land. *Further details on the delineation method used can be found in* ***Annexure A1***.

The riparian area associated with the Bedlane River (R01 in Figure 6) was delineated based on a unique set of delineation indicators for riparian areas delineation which included: (i) presence of alluvial soils and recent river deposits, (ii) channel morphology/topography and (iii) differences in vegetation composition and structure between riparian areas and adjacent terrestrial habitat. As the sole reliance on one indicator can be misleading (e.g. many species of plants can successfully grow within aquatic and semi-aquatic / terrestrial habitats), a combination of all three indicators was used to provide for a logical, defensible and technical basis for riparian area delineation. *Further details on the method of delineation for riparian areas can be found in* ***Annexure A1.***

5.1.2 Classification and description of wetlands and riparian areas

A summary of the basic biophysical details for the two watercourses is provided in Table 7, below. Further descriptions for each wetland/ river are provided in the text that follows.

Table 7. Summary of basic biophysical details of wetlands and rivers assessed.

ATTRIBUTES	WETLAND HGM UNITS	
	W01	R01
Type	**Channelled valley bottom wetland**	**Transitional River**
Extent/area	~7.9 ha	N/A
Landform	Valley bottom	Valley bottom
Dominant water input	Combination of subsurface/ groundwater and overland flow	Overland flows
Wetness regime	Seasonal	Seasonal
Dominant Vegetation	*Phragmites australis* reedbed (above bridge), Hygrophilous grassland (below bridge)	*P. australis* reedbed (above bridge), closed canopy riparian forest (below bridge).
Existing Impacts	• Moderate to high levels of Invasive Alien Plants (IAPs) • Infilling associated with existing road and bridge development • Sedimentation • Erosion • Soil disturbance • Small upstream dams	• Moderate to high levels of IAPs • Infilling associated with existing road and bridge development • Vegetation clearing • Reduced flows within the unit as a result of flow impoundment via a large upstream dam

1. Wetland W01: channelled valley bottom wetland (associated with the Dango River)

Wetland W01 is a large channelled valley bottom (CVB) wetland associated with the Dango River. The channel is approximately 1.5m deep and 3-4m wide below the bridge, whilst, above the bridge the channel is considerably less confined and is approximately 1m deep and 6m wide. The wetland unit comprised a mixture of vegetation types with two key vegetation communities identified, with the vegetation above the bridge and within the macro channel below the bridge comprised of a *Phragmites australis* reedbed with moderate to high abundances of Invasive Alien plants (IAPs), most notably *Coix lacryma-jobi* and *Chromolaena odorata*. The vegetation flanking either side of the macro channel below the bridge comprised of a hygrophilous grassland vegetation community dominated by *Panicum maximum* with moderate abundances of *Sporobolus africanus* and *Arundo donax*, with the latter being more prevalent near the edge of the macro channel. Sub-dominant species located above the bridge included *Bridelia micrantha, Trema orientalis, Casuarina equisetifolia, Melia azedarach* and *Ricinus communis* whilst sub-dominant species below the bridge including *Paspalum* *urvillei, Setaria megaphylla, Cyperus sexangularis, Rubus cuneifolius, Ricinus communis* as well as *Melia azedarach* saplings.

Photo 1. View from the top of the infilled right hand bank (RHB), above the Dango River bridge, showing wetland unit W01 looking downstream. The *Phragmites australis* reedbed is a prominent feature of the wetland at this location.

Photo 2. View from the top of the infilled RHB, above the Dango River bridge, showing wetland W01 looking from west to east across the unit. Note the level of sedimentation within the wetland and woody alien trees colonising disturbed peripheral wetland areas.

Photo 3. View from the Dango bridge looking downstream showing the dominance by *P. australis* reeds within the macro channel of the wetland, flanked by short hygrophilous grassland.

Photo 4. View from the the top of the infilled RHB looking beneath the existing bridge on the Dango River.

2. River R01: Transitional River (Bedlane River)

River unit R01 ('Bedlane River') has been classified as a small mixed bedrock-alluvial transitional river containing localised riffles and shallow pools. The active channel of the river was approximately 0,5m deep and varied between 2-3m in width whilst the macro channel was approximately 4m deep and 8-10m wide. A large farm dam is located approximately 1km upstream from the location of the existing Bedlane River bridge.

Instream vegetation was found to be variable, with communities above the bridge comprising *P. australis* reeds with moderate to low abundances of *B. micrantha*, *Canna indica* and *C. lacryma-jobi* whilst instream vegetation below the bridge was largely limited except for very low abundances of *C. lacryma-jobi* and *C. odorata*. The riparian vegetation upstream was also markedly distinct from the riparian vegetation downstream with upstream riparian vegetation comprising a secondary riparian forest community dominated by *M. azedarach* and *B. micrantha* with sub-dominant species including P. *maximum, P. australis, Commelina erecta, , C. lacryma-jobi, A. donax*, and *Lantana camara*. The riparian vegetation downstream of the bridge comprised a closed canopy riparian forest dominated by *B micrantha* and *Ficus sur* with sub-dominant species including *Syzigium cordatum, Oplismenus* *hirtellus, Pteridium aquilinum, C. odorata, Psidium guajava, M. azedarach* and *C. equisetifolia*. Some localised harvesting of instream *P. australis* reeds was noted within the macro channel immediately above the bridge.

Photo 5. View above the Bedlane bridge looking across unit R01, from the Left Hand Bank (LHB). Note the small scale harvesting of reeds by locals.

Photo 6. View from east to west looking across unit R01 from above the Bedlane bridge. The secondary riparian forest at this locality comprised a mix of alien and indigenous woody vegetation.

Photo 7. View looking downstream of unit R01 from below the Bedlane bridge. Note the cobble-dominated instream habitat with limited vegetation within the active river channel.

Photo 8.View from the Bedlane bridge looking dowstream of unit R01. Note the disturbed habitat next to the bridge which then graduates into a largely indigenous riparian forest.

5.2 Baseline Ecological Assessment of Wetlands

5.2.1 Present Ecological State (PES) of Wetlands

Wetlands form at the interface between terrestrial and aquatic environments, and between groundwater and surface-water systems. The complex interaction of inflows and outflows of water, sediment, nutrients and energy over time is what shapes the physical template of the wetland and understanding theses fluxes and interactions considered is fundamentally important in developing an understanding the occurrence, morphology and dynamics of different wetland systems (Ellery et al., 2009). The current health or Present Ecological State (PES) of wetlands was assessed using the WET-Health tool (Macfarlane et al. 2007) which was applied at a rapid level 1 assessment level. WET-Health assesses wetland condition or PES based on an understanding of both catchment and on-site impacts. The approach to assessing wetland PES essentially works by comparing a wetland in its current state with the estimated/anticipated baseline/reference conditions for the wetland. Specification of the reference state (see Table 8, below) is followed by an impact-based approach, whereby the extent and intensity of anthropogenic impacts are interrogated to interpret the level of modification to the *primary drivers of wetland health, namely (i)* ***hydrology****, (ii)* ***geomorpholog****y and (iii) the structure and composition of wetland* ***vegetation****.*

Table 8. Comparing anticipated wetland reference state with present state for wetland 'W01' associated with the Dango River.

Component of Wetland Health	Reference State	Present State
Hydrology	Water inputs to the wetland dominated by surface flows from overtopping of the river channel with lateral subsurface inputs contributing to a far lesser extent. Through flows a mix of channelled surface flows and diffuse flows outside of the channel.	Seasonal to permanent wetland, flows are largely confined to a single channel which has become somewhat incised, resulting in limited overtopping of the banks thereby altering the natural wetness regime with peripheral wetland areas.
Geomorphology	Gradual slope with naturally even/slightly undulating topography, flows concentrated along a central channel.	Infilling due to artificial activities, channel incision and erosion gulley formation linked with surface runoff from altered/hardened catchment areas, increased sedimentation due to increased agricultural practices in the catchment. Reduced sediment inputs due to upstream farm dams.
Vegetation	100% native vegetation dominated by mixed hygrophilous grassland and sedgeland habitat of the Sub-escarpment savanna vegetation group. No alien/exotic vegetation.	Monotypic reedbeds and hygrophilous grassland community with moderate to high levels of alien/exotic vegetation.

A summary of the results of the WET-Health condition/PES assessment (i.e. impacts to and current state of each component of wetland health: hydrology, geomorphology and vegetation) is included below in Table 9 for the channelled valley bottom wetland W01 associated with the Dango River bridge, which was found to be in a **'*Largely Modified*' state ("D" PES category).**

Table 9. Summary of the WET-Health assessment results for wetland W01.

Wetland Unit	HGM TYPE	Extent	Hydrology	Geomorphology	Vegetation	Overall PES
			Impact Score	Impact Score	Impact Score	Impact Score
W01	Channelled valley-bottom wetland	~7.9ha	4.5	3.9	5.2	**4.5**
PES Category			**D**	**C/D**	**D**	**D: Largely Modified**

Key impacts to this wetland include:

1. Moderate to high levels of invasive alien plant colonisation of wetland areas.
2. Infilling associated with the construction of the existing bridge over the wetland.
3. Sedimentation resulting from agricultural practices (sugarcane farming) within the upstream catchment.
4. Channel incision due to increased floodpeaks resulting from land use change in the catchment.
5. Reduced flows and sediment inputs due to upstream farm dams.
6. Soil disturbance resulting from historic agricultural practices within the wetland.

Note that individual WET-Health assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

5.2.2 Wetland Functionality (Ecosystem Services) assessment

Wetlands are known to provide a range of ecosystem goods and services to society, and it is largely on this basis that policies aimed at protecting wetlands have been founded. This section of the report provides a summary of the predicted level of importance of the various wetland ecosystems in terms of *their effectiveness in providing aquatic ecosystem goods and benefits. The WET-Ecoservices assessment method (Kotze et al., 2009) was used for this purpose.*

The predicted level of importance of the various potential goods and services have been summarised in Table 10, below, with some of the key findings of the WET-Ecoservices (wetland functionality) assessment including:

- The level of supply provided for several regulating and supporting services (such as stream flow regulation water quality enhancement and sediment trapping) is generally regarded as moderate, which is driven by a moderate to moderately low local/regional demand and a moderate to moderately-high capacity for the wetland to provide these key services in the landscape.
- With the exception of harvestable resources (wetland is regarded as moderately important at providing reeds and other natural resources), provisioning and cultural services are not considered particularly important for the wetland which can be linked to low supply/demand levels and due to the moderate to large level of modification due to anthropogenic impacts, the wetland is not considered a useful reference wetland site with very few opportunities for educational/tourism/research use identified.

Table 10. Summary of the importance of wetland unit W01 in providing ecosystem goods & services.

Ecosystem Service/Benefit		**W01:** Importance Rating and Score (/4)
REGULATING AND SUPPORTING SERVICES	**Flood attenuation**	Moderately Low (1.2)
	Stream flow regulation	Moderate (1.9)
	Sediment trapping	Moderate (2.3)
	Erosion control	Moderately Low (1.4)
	Phosphate removal	Moderate (2.1)
	Nitrate removal	Moderate (1.6)
	Toxicant removal	Moderate (1.6)
	Carbon storage	Moderately Low (1.3)
	Biodiversity maintenance	Moderately Low (1.4)
PROVISIONING SERVICES	**Water supply**	Moderately Low (1.4)
	Harvestable natural resources	Moderate (1.6)
	Food for livestock	Very Low (0.5)
	Cultivated foods	Very Low (0.5)
CULTURAL SERVICES	**Cultural significance**	Moderately Low (1.5)
	Tourism & recreation	Very Low (0.3)
	Education and research	Very Low (0.1)

Note that individual WET-Ecoservices assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

5.2.3 Ecological Importance & Sensitivity (EIS) of Wetlands

Ecological Importance is an expression of the importance of an aquatic resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to an ecosystem's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).

Based on the PES assessment and importance of the wetland in terms of wetland goods and services, the Ecological Importance and Sensitivity (EIS) of the wetland was rated using the Wetland EIS tool developed by Eco-Pulse (2015). A summary of the EIS assessment for wetland unit W01 is provided below in Table 11. Generally speaking, the wetland (W01) was found to be of Moderate Ecological Importance & Sensitivity (EIS), which is driven largely by the moderate importance of the wetland in terms of providing key regulating and supporting services, particularly flow regime regulations, sediment trapping and water quality enhancement. This is despite the wetland obtaining a relatively low ecological sensitivity rating (due to the existing level of habitat degradation and poor condition of the wetland).

Table 11. Summarised EIS assessment results for the wetland unit W01.

	W01 (Score out of 4)
Ecological Importance	**2.3**
Biodiversity maintenance	1.4
Flow regime regulation	1.9
Water quality enhancement	1.8
Sediment & erosion regulation	2.3
Climate regulation	1.3
Ecological Sensitivity	**1.2**
EIS	**2.3**
EIS Rating	**Moderate**
Socio-cultural Importance	**1.6**
Provisioning services	1.6
Cultural services	1,5
Socio-cultural Importance Rating	**Moderately Low**

Note that individual wetland EIS assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

5.3 Baseline Ecological Assessment of Rivers

5.3.1 Present Ecological State (PES) of Rivers

The Present Ecological State (PES) refers to the health or integrity of a river system, and includes both in-stream habitat as well as riparian habitat adjacent to the main channel. Habitat is considered one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996).

The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes. Habitat integrity for instream and riparian habitats was assessed separately based on the following indicators of habitat integrity:

1. Water abstraction
2. Flow modification
3. Inundation
4. Bed modification
5. Bank erosion
6. Channel modification
7. Water quality
8. Solid waste disposal
9. Vegetation removal
10. Exotic vegetation
11. Connectivity

A summary of the results of the IHI assessment undertaken for the riverine unit R01 (Bedlane River) is presented below in Table 12 and Figure 7. The results of the IHI assessment undertaken suggests that River R01 can be regarded as being in a **'Moderately Modified'** state (reflected by a "C" PES Category), which is based on the combined assessment of both instream and riparian habitat integrity. The moderate level of modification is primarily attributed to the extent of woody and herbaceous alien plant infestation of the instream and riparian areas of the river as well as the significant effect of upstream dams and abstraction on flows to the downstream river.

Table 12. Summary of the Index of Habitat Integrity (IHI) results for river R01: Bedlane River.

HGM	Zone	IHI Score & IHI Class	Description	Weighted overall Score
R01: mixed bedrock-alluvial transitional river	Instream	77% Fair	The combined habitat integrity rating for this river reach assessed was regarded as "fair" or "moderately modified" ("C' ecological category). The reason for the moderate reduction in habitat integrity which has resulted in the river attaining a PES rating of 'fair" is as a result of the impacts vegetation clearing which were considered moderate, with riparian vegetation being the most affected by moderately high levels of exotic/alien vegetation which has replaced much of the natural vegetation.. Hydrological modifications were also apparent, with the impact of an upstream dam on flows being regarded as large and mainly affecting the instream habitat associated with the active river channel and with mainly low flows affected. Water quality was deemed to be fair,	**78%** **Fair** ('C' Ecological Category)
	Riparian	80% Good/ Fair		

HGM	Zone	IHI Score & IHI Class	Description	Weighted overall Score
			with elevated nutrients likely due to various forms of agriculture and scattered settlements in the catchment area upstream of the river reach assessed.	

Note that individual river IHI assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

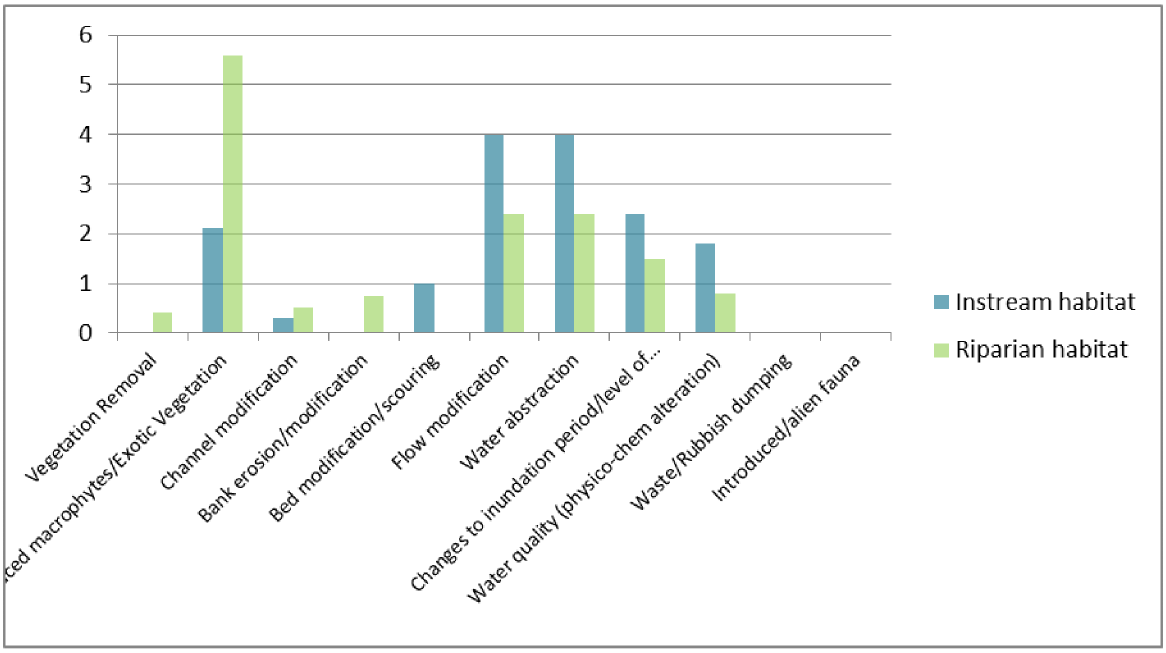


Figure 7 Graphs comparing the level of habitat modification as a result of a number of modifying determinants for river unit R01 assessed using the rapid IHI (Index of Habitat Integrity) assessment.

5.3.2 Ecological Importance & Sensitivity (EIS) of Rivers

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 local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).

For the purposes of this assessment, river EIS was based on rating the importance and sensitivity of riparian & in-stream biota (including fauna & flora) and habitat, using both desktop and on-site indicators. A breakdown of the EIS scores and ratings for the mixed bedrock-alluvial transitional river (R01) has been provided in Table 13, below.

For the bedrock-alluvial river, river EIS was regarded as **Low**: *the functioning and/or biodiversity features have a low-medium sensitivity to anthropogenic disturbance and they typically play a very small role in providing ecological services at the local scale*. This can be attributed to the following:

- The small river is unlikely to harbour any rare or endangered species due to fairly high levels of hydrological modification and habitat degradation;

- Despite being relatively small and inherently sensitive to flow related changes, the level of modification of instream and riparian habitat (fair condition) somewhat reduces overall sensitivity to flow-related water quality changes;
- The river has a fairly low diversity of instream and riparian habitat types with few biotopes present in the river and it is likely that only some intolerant biota will be present within the system;
- During times of environmental stress the instream and riparian habitat is likely to offer very limited refugia for biota due to limited diversity of habitat types and presence of other anthropogenic impacts;
- Instream and riparian habitat exhibits low connectivity within a relatively transformed agricultural landscape; and;
- The river has not been identified as being of particular national/provincial conservation importance in terms of the available plans for the region.

Table 13. Summary of the EIS assessment for the river unit R01

Determinant		River EIS Assessment
		R01 (stream)
RIPARIAN & INSTREAM BIOTA	**Rare & endangered species**	Very Low
	Unique species (endemic, isolated, etc.)	Very Low
	Intolerant species sensitive to flow/water quality modifications	Moderate
	Species/taxon richness	Moderate
RIPARIAN & INSTREAM HABITAT	**Diversity of habitat types**	Low
	Refugia	Very Low
	Sensitivity to flow changes	Moderate
	Sensitivity to flow related water quality changes	Moderate
	Migration route/corridor (instream & riparian)	Very Low
	Importance of conservation & natural areas	Very Low
EIS Category		**Low**

Note that individual river EIS assessment Excel ™ spreadsheets can be made available by Eco-Pulse upon request.

5.4 'Seasonality' of the Assessment

The wetland and aquatic assessments involved a single field survey which was undertaken in late summer (March 2017). The field survey therefore does not cover the full seasonal variation in conditions for the entire site. However, seasonality is not such an issue for the target study area surveyed which does not warrant the need for further seasonal surveys for the following reasons:

- Soil wetness indicators (i.e. soil mottles, grey soil matrix), which in practise are primary indicators of hydromorphic soils, are not seasonally dependent (wetness indicators are retained in the soil for many years) and therefore seasonality has no influence on the delineation of wetland areas.

- Seasonality can also influence the species of flora encountered on site, with the flowering time of many species often posing a challenge in species identification. The seasonality of the assessment should not be seen a significant limitation in this environment, with the flowering time of wetland plant species being largely linked to the wet/rainy season (summer) – hence species identification was not a limiting factor on the outcomes of the assessment.
- The location of the study area near the KZN coast (subtropical climate), h means that climate has less of an effect on aquatic ecosystems and vegetation characteristics than inland systems which are exposed to more extreme variations in temperatures between seasons. Thus, vegetation response is limited and plant species structure and composition tend to remain the same or very similar between seasons.

6 AQUATIC RESOURCE MANAGEMENT PRINCIPLES AND OBJECTIVES

The future management of the freshwater ecosystems identified for the project area should be informed by recommended management objectives for the water resource which, in the absence of classification, is generally based on the current ecological state or PES (Present Ecological State) and the EIS (Ecological Importance and Sensitivity) of water resources (DWAF, 2007 – see Table 14, below).

Table 14. Management measures for water resources.

			EIS			
			Very high	**High**	**Moderate**	**Low**
PES	**A**	**Pristine/Natural**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Largely Natural**	A Improve	A/B Improve	B Maintain	B Maintain
	C	**Good - Fair**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Poor**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Very Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Recommended management objectives for the water resource units were assessed as being to ***'maintain the current status quo of aquatic ecosystems without any further loss of integrity (PES) or functioning (EIS)'*** (Table 15, below). This management objective is driven by the generally fair PES condition and moderate EIS.

Table 15. Recommended management objectives for delineated and assessed water resource units based on their individual PES and EIS ratings.

Watercourse Unit	PES	EIS	Recommended Management Objective
Wetland W01	D: Largely Modified / Poor	Moderate	*Maintain PES/EIS*
River R01	C: Moderately Modified / Fair	Low	

This is also supported by Ezemvelo KZN Wildlife (EKZNW) in their guideline document: Guidelines for Biodiversity Impact Assessment (EKZNW, 2013). According to the document, the guiding principle with regards to biodiversity conservation and sustainable development adopted by EKZNW is one of *no net loss of biodiversity and ecosystem processes*. To achieve this principle, a proactive approach to planning and biodiversity conservation must be adopted to ensure:

- The early identification and evaluation of potential ecological impacts that may constitute 'fatal flaws', or significant biodiversity related/management issues;
- The early identification and evaluation of conceptual alternatives which could prevent, avoid or reduce significant impacts on aquatic biodiversity, or enhance or secure opportunities for ecosystem conservation; and

- The appropriate design of mitigation through the mitigation hierarchy which should strive first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining residual negative impacts on biodiversity.

Aquatic ecological impacts have been identified and assessed in Section 7 of this report in order to inform and provide for the appropriate mitigation and management of impacts (Section 8) associated with the proposed bridge upgrades in an effort to meet the management objectives defined for the water resources in the area of study (see Table 15).

7 AQUATIC ECOLOGICAL IMPACT ASSESSMENT

7.1 Ecological Impact Prediction and Description

Freshwater ecosystems, including wetlands and rivers, are particularly vulnerable to human activities and these activities can often lead to irreversible damage or longer term, gradual/cumulative changes to these ecosystems. Threats to freshwater biodiversity include processes and activities which reduce system persistence, and alter community diversity and patterns, including reduced genetic diversity (Rivers-Moore *et al.*, 2007). One such threat to biological process could be the loss of aquatic species due to loss or transformation of wetland/riverine habitat. Since rivers and wetland typically assimilate what is happening in the catchment area drained, threats also include changes to flow patterns, changes to flow patterns result in changes in the timing, duration, magnitude and frequency and high and low flow events. This in turn impacts on, inter alia, water chemistry and water temperatures. The combined effect of these changes is likely to alter cues for migrations and life history events (Rivers-Moore *et al.*, 2007). When making inferences on the impact of development activities on aquatic ecosystems it is important to understand that these impacts speak specifically to their effect on the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) or functional importance/value of aquatic ecosystems. All of these are linked to the physical components and processes of aquatic ecosystems, including hydrology, geomorphology and vegetation as well as the biota that inhabit these ecosystems. Anthropogenic activities can generally impact either directly (e.g. physical change to habitat) or indirectly (e.g. changes to water quantity & quality). Figure 8 (below) shows how impacts to aquatic ecosystems such as habitat loss, flow modification and pollution can have a number of negative ecological consequences for the receiving aquatic environment, ranging from loss of sensitive species to reduced ecosystem goods & services provision.

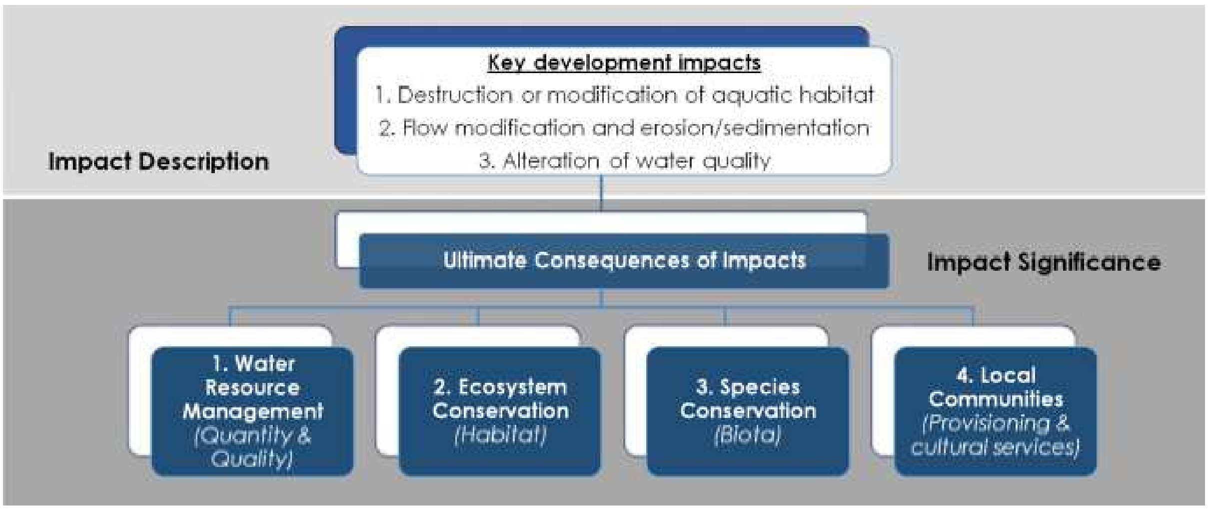


Figure 8 Diagram showing the range of typical negative ecological consequences for aquatic resources as a result of direct and indirect anthropogenic impacts.

For the purposes of this freshwater wetland/aquatic habitat impact assessment 'physical habitat modification' associated with the bridges upgrade (widening) is defined as the primary 'impact causing activity'. The secondary impacts associated with this activity form part of the impact pathway that is initiated by this impact causing activity and will be described and assessed thereunder. For descriptive purposes an attempt had been made to sub-divide impacts associated with (a) Physical destruction and/or modification of aquatic habitat, (b) Flow modification and erosion/sedimentation impacts and (c) Water quality impacts.

The direct and indirect impacts associated with each of the impact causing activities is discussed in the following section based on a 'Standard Mitigation' scenario for both construction and operation phases, separately.

7.1.1 Impact 1: Physical destruction and/or modification of aquatic habitat

This first impact type refers to potential to physically destroy, disturb or modify aquatic habitat (includes effects on wetland, instream or riparian vegetation condition and habitat suitability for biota) caused by vegetation clearing, excavation and/ or infilling (i.e. within the construction zone) and all associated unintended indirect/ secondary disturbances that are likely to persist during the operational phase of the bridge widening/upgrade project.

Construction phase habitat destruction/modification impacts:

Direct habitat destruction and modification impacts are likely to be localised and remain largely within the construction footprint/impact zone. Given that the project entails a bridge upgrade (widening) and not an entirely new bridge development (i.e. widening of the bridge/deck by 2.825m upstream and 1.225m downstream for the Bedlane Bridge ; 3.129m upstream and 1.329m downstream for the Dango Bridge), direct impacts are already present and additional direct loss or destruction of aquatic habitat is likely to be limited to small sections of already disturbed riparian/wetland habitat upstream and downstream of the existing bridges across the Bedlane and Dango Rivers. The most noteworthy direct impacts will arise from instream (river bed) and bank modifications resulting from the extension of bridge piers, which will require vegetation clearing within the impacted area. The overall extent of the impact will be very limited and located within an area already impacted by the disturbance caused by the existing bridge structure. Direct impacts to aquatic vegetation/habitat caused by construction taking place within and across the river channel and riparian zone of the Bedlane River and the wetland associated with the Dango River will likely include the following:

- Destruction or modification of instream habitat (biotopes) where piers are extended within the natural channel (river bed modification);
- Destruction or modification of wetlands or riparian vegetation and river banks (bank modification) at the approach to the bridge resulting from widening of the bridge structure in both an upstream and downstream direction;
- Unintentional physical destruction or modification of wetland and instream or riparian habitat outside of the construction zone caused by machinery and construction staff accessing areas upstream and downstream of the bridge crossing; and

- Sedentary (slow moving) fauna such as invertebrates, slow moving reptiles and amphibians may be killed within the construction servitude or forced to migrate into adjoining habitats.

Indirect habitat modification and subsequent biota impacts will be localised and limited to the affected wetland, river reach and aquatic biota (fauna) utilising the aquatic habitats and will be short-term in terms of impact duration. The intensity of these impacts is also negated by an abundance of available habit for fauna both upstream and downstream of the bridge crossing which should provide suitable refugia during the construction phase. Indirect/secondary impacts to aquatic vegetation/habitat caused by construction within and across the wetland/river channel and riparian zone may include the following:

- Temporary noise, dust and light disturbance which will cause local fauna to move away from the construction zone in the short-term; and
- Temporary instream river fragmentation impacts from any required temporary diversions which can inhibit/reduce the mobility of aquatic fauna between successive wetland/river reaches in the short-term.

Operation phase habitat destruction/modification impacts:

During the operational phase of the project (i.e. once construction upgrades to the bridges cease, flows are reinstated and the widened bridge structures become operational) any disturbance caused during construction is likely to promote the establishment of disturbance-tolerant species, including Invasive Alien Plants (IAPs), weeds and pioneer species within wetland and riverine habitats. Whilst initiated during construction, the persisting impact of invasive alien plants (IAPs) and pioneer plants is generally considered an operational and long-term issue. Since these species of plants typically have rapid reproductive turnover and are able to outcompete native species for environmental resources, alter soil stability, promote erosion, change litter accumulation and soil properties and promote or suppress fire, IAPs are widely recognised as one of the single largest impacts on biodiversity in South Africa. Encroachment by alien plants will result in the deterioration of freshwater habitat integrity if rehabilitation and monitoring are not implemented correctly. The extent and severity of existing alien plant populations within the wetland and river reach of the Dango and Bedlane Rivers, respectively, somewhat lowers the intensity of expected alien plant impacts, however, this should not negate the need to manage IAPs at the site.

Note that long-term wetland and river connectivity / fragmentation impacts are unlikely to result from the bridge widening, as instream flows and habitat will be maintained during bridge operation.

7.1.2 Impact 2: Flow modification and erosion/sedimentation impacts

This impact category refers to the short term / temporary modification in local hydrological regimes as a result of construction activities occurring within a wetland or river channel, including temporary impoundment, diversions and dewatering activities. These activities will temporarily alter the volume, timing and pattern of flows within the immediate river reach and downstream, ultimately effecting the rate of erosion and/or the distribution of sediment.

Construction phase flow modification and erosion impacts:

Given the need for construction works within an active wetland/river channel, flow and associated erosion and sediment regime impacts will be largely unavoidable but short-term in nature and can be managed though the correct timing of construction and the implementation of the key mitigation measures provided in this report concerning works taking place within a watercourse. Temporary direct flow modifications may need to take place during bridge construction to facilitate the construction process and manage environmental and occupational risks, and may include:

- Coffer dams and/or temporary diversions, which can result in a reduction in flows downstream if environmental flows are not catered for, thus affecting the maintenance of key shallow riffle or run biotopes directly downstream of the bridge.
- Inundation or back-flooding upstream of cofferdams altering naturally occurring instream habitats such as wetland habitat, sediment bars, riffles and runs.
- While no indication of any abstraction has been provided for construction purposes, where this does occur, abstraction can potentially result in the reduction of flows downstream, potentially affecting the maintenance of key shallow water biotopes (runs and riffles) on which species rely.

Indirect flow-related erosion and sedimentation/ turbidity impacts during the bridge widening process may include:

- Disturbance of wetland and river bed & bank profiles associated within widening of bridge infrastructure which may render soil particles susceptible to suspension and transport downstream, resulting in the sedimentation and increased turbidity of downstream wetland areas and river reaches.
- Dewatering and diversion of flows around instream work areas (usually required to ensure a 'dry working area' for the duration of construction) can focus flows downstream, thus altering the rate and distribution of flows and resulting in potential scouring/erosion. This may also disconnect instream habitat reaches or microhabitats from flow or change the nature of flows in these biotopes.
- Note that flow-related erosion (i.e. scouring) and/or sedimentation and turbidity impacts will be more pronounced during rainfall events and higher rainfall periods of the year and are directly linked with flow volumes and velocities. Some of the key ecological consequences associated with the sedimentation of freshwater habitat and increased water turbidity include:
    - Partial to complete burial of aquatic vegetation and instream biotopes such as runs, riffles and pools due to sediment deposition;
    - Reductions in soil saturation rates of areas buried with sediment and/or eroded,
    - Colonisation by alien invasive and weedy plant species associated with recent erosional and depositional features.
    - The creation of low light conditions reducing photosynthetic activity and the visual abilities of foraging instream aquatic biota;
    - Increased downstream drift by benthic invertebrates causing localised reductions in population densities; and

- o Reduced density and diversity in benthic invertebrate and fish communities as a result of reduced water quality (suspended solids impacting intolerant taxa).

Due to existing sediment impacts and flow modifications (as a result of upstream dams and agricultural activities), any additional short-term impacts associated with bridge construction, across both the Dango River and Bedlane River, are unlikely to be significant.

Operation phase flow modification and erosion impacts:

Since the bridge widening project only considers the extension of existing infrastructure, with no new instream piers or culverts planned, potential long-term modifications to local river and wetland hydrological and sediment regime as a result of the bridge widening are highly unlikely. and where these do occur, impacts are likely to be of low/negligible significance.

7.1.3 Impact 3: Water quality impacts

This impact refers to the alteration or deterioration in the physical, chemical and biological characteristics of the river water. The term 'water quality' must be viewed in terms of the fitness or suitability of the water for a specific use (DWAF, 2001). In the context of this impact assessment, water quality refers to its fitness for maintaining the health aquatic ecosystems and for domestic and livestock consumption.

Construction phase water quality impacts:

Pollutants/contaminants associated with construction projects vary and may enter the watercourses during construction activities and have the capacity to negatively affect receiving water resource integrity/quality, the direct result of which is reduced suitability for consumption (humans and livestock). Secondary to the direct use value of the water resource is the sensitivity of aquatic biota (particularity fauna as vegetation is highly degraded) to changes physio-chemical water quality. Where significant changes in water quality occur, a shift in species composition will result, favouring tolerant species, and potentially resulting in the localised reduction of sensitive species. Sudden drastic changes in water quality can also have chronic effects on aquatic biota such as fish, invertebrates and amphibians which have specific pollution tolerances. Where these tolerances are exceeded localised extinctions may result. While water quality impact are possible and may have a measurable effect of water resource quality and aquatic biota sensitive to water quality modifications, these impacts are unlikely and in the event that they do occur will probably be short-lived. Potential construction phase contaminants and their relevant sources may include:

- Hydrocarbons – leakages from petrol/diesel stores and machinery/vehicles, spillages from poor dispensing practices.
- Oils and grease - leakages from oil/grease stores and machinery/vehicles, spillages from poor handling and disposal practices.
- Cement - spillages from poor mixing and disposal practices.
- Bitumen - spillages from poor application, handling and disposal practices.

- Sewage – leakages from and/or poor servicing of chemical toilets and/or informal use of surrounding bush by workers.
- Suspended solids – suspension of fine soil particles as a result of soil disturbance and altered flow patterns (covered above).
- Workers are likely to generate solid waste during construction which could easily end up contaminating the riparian zone and river water, and would migrate downstream to disturb downstream ecosystems.

Operation phase water quality impacts:

Potential operation phase contaminants and their relevant sources can be variable but are likely to be considerably fewer and of less of a concern than construction phase contaminant risks. Given that the bridge widening is not a new development but merely an upgrade to an existing structure, the operational-phase water quality impacts will remain as per the existing road and bridge structure. This includes the potential accumulation of pollutants on the road surface where they will be flushed into adjacent/downstream watercourses after rainfall events, albeit to a very low level. Operation phase water quality impacts are therefore likely to be of very low intensity or significance for a project of this nature and are unlikely to have a negative biotic response within the receiving river habitat. Operation phase contaminants/pollutant may include:

- Suspended solids (turbidity) – should scouring and channel erosion result from poor bridge design and installation leading to sedimentation and increased water turbidity downstream.
- Heavy metals – from car engine wear and fluid leakage.
- Hydrocarbons, oils and grease – from petrol/ diesel leakages from vehicles or incomplete fuel combustion.
- Solid waste- from littering associated with vehicle drivers.

7.2 Impact Significance Assessment

Impact significance is defined broadly as a measure of the '*desirability, importance and acceptability of an impact to society*' (Lawrence, 2007). The degree of significance depends upon two dimensions: the measurable characteristics of the impact (e.g. intensity, extent, duration) and the importance societies/communities place on the impact. Put another way, impact significance is the product of the value or importance of the resources, systems and/or components that will be impacted and the intensity or magnitude (degree and extent of change) of the impact on those resources, systems and/or components.

An attempt has been made to quantify the relative significance of the range of potential negative impacts to wetlands and rivers identified for the construction and operational phases of the Bedlane and Dango River bridge widening/upgrade (see Section 7.1) at a 'project level' (i.e. for both bridges), with a summary of the results of the impact significance assessment provided in Table 16, below (with detailed impact assessment results contained in **Annexure C**). The significance of the identified potential impacts of the proposed bridges widening on freshwater ecosystems (i.e. river R01 and wetland W01) was assessed for the following realistically possible scenarios:

i. **Realistic "poor mitigation" scenario** – this is a realistic worst case scenario involving the poor implementation of impact mitigation, bare minimum incorporation of proper design mitigation, poor operational maintenance, and poor onsite rehabilitation.

ii. **Realistic "good mitigation" scenario** – this is a realistic best case scenario involving the effective implementation of impact mitigation, incorporation of the majority of best-practice design mitigation, good operational maintenance and successful rehabilitation. *This essentially takes into account then the recommendations of the wetland/aquatic ecologists from Eco-Pulse, contained in Section 8 of this report.*

The significance of these impacts has been assessed in in terms of the 'ultimate consequences' to the receiving watercourses, in terms of the following:

(i) Impacts to water resources and the ability to meet water resource management objectives;
(ii) Impacts to ecosystem conservation and the ability to meet of ecosystem conservation targets;
(iii) Impacts to species conservation and the ability to meet species conservation targets; and
(iv) Impacts to ecosystem goods and services of direct value to communities and resultant potential impacts to human health, safety and livelihood.

Table 16. Estimation of the potential significance of potential construction and operational-phase impacts to wetlands and rivers associated with the P393 bridges widening project.

POTENTIAL IMPACTS	IMPACT SIGNIFICANCE		KEY MITIGATION CONSIDERED
	'Poor' mitigation	Recommended Scenario: 'Good' mitigation	
CONSTRUCTION PHASE			
1 Physical destruction and/or modification of aquatic habitat	Moderately-Low	Moderately-Low	• Appropriate design • Access control • Onsite BMPs (sediment and pollution controls) • Post-construction rehabilitation
2 Flow modification and erosion/sedimentation impacts	Moderately-Low	Low	
3 Water quality impacts	Low	Low	
OPERATION PHASE			
1 Physical destruction and/or modification of aquatic habitat	Moderately-Low	Low	• Appropriate design • IAP control • Ecological monitoring • Long-term bridge maintenance
2 Flow modification and erosion/sedimentation impacts	Low	Low	
3 Water quality impacts	Low	Low	

Key observations and findings of the aquatic ecological impact significance assessment include:

- Whilst localised impacts to habitat, flow, water quality and biota may result in a very small reduction in wetland/river habitat condition (PES), these localised impacts are unlikely to translate into a significant reduction in ecosystem related services and the ability to meet water resource management objectives at a broader scale should the mitigation measures recommended in Section 8 of this report be applied.

- No species of conservation concern (such as rare, endangered, protected plants/animals) were recorded during field surveys, neither are these flagged in available conservation planning information for the study area.
- The design of the bridge infrastructure will cater for the migration requirements of aquatic biota (fish, invertebrates) between upstream and downstream reaches as the bridge will span the width of the channel.
- The expected disturbances associated with the bridge widening are also highly unlikely to result in the loss of important ecosystem services provided by the wetlands and rivers for local communities.
- In terms of implications for the project, all impacts assessed can be potentially mitigated and reduced from moderately-low to low significance levels, which can generally be considered acceptable as no loss of critical resources, habitats, services or threatened/endangered species is likely to be associated with the bridges upgrade development project. Based on this assessment then, there are unlikely to be any potential 'fatal flaws' associated with the proposed bridge widening project from an aquatic ecosystems perspective, granted that mitigation measures are applied to best practise standards and in accordance with the recommendations made in Section 8 of this specialist aquatic assessment report.

8 IMPACT MITIGATION & MANAGEMENT

According to the National Environmental Management Act No. 107 of 1998 (NEMA), sensitive, vulnerable, highly dynamic or stressed ecosystems, such as wetlands, rivers and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. The management principles for sustainable development supported by NEMA includes the requirement that disturbance of ecosystems, pollution and degradation of the environment, generation of waste and loss of biological diversity be avoided and where they cannot be altogether avoided, are minimised and remedied. NEMA also requires "*a risk-averse and cautious approach which takes into account the limits of current knowledge about the consequences of decisions and actions*". The 'precautionary principle' therefore applies and cost-effective measures must be implemented to pro-actively prevent degradation of the region's water resources and the social systems that depend on it. ***Ultimately, the risk of water resource degradation and biodiversity reduction/loss must drive sustainability in development design and operation.***

The protection of water resources (wetlands & rivers) begins with the avoidance of adverse impacts and where such avoidance is not feasible; to apply appropriate mitigation in the form of reactive practical actions that minimizes or reduces in situ impacts. Driver *et al.* (2011) recommend that the management of freshwater ecosystems should aim to prevent the occurrence of large-scale damaging events as well as repeated, chronic, persistent, subtle events which can in the long-term be far more damaging (e.g. as a result of sedimentation and pollution). 'Impact Mitigation' is a broad term that covers all components involved in selecting and implementing measures to conserve biodiversity and prevent significant adverse impacts as a result of potentially harmful activities to natural ecosystems. The mitigation of negative impacts on aquatic resources is a legal requirement for authorisation purposes and must take on different forms depending on the significance of impacts and the particulars of the target area being affected. This generally follows some form of 'mitigation hierarchy' (see Figure 9, on the next page) which aims firstly at avoiding disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided, to minimise, rehabilitate, and then finally offset any remaining significant residual impacts.

The mitigation hierarchy is inherently proactive, requiring the on-going and iterative consideration of alternatives in terms of project location, siting, scale, layout, technology and phasing until the proposed development can best be accommodated without incurring significant negative impacts to the receiving environment. In cases where the receiving environment cannot support the development or where the project will destroy the natural resources on which local communities are wholly dependent for their livelihoods or eradicate unique biodiversity; the development may not be feasible and the developer knows of these risks, and can plan to avoid them, the better. In the case of particularly sensitive ecosystems, where ecological impacts can be severe, the guiding principle should generally be "*anticipate and prevent*" rather than "*assess and repair*".

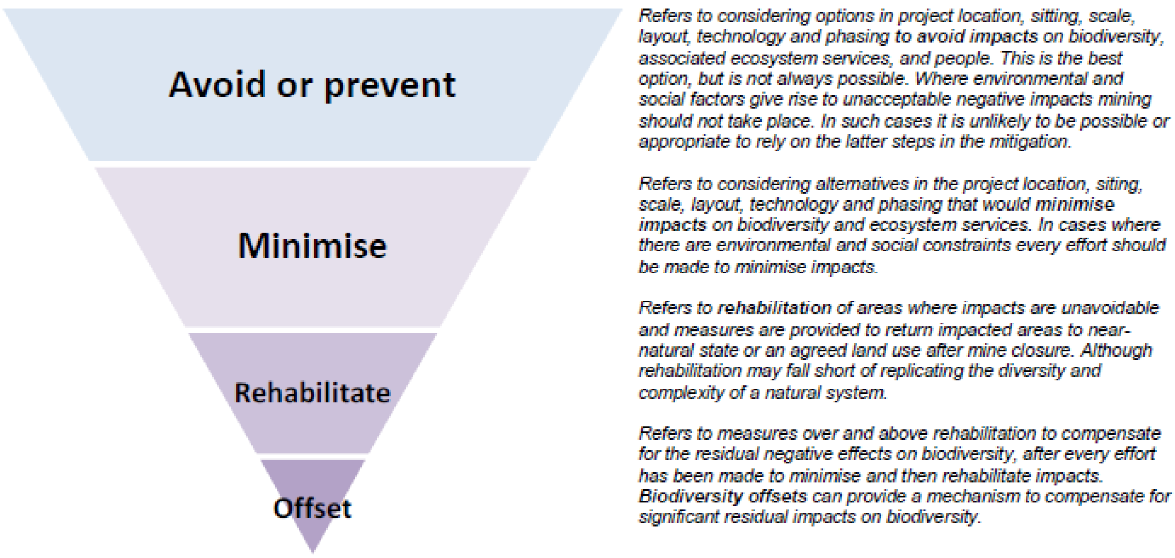


Figure 9 Diagram illustrating the 'mitigation hierarchy' (after DEA *et al*., 2013).

A stepped approach must therefore be followed in a concerted effort to minimize the extent, probability and intensity of potential aquatic ecological risks and impacts, which should include:

1. Firstly, attempting to avoid/prevent impacts through appropriate bridge design that takes into account any environmental sensitivities identified;
2. Secondly, employing mitigation aimed at minimizing the magnitude/significance of impacts where these are unavoidable; and

3. Lastly, compensating for any remaining/residual impacts through on-site habitat rehabilitation or through the application of biodiversity offsets (note that offsets are not applicable to this project as mitigated impacts are likely to be of low significance).

Mitigation would be best achieved through the incorporation of the mitigation measures recommended in this section of the specialist aquatic report into an Environmental Management Programme (EMPr) for the bridges upgrade project. The following guidelines for EMPr implementation should be considered:

- This EMPr must define the responsibilities, budgets and necessary training required for implementing the recommendations made in this report. This will need to include impact management and the provision for regular auditing to verify environmental compliance.
- A document handling system must be established to ensure availability of all documents required for the effective functioning of the EMPr. Supplementary EMPr documentation should include: Incident reports; Training records; Site inspection reports; Monitoring reports; Auditing reports; and Complaints received.
- The Contractor will need to develop an internal reporting structure to monitor compliance with the commitments given in the EMPr as construction progresses.
- The EMPr will need to be enforced and monitored for compliance by a suitably qualified/trained ECO (Environmental Control Officer) with any additional supporting EO's (Environmental Officers) having the required competency skills and experience to ensure that environmental mitigation measures are being implemented and appropriate action is taken where potentially adverse environmental impacts are highlighted through monitoring and surveillance.
- The ECO will need to be responsible for conducting regular site-inspections of the construction, rehabilitation and operation processes, reporting back to the relevant environmental authorities with findings of these investigations.
- All incidents must be investigated in association with the ECO. The cause should be highlighted and training should be provided to the workers to prevent a recurrence of similar incidents. Incidents must be handled appropriately and a record kept of all incidents. Photos should be taken of the incident and a comprehensive record must be kept of the incident and the corrective and preventative actions taken.
- The ECO will also need to prepare a training programme to educate machine operators about the sensitivity of constructing within aquatic environments and also be responsible for preparing a monitoring programme to evaluate construction compliance with the conditions of the EMPr.

Mitigation measures specific to the potential aquatic impacts identified and discussed in Section 7 of this report have been provided below and include:

- **Pre-Construction Planning and Design Phase Recommendations (section 8.1);**
- **Construction Phase Mitigation Measures (section 8.2);**
- **Post-construction Rehabilitation Guidelines (section 8.3);**

- **Operation Phase Mitigation Measures (section 8.4); and**
- **Ecological Monitoring Recommendations (section 8.5).**

8.1 Pre-construction Planning & Design Phase Recommendations

In line with the overarching principles of the mitigation hierarchy of 'avoid, minimise, remediate and offset', it is recommended that potential impacts to aquatic ecosystems first be avoided and minimised as far as possible through implementation of the design/planning guidelines to be considered prior to construction. At the forefront of mitigating impacts to the Bedlane and Dango Rivers and associated aquatic ecosystems, must be the incorporation of sound ecological and environmental sustainability concepts into the design of the bridge upgrade project, with a central focus around:

1. Ensuring that direct impacts to wetlands and riparian areas are avoided wherever possible through ecologically sound and sustainable development planning that takes into account the location and sensitivity of the remaining ecological infrastructure (i.e. the delineated wetlands/riparian habitat);
2. Employing creative design principles and ecologically sensitive methods in infrastructure design and construction to minimise the risk of indirect impacts; and
3. Ensuring that storm water and erosion management takes into account the requirements of the receiving aquatic environment, including wetlands and rivers.

To this end, a number of planning and environmental design guidelines and recommendations have been proposed. These are discussed in detail below.

A. Bridge Design Recommendations

Two alternative bridge design options have been considered by the design engineers from RHDHV for each bridge upgrade. These are summarised below.

1 <u>Bedlane River bridge upgrade:</u>

Option 1 (preferred): Widening 2.825m upstream and 1.225m downstream of the existing bridge structure. This is the preferred engineering design option as this option will follow the proposed geometric design of the upgraded road and will not result in encroachment outside of the road reserve which will require expropriation of land. ***Ecologically, this option is also preferred over option 2 (which will require large quantities of earthworks and road formation when compared to option 1).***

Option 2: Widening 4.05m upstream only. This option will require a realignment of the proposed geometric design of the upgraded road and resulting in large quantities of earthworks and road formation when compared to option 1, and will also result in encroachment outside the road reserve requiring additional expropriation.

2 Dango River bridge upgrade:

Option 1 (preferred): Widening 3.125m upstream and 1.325m downstream of the existing bridge structure. This is the preferred engineering design option as this option will follow the proposed geometric design of the upgraded road and will not result in encroachment outside of the road reserve which will require expropriation of land. ***Ecologically, this option is also preferred over option 2 (which will require large quantities of earthworks and road formation when compared to option 1).***

Option 2: Widening 2.225m both upstream and downstream of the existing bridge structure. This option will require a realignment of the proposed geometric design of the upgraded road and resulting in large quantities of earthworks and road formation when compared to option 1, and will also result in encroachment outside the road reserve requiring additional expropriation.

In addition to the preferred alternative design option selection (see above), the following environmental design recommendations should be incorporated into the design of the bridge upgrades:

- The design of the bridge infrastructure will need to seek a balance of economic, technical and safety requirements whilst also ensuring that risks and impacts to the wetland and riverine environment are minimised as far as possible.
- It is recommended that instream structures such as piers are limited as far as practically possible without compromising the structural integrity and safety of the bridge structure and taking into consideration technical/engineering limitations and financial constraints.
- The base of any instream pier structures receiving almost constant flows should be designed to deflect debris and sediment / other natural substrate (stones, rock and boulders) around these structures in such a way as to avoid accumulating these materials behind and/or around the piers. This may be achieved through the use of narrow and/or convex piers that deflect flows around these structures, thus reducing turbulence and therefore scouring and sedimentation (see image below for a basic example of pier design to encourage deflection of water flows and fluxes of transported debris/sediment
- Importantly, bridge infrastructure will need to be designed to be appropriately protected and robust enough in the long-term to withstand a significant flood event and designed bearing in mind the dynamic nature of large perennial rivers (i.e. fluctuating flows and sediment loads, bank erosion and undercutting, constant redistribution of river substrate potential for the river channel, river banks and terraces to adjust to flood conditions, etc.).
- The extent of infilling within instream aquatic and riparian habitat must be minimised as far as possible where the road-bridge crosses the riparian zone and should remain within existing disturbed areas as far as possible.

8.2 Construction Phase Impact Mitigation Measures

The following project-specific mitigation measures are recommended during the construction phase of the project:

A. Phasing and Timing of Construction Activities

It is recommended that construction take place ONLY during the dry/winter months to reduce risk of erosion and sedimentation associated with summer rainfall in the region. If construction is timed correctly the risk and intensity of sedimentation impacts to downstream river reaches will be greatly reduced.

B. Site Establishment and Access Control

I. Defining the Construction Servitude/Working Area:

- The construction servitude must be limited to the proposed development footprint and a reduced (10m) working servitude either side thereof. This working servitude must accommodate all construction related activities, including materials storage, access routes, etc.
- The outer edge of the construction servitude/working area (as defined above) must be clearly demarcated for the entire construction phase using a brightly coloured hazard fence or danger tape with steel droppers.
- Maintain site demarcations in position until the cessation of construction works.
- The demarcation work must be signed off by the Environmental Control Officer (ECO) before any work commences.
- The location of stockpile areas, site camps and equipment lay down areas must be agreed to and demarcated to the satisfaction of the ECO prior to the clearing. A recommended set-back distance of at least 30m from the active river channel is recommended.
- No soil stockpile areas must be located within 30m of any delineated watercourse, including those not effected by the bridge development.
- Construction materials must only be brought to the equipment laydown area 3 days prior to use and must not be kept for more than 2 weeks. Timing of delivery is critical.
- No equipment laydown or storage areas must be located within 30m of any delineated watercourse and/or within the 1:100 year floodline.
- Access to and from the existing bridges must be ONLY via existing roads or within the construction servitude itself (as defined above) unless alternative access is essential to the project.
- If for practical reason additional access road be required to and from site and construction site camps/equipment lay-down areas, these must be agreed upon by the Environmental Control Officer (ECO) and the outer edge of the access route must be staked out by the contractor using brightly coloured stakes prior to the access route being used by machinery.

II. Demarcations and 'No-go' Areas:

- All areas outside (including upstream and downstream) of this demarcated construction servitude must be considered 'No-Go' areas.
- Vegetation removal/ stripping must be limited to the construction footprint. No areas outside the construction footprint may be cleared.
- Watercourses (wetlands and rivers) outside of the demarcated construction area (i.e. water resources downslope of the development) are strictly 'No Go' areas. These areas may not be accessed by machinery or workers for any reason. This includes water resources originally rated as of low to very low risk during the desktop mapping and risk screening section of the report.
- Any contractors found working inside the 'No-Go' areas (areas outside the working servitude) should be fined as per fining schedule/system setup for the project.
- Do not paint or mark any natural feature. Marking for surveying and other purposes must be done using pegs, beacons or rope and droppers.

C. Accidental Incursions into 'No-Go' Areas

- Any contractors found working inside the 'No-Go' areas (areas outside the construction/ working servitude) should be fined as per fining schedule/system setup for the project.
- Should any accidental/ unintentional disturbance of watercourse areas outside of the construction corridor occur, these areas must be rehabilitated immediately (as per the post-construction rehabilitation guidelines contained in Section 8.3, below). All disturbed areas must be prepared and then re-vegetated to the satisfaction of the ECO as per the relevant re-vegetation/re-planting plan.

D. Financial penalty clause

An appropriate fining system should ideally be developed and implemented for any infringements to the EMPr. The following financial penalty clause must be included in the EMPr and contract for the project:

- The penalty clause for stripping vegetation within the construction footprint but without approval from the ECO shall be R50, 000 per incident.
- The penalty clause for stripping natural indigenous vegetation outside the construction footprint without approval from the ECO shall be R100, 000 per incident and the disturbed areas shall be re-vegetated with trees saplings to match the tree density of adjoining habitats.
- The penalty clause for stripping natural indigenous vegetation without any relevant plant permits and licences shall be R100, 000 per incident.

E. Contractor Induction and Staff Education (environmental awareness/training)

- Training needs must be identified prior to commencement of the project, based on the available and existing capacity of site and project personnel.
- Staff environmental induction must take place prior to construction commencing and any sub-contractors utilised must be inducted before starting work onsite. All contractor employees

must receive basic environmental awareness training and shall be educated on the requirements of the EMPr and relevant method statements. The environmental induction training is the responsibility of the project manager and the contractor and should be undertaken by the EO or a suitably qualified person. The Environmental Control Officer (ECO) must oversee and monitor the induction training to ensure that the training is sufficient and that adequate training is provided prior to construction commencing.

- All staff involved in work within wetlands, rivers channels and riparian habitats must receive specific inductions related to the detailed methods statements compiled for working in these areas.
- It is vital that all personnel are adequately trained to perform their designated tasks to the accepted standards.
- The ECO must monitor the compliance of the Contractors and instruct the Contractors where necessary. The ECO may request that the Project Manager suspend part or all the works if the Contractors repeatedly cause damage to the environment. The suspension should be enforced until such time as the offending actions, procedure or equipment is corrected and the environmental damage repaired.
- A copy of the EMPr and relevant method statements must be made available at the construction site offices/site camp at all times.

F. Specific Measures for Working within or Near Rivers and Streams

I. <u>Working Servitude Clearing:</u>

- No clearing of indigenous vegetation outside of the defined working servitudes is permitted for any reason (i.e. for fire wood or medicinal use).
- Before any work commences, a series of sediment control/silt capture measures (e.g. bidim/silt curtains) must be installed in the downstream reaches of the wetland or river at regular intervals. Quantities of silt fences/curtains shall be decided on site with the engineer, contractor and ECO. The ECO should be present during the location and installation of the silt curtains.
- Silt fences/curtains must be regularly checked and maintained (de-silted to ensure continued capacity to trap silt), and repaired where necessary.
- Movement of construction vehicles across watercourses (wetlands/river channels) must be minimised as much as possible.
- Excavated rock and sediments from the construction zone, and including any foreign materials, may not be placed within the delineated wetlands, rivers and riparian areas in order to reduce the possibility of material being washed downstream.
- No physical damage shall be done to any aspects of the channel and banks of watercourses other than those necessary to complete the works as specified. Channel bed and bank materials are not to be removed from the watercourse or used for construction purposes. Bed material disturbed during construction must be stockpiled for use in rehabilitation.
- Prior to the stripping, infilling, excavation and re-shaping of the aquatic habitat within the development footprint/corridor, a search and rescue of indigenous flora and fauna must be

undertaken prior to habitat destruction (if present). Based on the sparse nature of vegetation and the dominance by alien species this requirement may be limited.

- Thereafter, any topsoil and vegetation from areas to be excavated will need to be stripped and stored at the designated soil stockpile area outside of the aquatic zone for use later in post-construction wetland/river rehabilitation.

II. Temporary River/Flow Diversions:

The following recommendations are applicable to the construction in the active channel.

- Temporary diversions will need to be put in place to temporarily divert water away from activities and ensure a dry work area.
- To reduce the requirements to divert water from the construction working area within or adjacent to a watercourse, all construction activities within wet areas should ideally take place in the dry season/winter (May to September) where this is possible and depending on project timeframes.
- Construction within the channel must progress as quickly as practical to reduce the risk of exceeding the temporary diversion capacity.
- Diversions will need to be temporary in nature and no permanent walls, berms or dams may be installed.
- Only one diversion is to be made at a time.
- Under no circumstance shall a new channel or drainage canals be excavated to divert water away from construction activities.
- Re-directed flow must not be channelled towards stream/river banks which could cause bank erosion.
- Sandbags used in any diversion or for any other activity within a watercourse must be in a good condition, so that they do not burst and empty sediment into the watercourse.
- Erosion protection measures such as sandbags must be placed at the downstream diversion outlet in order to reduce outlet flow velocities and erosion potential.
- Upon completion of the construction at the site, the diversions need to be removed to restore natural flow patterns, and the channel and riparian zone rehabilitated/restored to their original configurations as soon as practically possible.
- Options for temporary flow diversion when working within channels may include:
  - diversion of the entire watercourse through use of a bypass large diameter pipe;
  - the installation of removable coffer dams; and
  - use of removable sandbags.
- It is recommended that either diversion via a bypass pipe/flume or isolation of the working area using a coffer dam be considered.

III. Compilation of Method Statements for Working within Watercourses:

As part of the finalisation of the Environmental Management Programme (EMPr), detailed method statements must be compiled using the recommendations contained in this report for all construction activities confirmed to occur within the watercourses. The method statements must provide detail on the following, where applicable:

- Working area extent and demarcation.
- Vegetation and soil clearing / grubbing / stripping and stockpiling.
- Access and running track establishment and decommissioning.
- Method of excavation.
- Temporary flow diversions. Instream isolation works (i.e. coffer dams) measures.
- Infrastructure placement measures.
- Rehabilitation – reshaping, soil preparation, stabilisation / erosion control, re-vegetation and monitoring.

Detailed method statements will need to be compiled by competent environmental consultant/ specialist in conjunction with the project engineer / civil contractor, prior to any construction commencing.

Based on the nature of the river channel and proposed activities it may be necessary for coffer dams/ diversion pipes to complete construction of bridge widening and a method statement for the implementation and removal of coffer dams/diversions will be required in this case. This should include, but not limited to the following three (3) stages:

Stage 1: Pre-construction

1. Refer to approved plans for construction.
2. Train staff in cofferdam construction.
3. Identify, demarcate and protect any affected water resources or sensitive habitat likely to be affected by the construction.

Stage 2: Installation

4. Site clearing.
5. Pre-dredge to remove soil or soft sediments and level the area of the cofferdam.
6. Drive temporary support piles.
7. Temporarily erect bracing frame on the support piles.
8. Set steel sheet piles, starting at all four corners and meeting at the centre of each side.
9. Drive sheet piles to grade.
10. Block between bracing frame and sheets, and provide ties for sheet piles at the top as necessary.
11. Excavate inside the grade or slightly below grade, while leaving the cofferdam full of water.
12. Drive or otherwise construct bearing piles.
13. Place rock-fill as a levelling and support course.
14. Place underwater tremie concrete seal.
15. Check blocking between bracing and sheet piles.
16. Remove water
17. Construct new permanent foundation and substructure of the bridge.

Stage 3: Removal

18. Flood cofferdam.
19. Remove sheet piles.
20. Remove bracing.
21. Backfill as required.
22. End of cofferdam removal.
23. Rehabilitate disturbed areas.

G. Water Abstraction and Use

The following guidelines pertain to the abstraction and general use of water from streams/rivers:

- No water is to be abstracted from the river for use in construction activities without prior approval by the Department of Water and Sanitation (DWS), subject to acquiring a relevant Water Use License in terms of Section 21 of the National Water Act for taking water from a water resource.
- Approved abstraction points must be carefully selected to minimize impacts to sensitive wetland habitat and river biotopes.
- The Contractor shall only be allowed to draw water from the source/s designated by the ECO.
- Excavating trenches or pits within rivers for the purpose of burying a pump to facilitate water abstraction is not to be permitted.
- Water abstraction is to be by suction pumps connected to water carts only. Water carts are to utilise existing access roads to abstraction points and are not to encroach into "no-go areas. Water carts are not to enter directly into the watercourse from which they are drawing water.
- Care is to be taken not to disturb the channel bed of watercourses during abstraction of water using suction pumps.
- Locate the suction pump inlet at a sufficient height above the channel bed/floor where bed-load sediments accumulate.
- Where necessary, install a suitable sediment filter/screen in front of the suction pump inlet to remove undesirable sediments, particles and debris from entering the pump.
- Employees are not to make use of any natural water sources (e.g. rivers) for the purposes of swimming, bathing or washing of equipment, machinery or clothes.
- Drinking water is to be provided to all employees and labourers are to be discouraged from drinking directly from rivers on site. Suitable domestic water supply to be sourced for human consumption by workers onsite (to comply with DWS specifications for drinking water). Water for human consumption will need to be made available at the site offices and at other convenient locations on site where work occurs.

H. Soil Management and Stockpile Areas

- Soil required for construction purposes must not be derived from the wetland, river channel or banks. Only approved borrow areas are to be used under the supervision of the ECO. Any soil removed from the river banks/channel must be stockpiled and used in post-construction aquatic habitat rehabilitation.

- Excavated material/sediments/spoil from the construction zone (including any foreign materials) must not be placed or stockpiled within the active channel of a wetland or river.
- The channel embankments must be rehabilitated to ensure both longitudinal and cross sectional stability against summer floods. Depending on the circumstances, this may necessitate stabilizing structures such as gabions or reno mattresses as well as careful attention to vegetation rehabilitation.
- No soil stockpile areas may be located within 30m of any watercourse (includes delineated riparian areas or rivers/streams).
- The stockpiles may only be placed within demarcated stockpile areas, which must fall within the demarcated construction area. The contractor shall, where possible, avoid stockpiling materials in vegetated areas that will not be cleared.
- Erosion/sediment control measures such as silt fences, concrete blocks and/or sand bags must be placed around soil/material stockpiles to limit sediment runoff from stockpiles.
- Stockpiled soils are to be kept free of weeds and are not to be compacted. The stockpiled topsoil must be kept moist and this can be achieved through irrigation of topsoil stockpiles on a weekly basis.
- If soil stockpiles are to be kept for more than 3 months, they must be hydro-seeded.
- The slope and height of stockpiles must be limited to 2m and are not be sloped more than 1:2 to avoid collapse.
- Spoil material must be hauled to a designated spoil site or landfill site. No spoil material must be pushed down slope or discarded on site.

I. Flow and Erosion/ Sedimentation Control Measures

Stormwater and erosion control measures must be implemented during the construction phase to ensure that erosion and sedimentation impacts to the water resources are minimised or possibly avoided. In this regard, the following measures must be implemented:

- Vegetation/soil clearing activities must only be undertaken during agreed working times and permitted weather conditions. If heavy rains are expected, clearing activities need to be put on hold. In this regard, the contractor must be aware of weather forecasts.
- Construction activities must be scheduled to minimise the duration of exposure bare soils on site, especially on steep slopes.
- Necessary instream sediment barriers (e.g. silt fences, sandbags) must be established to protect water resources from erosion and sedimentation impacts from upslope. Sediment barriers must be regularly maintained and cleared so as to ensure effective drainage.
- Sandbags and/or silt fences employed must be maintained and monitored for the duration of the construction phase and repaired immediately when damaged. The sandbags and silt fences must only be removed once construction has been completed and disturbed areas rehabilitated.

- During construction, the contractor must check the site for erosion damage after every rainfall event and rehabilitate this damage immediately.

J. Management of Construction Material/ Building Rubble

- No building material, soils or rubble is to be disposed of within any watercourse, including wetlands or river channels.
- Excess rubble must be taken to a landfill site and a waybill must be retained as proof of safe disposal.
- Should rubble be required as a raw material for the construction, it must be taken to a designated stockpile area – which must be approved by the ECO and located outside of sensitive riverine areas designated as 'No-Go' areas.

K. Pollution Prevention Measures

The following measures must be implemented in conjunction with the generic pollution prevention measures provided in the Construction Environmental Management Programme (EMPr):

- No refueling, servicing nor chemical storage is to occur within 50m of the delineated aquatic habitat or within the 100-year flood line, whichever is applicable.
- Hazardous storage and refueling areas must be bunded prior to their use on site during the construction period following the appropriate SANS codes.
- The bund wall will need to be high enough to contain at least 110% of any stored volume.
- The surface of the bunded area must be sloped to the centre so that spillage may be collected and satisfactorily disposed of.
- The proper storage and handling of hazardous substances (e.g. fuel, oil, cement, bitumen, paint, etc.) needs to be administered. Storage containers must be regularly inspected so as to prevent leaks.
- Mixing and/or decanting of all chemicals and hazardous substances must take place on a tray, shutter boards or on an impermeable surface and must be protected from the ingress and egress of stormwater.
- Drip trays are to be utilised at all dispensing areas.
- No vehicles transporting concrete, asphalt or any other bituminous product may be washed on site.
- Vehicle maintenance may not take place on site unless a specific bunded area is constructed for such a purpose.
- Ensure that transport, storage, handling and disposal of hazardous substances is adequately controlled and managed. Correct emergency procedures and cleaning up operations needs be implemented in the event of accidental spillage.
- All equipment to be used within the sensitive working areas (within the channel) must be checked daily for oil and diesel leaks before gaining access to these working areas.
- An emergency spill response procedure must be formulated and staff are to be trained in spill response. All necessary equipment for dealing with spills of fuels/chemicals must be available

at the site. Spills must be cleaned up immediately and contaminated soil/material disposed of appropriately at a registered site.

- 44-gallon drums must be kept on site to collect contaminated soil. These must be disposed of at a registered hazardous waste site.
- Fire prevention facilities must be present at all hazardous storage facilities.
- Sanitation - portable toilets (1 toilet per 10 users) to be provided where construction is occurring. Workers need to be encouraged to use these facilities and not the natural environment. Toilets must not be located within the 1:100yr flood line of a watercourse or closer than 50m or from any natural water bodies including wetlands, rivers and riparian areas. Waste from chemical toilets must be disposed of regularly (at least once a week) and in a responsible manner by a registered waste contractor. Toilet facilities must be serviced weekly and in a responsible manner by a registered waste contractor to prevent pollution and improper hygiene conditions.
- Contaminated water containing fuel, oil or other hazardous substances must never be released into the environment. It must be disposed of at a registered hazardous landfill site.

L. Management of Solid Waste

- Eating areas must not be located within 15m of delineated wetlands and river channels.
- Provide adequate rubbish bins and waste disposal facilities on-site and educate/encourage workers not to litter or dispose of solid waste in the natural environment but to use available facilities for waste disposal.
- Litter bins must be equipped with a closing mechanism to prevent their contents from blowing out or wild animals from accessing the contents.
- Clear and completely remove from site all general waste, constructional plant, equipment, surplus rock and other foreign materials once construction has been completed.
- Recycling/re-use of waste is to be encouraged.
- Litter generated by the construction crew must be collected in rubbish bins and disposed of weekly at registered sites by a registered waste management company.
- No litter, refuse, wastes, rubbish, rubble, debris and builders wastes generated on the premises be placed, dumped or deposited on adjacent/surrounding properties during or after the construction period, but disposed of at an approved dumping site. The construction site must be kept clean and tidy and free from rubbish.

M. Alien Plant Control

- All alien invasive vegetation that has colonised the construction site must be removed, preferably by uprooting. The contactor may need to consult the ECO regarding the method of removal.
- All bare surfaces across the construction site must be checked for alien invasive plants at the end of every month and alien pants removed by hand pulling/uprooting and adequately disposed.

- Herbicides may be utilised where hand pulling/uprooting is not possible. Only herbicides which have been certified safe for use in freshwater habitats by independent testing authority to be used. The ECO must be consulted in this regard.
- The ECO will need to assess the need / desirability for further monitoring and control after the first 12 months and include any recommendations for further action to the relevant environmental authority (EDTEA).

N. Wildlife Management

- Education of workers/employees onsite on not to harm wildlife unnecessarily will assist in mitigating this impact. Contractor induction and staff/labour environmental awareness training needs are to be identified and implemented through staff/contractor environmental induction training. This must include basic environmental training based on the requirements of the EMPr, including training on avoiding and conserving local wildlife.
- No wild animal may under any circumstance be hunted, snared, captured, injured, killed, harmed in any way or removed from the site. This includes animals perceived to be vermin (such as snakes, rats, mice, etc.).
- Any fauna that are found within the construction zone must be moved to the closest point of natural or semi-natural habitat outside the construction corridor.
- The handling and relocation of any animal perceived to be dangerous/venomous/poisonous must be undertaken by a suitably trained individual.
- All vehicles accessing the site to adhere to a low speed limit (30km/h is recommended) to avoid collisions with susceptible species such as reptiles (snakes and lizards).
- No litter, food or other foreign material to be disposed of on the ground or left around the site or within adjacent natural areas and may only be placed in demarcated and fenced rubbish and litter areas that are animal proof.
- Ensure that workers accessing the site conduct themselves in an acceptable manner while on site, both during work hours and after hours.
- Temporary noise pollution to be minimized by ensuring the proper maintenance of equipment and vehicles, and tuning of engines and mufflers as well as employing low noise equipment where possible.
- No activities to be permitted at the site after dark (between sunset and sunrise), except for security personnel guarding the development site.

O. Fire Management

- No open fires are to be permitted. Fires may only be made within the designated areas at construction camps for purposes approved by the ECO.
- Fire prevention facilities must be present at all hazardous storage facilities.
- Ensure adequate fire-fighting equipment is available and train workers on how to use it.
- Ensure that all workers on site know the proper procedure in case of a fire occurring on site.
- Smoking must not be permitted in areas considered to be a fire hazard.

- Ensure that no refuse wastes are burnt or buried on the construction site or on surrounding areas.

8.3 Post-Construction Rehabilitation Guidelines: Aquatic Habitat

8.3.1 Purpose

The P393 road bridge widening is likely to affect aquatic (wetland/riparian) habitat associated with the Dango and Bedlane Rivers, both directly and indirectly, with the degraded habitat upstream and downstream of the existing bridge structures likely to be disturbed. Whilst a range of construction phase impact mitigation and management measures have been provided in Section 8.2 of this report, the need for post-construction aquatic habitat rehabilitation guidelines/recommendations was identified for areas that are likely to be directly impacted by construction activities and where the general disturbance of habitat after on-site mitigation will remain and require remediation.

These rehabilitation guidelines are designed to address residual construction-related impacts and disturbances for the road bridges widening/upgrade development project and provides guidance on the proposed methods of habitat rehabilitation including rehabilitation timing, land preparation, soil stabilisation and re-vegetation for all those freshwater habitats directly disturbed and modified by the construction of the bridge upgrades.

8.3.2 What is ecosystem 'rehabilitation'?

Ecosystem 'rehabilitation' refers to the process of reinstating the natural hydrological, geomorphological and ecological processes of a degraded riverine/wetland habitat system with the aim of recovering system integrity and ecosystem service delivery (Russell, 2009). Rehabilitation in this context also refers to the halting and decline in integrity (stabilisation) of an ecological system that is in the process of degrading with the aim of maintaining system integrity and ecosystem service delivery (Russell, 2009). The rehabilitation process essentially involves the following tasks:

- Identification of causes of system degradation.
- Identification of rehabilitation interventions to address causes of degradation.
- Location and design of rehabilitation structures.
- Compilation of intervention plans and programmes e.g. re-vegetation plans.
- Compilation of monitoring programme.

8.3.3 Legal Context to Rehabilitation in the South African

Given the value of wetlands and aquatic ecosystems (such as rivers and estuaries) and the fact that humans depend on aquatic resources, it is against the law to deliberately damage wetlands and rivers. The law places, directly and indirectly, the responsibility on landowners and other responsible parties, such as managers, to repair or rehabilitate damaged or lost wetlands and riparian areas (Armstrong, 2009). Of particular importance is the requirement of 'duty of care' with regards to environmental remediation: stipulated in Section 28 of NEMA (National Environmental Management Act, Act 107 of 1998):

Duty of care and remediation of environmental damage: "(1) *Every person who causes has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot be reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.*"

The requirements for rehabilitation of disturbed wetland/riparian areas stipulated in the National Water Act (No 36 of 1998) are also noteworthy:

> *'A person who lawfully impedes or diverts the flow of water in a wetland, or who alters the beds, banks or characteristics of a wetland must take necessary measures to stabilise the diversion structure and surrounding area through:*
>
> - *rehabilitation of the riparian habitat using only indigenous shrubs and grasses;*
> - *rehabilitation of disturbed and degraded riparian areas;*
> - *restoring and upgrading the riparian habitat integrity to sustain a biodiverse riparian ecosystem;*
> - *removal of alien vegetation, and*
> - *conducting an annual habitat assessment.'*

8.3.4 Key Issues and Construction-Related Impacts Informing the Rehabilitation Plan

Key environmental issues and construction-phase (bridge widening/upgrade) impacts related to the development project that have the potential to degrade aquatic ecosystems in the study area and that demand the most attention have been highlighted in particular for informing rehabilitation requirements for the project. The following list of key issues/impacts is not intended to be exhaustive but serves as an indication of broad aquatic environmental impacts and forms a basis for addressing residual impacts through on-site rehabilitation:

a) Direct loss of aquatic (wetland and riparian) habitat due to widened bridge infrastructure crossing these areas;
b) Disturbance of aquatic habitat adjacent to the proposed bridge extension and development footprint (i.e. necessary to undertake construction activities);
c) Erosion and sedimentation of watercourses during and after construction;
d) Increased levels of infestation by Invasive Alien Plants (IAPs) as a result of soil disturbance and vegetation clearing;
e) Temporary hydrological impacts linked with construction works within watercourses;

f) Potential water quality impacts caused primarily by fine sediment (i.e. increased water turbidity) and hazardous substances (oils, grease, fuels, solid etc.) used during construction; and

g) Solid waste contamination of aquatic habitats associated with wetland, river channel and riparian areas.

8.3.5 Objectives of the Rehabilitation Plan

In light of the low to moderately-low significance of anticipated aquatic impacts and the localised nature of planned disturbances, the rehabilitation plan should focus primarily on the rehabilitation of disturbed areas within the construction zone/development footprint, thus ensuring that soils and channel banks are adequately stabilised and re-vegetated similar to the pre-development scenario. The following key rehabilitation objectives are proposed:

1. To reshape, stabilise and re-vegetate (reinstate) wetland, river bed & banks and riparian areas physically disturbed by construction activities, both planned and accidental. Rehabilitation should be pragmatic and focus on the stabilisation and revegetation of disturbed areas, with less focus on biodiversity aspects (i.e. reinstating reference species diversity).
2. To remove all sediment and construction materials washed into wetlands and rivers during construction and reshape and revegetate the affected surface (if applicable).
3. To eradicate and control invasive alien plants and weeds that invade and colonise the watercourses post-disturbance; and
4. To monitor the success of the rehabilitation actions and ensure that the above-listed objectives are achieved.

8.3.6 Roles and Responsibilities for Rehabilitation Implementation & Monitoring

The ultimate responsibility for the implementation of this rehabilitation plan lies with the contractor/parties responsible for any direct or indirect disturbance of river and associated riparian areas. They will be tasked with overseeing the rehabilitation and/or appointing an appropriately qualified/experienced wetland rehabilitation implementer to undertake the required rehabilitation should they not have the required expertise needed to complete the recommended tasks. The rehabilitation implementer will also be required to undertake post-rehabilitation monitoring in order to ensure that rehabilitation has been completed satisfactory. The contractor/parties responsible for the project will need to sign-off on the rehabilitation once they are satisfied with the product. It is also recommended that a suitably qualified rehabilitation specialist/ wetland ecologist with experience in wetland rehabilitation be appointed to provide input into the rehabilitation during implementation of the rehabilitation plan. The Contractors and all relevant parties involved in the wetland rehabilitation must be familiar with the relevant Rehabilitation Plan and Method Statement and implement rehabilitation in accordance with the guidelines and requirements contained therein. The roles and responsibilities of Key Stakeholders has been summarised as per Table 17, below.

Table 17. Roles and key responsibilities for Key Stakeholders involved in the implementation of the Rehabilitation Plan.

Stakeholder		Roles and responsibilities
Main Contractor	i.	Shall be responsible on for the implementation of the rehabilitation measures as set out in this document;
	ii.	Shall be responsible for monitoring all rehabilitation efforts for a minimum of one year post construction or as stipulated in the contractual agreement;
	iii.	Shall be responsible for the actions of all sub-contractors as well as disseminating information pertaining to rehabilitation of the site;
Environmental Control Officer (ECO)	iv.	Shall be responsible for providing basic training and environmental awareness to the contractors and labourers undertaking rehabilitation;
	v.	Shall be responsible for monitoring and reporting on the rehabilitation process;
	vi.	Shall be responsible for making amendments and exceptions to rehabilitation measures provided in this document;
	vii.	Signing off on all rehabilitation related activities;
Rehabilitation Specialist / Horticulturalist	viii.	A suitably qualified rehabilitation specialist or horticulturalist with a proven track record in wetland/ watercourse rehabilitation may need to be appointed to oversee and manage the rehabilitation process implemented by either the contactor or a landscaping company. Those appointed for this task will need to use the principles and guidelines contained in this plan to formulate a detailed rehabilitation plan that includes a detailed bill of quantities for rehabilitation tasks. These criteria should be a requirement for appointment.
Project Manager/ Resident Engineer	ix.	Shall be responsible for making sure that the Main Contractor fulfils his contractual agreement with regards to rehabilitation and undertakes the rehabilitation to the satisfaction of the ECO and Competent Authority.

8.3.7 Term of the Plan

The implementation of this Plan shall be an on-going process until such time as rehabilitation has been deemed successful through an appropriate monitoring programme.

8.3.8 Budget for Rehabilitation

This Plan has not attempted to address financial requirements associated with the implementation of the recommended rehabilitation activities. The Applicant/Developer (KZN DoT) is however responsible for securing adequate funding to implement this Plan and a budget for the implementation of key activities will therefore need to be developed to support key activities, including costing of all management and rehabilitation activities and equipment costs which should be compiled prior to any rehabilitation activities occurring in collaboration with the contracted parties (rehabilitation implementer, landscapers, etc.), and should form part of the overall development project budget.

8.3.9 Conceptual Rehabilitation Strategy

This section of the rehabilitation plan defines the key tasks and methods to be undertaken as part of a rehabilitation programme for the wetland and riparian areas associated with the Bedlane and Dango River bridge widening project.

Rehabilitation will aid the recovery of the ecosystems and can be seen as critical in preventing further impacts including those associated with alien plant infestations, soil erosion and sedimentation. Table 18 (below) outlines the rehabilitation steps and associated recommendations and actions to be taken.

Table 18. Post-construction habitat rehabilitation guidelines disturbed wetland and riparian habitat.

Rehabilitation Step	Rehabilitation Guidelines and Specific Actions
STEP 1: Initial planning	• A budget including costing of all rehabilitation and revegetation activities detailed in this plan and equipment costs will need to be compiled prior to commencement of construction. Ideally the cost should be included in the contractual agreement for the project. • Rehabilitation and management target areas must be identified prior to the implementation of the Plan. These include areas affected by erosion, IAPs and pollution for example. • Whilst appointment of external landscapers is a feasible and acceptable option, a lot of preparation will need to be undertaken exclusively by the main contractor at the inception of the project. Preparation activities include correct stockpiling of topsoil needed for rehabilitation, harvesting of indigenous plants for use later on in rehab, managing a nursery for rescued plants, etc. • A suitably qualified aquatic/ river ecologist with experience in rehabilitation may be required to provide practical input into the rehabilitation during implementation of the rehabilitation plan. • Identify key areas requiring rehabilitation. In this case river bed and banks should be the focus for rehabilitation efforts. • Rehabilitation of disturbed watercourses should ideally be initiated as soon as possible and occur concurrently as construction works progress. • If plant plugs are to be used to transplant whole plants or seed are to be sourced from a donor site, a permit for sourcing such plants will need to be applied for prior to plant harvesting.
STEP 2: Remove any waste products	• All waste products (spoil, construction materials, hazardous substances and general litter) need to be removed from wetland/riparian areas and disposed of in proper local waste facilities. • Minimise additional disturbance by limiting the use of heavy vehicles and personnel during clean-up operations. • Any large plumes of sediment washed into river or riparian habitat from upslope must be removed, taking care not to remove or disturb the natural soil profiles including instream and riparian habitats.
STEP 3: Remove/control invasive alien plants	• All exotic/alien plants and weeds to be removed and properly disposed of prior to the implementation of rehabilitation measures (see Box 3 in Section 8.3.10 below for Guidance on Invasive Alien Plant Control). • Note that frequent <u>mechanical removal is the most preferred option</u> and only in the event that this is not a viable means of control and eradiation, should additional means be considered. • ONLY herbicides which have been certified safe for use in aquatic environments by an independent testing authority may be considered. The ECO must be consulted in this regard.
STEP 4: Stabilise, reshape and prepare soil profiles	• Any erosion features created by construction need to be stabilised. • Exposed embankments are to be stabilized and vegetated as soon as practically possible. • Erosion control measures such as soil savers, eco-logs, sand bags and biodegradable silt fences must generally be installed prior to revegetation. • Re-establish the natural water flow patterns within the channel through re-shaping of disturbed areas. • Channel banks on the approach to the bridge need to be shaped to a stable angle of repose to avoid slumping and prepared for revegetation immediately. • Any sediment washed into wetlands and channels will need to be removed by hand (no heavy machinery in these sensitive areas). • Prior to commencing with any revegetation activity (e.g. planting/seeding), it is important that disturbed areas are adequately prepared in advance. • Where significant soil compaction has occurred, the soil may need to be ripped in order to reduce the bulk density of the soil such that vegetation can become established at the site. Rip and / or scarify all disturbed and compacted areas of the construction site. The ECO with the assistance of the engineer will specify whether ripping and / or scarifying is necessary, based on the site conditions. Do not rip and / or scarify areas that are saturated with water, as the soil will not break up. • Where good topsoil exists, no specific preparation is required. • Where topsoil is lacking, about 300mm of topsoil must be applied on top. The thickness of the topsoil maybe reduced at the instruction of the engineer only if 300mm of topsoil compromises the integrity of the works.

	• For seeding the soil needs to be prepared to optimise germination. Such preparation is undertaken by hand hoeing. The soil in the seedbed should be loosened but firmed to facilitate good contact between the seeds and the soil. • In general, fertilizer/lime is not necessary nor is it recommended for re-vegetation in rivers and riparian areas as this may promote increased weed growth. • A weed-free mulch is recommended to help retain moisture for germination on channel banks and road embankments. Mulch should be crimped in if possible to limit floatation if flooding is likely to occur. It is very important that mulch not be derived from stands of invasive exotic species or weeds.
STEP 5: Re-vegetation of disturbed areas	• Once construction is completed and alien vegetation and waste products have been removed and soils are prepared for planting, vegetation is to be reinstated as soon as weather conditions allow for good plant growth. • Revegetation should focus primarily on bare/exposed and unstable soils. Key focal areas include channel banks/margins of the active channel and riparian areas on the approach to the bridge but also includes road embankments on the approach to the bridge. • A trained revegetation/ rehabilitation expert should be contracted to oversee the rehabilitation of areas. • A minimalistic approach to re-vegetation of the disturbed areas is proposed for this site that will involve the rapid re-establishment of an indigenous pioneer plant dominated vegetation cover via a combination of cost-effective planting methods. • This should comprise a mix of rapidly germinating locally common indigenous grass species (e.g. *Cynodon dactylon*) as the basis where necessary. Based on the disturbed nature of the construction zone, which is currently very sparsely vegetated, establishing grass cover with stabilisation as the key objective is the primary goal and not restoring biodiversity aspects. • Damaging/destroying indigenous trees should be avoided unless absolutely necessary for construction works. Trees that are removed should either be relocated if possible or replaced through planting new trees of the same species. • Alien plant species are not to be used for re-vegetation, particularly those with invasive potential (Category 3 and above – National Environmental Management: Biodiversity Act or NEMBA). • It would be advisable to plant at the onset of the wet season (early spring – August to October) so that watering requirements are minimal. This may however not coincide with the construction period and need to be carefully planned. • Do not use fertilizer, lime, or mulch unless required. • The recommended methods for consideration when re-vegetating areas include: sodding, hydro-seeding, broadcasting and transplanting of live plants or plugs. These methods are discussed below in more detail. **5-1 Sodding:** • Runner grass sods composed of indigenous species must be laid out on disturbed river road embankments and channel banks and secured in place using wooded pegs. Use of grass sods is the most preferred re-vegetation method because it offers instant protection of vulnerable areas. It is best to install the sod as soon as it is delivered. • Lay the grass sods as indicated in photo below (right hand side) then peg each on to the ground using wooden pegs/stakes. • When sodding is carried out in alternating strips, or other patterns the areas between the sods should be seeded immediately after the sodding (photo on left hand side below). • Immediately after re-vegetation, the grass sods must be watered thoroughly. **5-2 Hydroseeding:** • Hydroseeding is the second preferred option to re-vegetating slopes. The advantages of hydroseeding include faster germination, increased plant survival, and the ability to cover large, often inaccessible areas rapidly. • Prior to hydroseeding water must be sprayed over target area to provide added moisture. • The target groundcover of re-vegetated areas shall be no less than 80% of specified vegetation and there must be no bare patches of more than 500 x 500 mm in maximum dimension. • Ideal species for hydroseeding include runner and short tufted species, such as *Stenotaphrum secundatum* and *Cynodon dactylon* or suitable alternative indigenous grasses species. **5-3 Broadcasting of Seed:** • On application, seeds must be manually/hand broadcasted or can be planted in rows

either by hand and then racked in the soil then watered immediately after.

- The seeding rate (seed used in kg/ha) varies according to the method and the type of seed being used. A good rule of thumb is to use twice the amount of seed used for row planting when broadcasting.
- The seed should be planted no deeper than 2.5 times the width of the seed but never left lying on the surface of the soil. The more sandy a soil, the deeper the seed should be planted and the more rich in clay a soil is, the shallower the seed should be sown (within the above limits).
- When broadcasting seed it is necessary to lightly cover the seed with soil by hand raking the seed into the soil to ensure the seed has good contact with the soil.
- Avoid sowing or thatching in areas where runoff concentrates (i.e. naturally channelled flow, drains, etc.).
- All planted areas should be mulched preferably immediately following planting, but in no later than 14 days from planting. Mulch conserves water and reduces erosion. The most common type of mulch used is hay or grass that is crimped into the soil to hold it.
- Thorough weed control is essential for the seeding method to be successful, as germinating native seedlings tend to be out-competed by faster growing introduced species.
- Temporary erosion protection measures must only be removed once good vegetation cover has established.

5-4 Planting of live plugs:

- Planting of live plugs may only be applicable to instream/wetland habitat, channel margins or riparian areas outside the construction zone that has been accidently disturbed. Given the very narrow construction zone, transplanting may not be required but will need to be assessed at a site level by those undertaking the rehabilitation and depending on impacts incurred during construction.
- When using vegetation plugs, the spacing of plugs should not be too wide and planting should be done in patches rather than wider spacing
- A recommended approximate planting density of 1–3 plants per m^2 generally applies to wetlands
- The plants should be planted with their roots in as much of the original soil medium as possible from which they were removed and in a water depth similar to that where they were collected.
- Plants in general must be planted with their tops out of the water or they will die.
- When planting the material, dig a hole deep enough to ensure that the roots do not bend upwards.
- The bottom of the root ball should be in contact with the saturation zone.
- The soil around the plant should be firmly compacted.
- Leaves of large plants must be trimmed back to about 10 to 15cm in length so as to reduce water losses through transpiration.
- Vegetation that has very recently been planted is generally susceptible to being washed away until it has become well established, particularly in areas of permanent water flow or high-energy environments. The plants may need to be secured using a coarse mesh (steel wire or plastic) and/or a fine biodegradable mat placed over the vegetation to secure the plants while they become established.
- Temporary erosion protection measures must only be removed once good vegetation cover has established.
- When sourcing plants from nurseries, it is important to consider the genetic origin of the plants. It is considered best to use small regional nurseries that breed plants from the region, instead of large commercial nurseries that are likely to obtain stock from large regional suppliers.
- It is important that the seed utilized is of adequate quality and certified, as well as tested for germinability prior to reseeding.
- Plugs will need to be sourced from the nearest nursery or harvested locally and/or grown by a nursery for the purposes of this project. The latter option is preferred. Such a nursery must have the required infrastructure and experience to harvest and propagate the required amount of plant material.

STEP 6: Monitor re-vegetation progress and administer alien plant control	• Recovery of disturbed wetland/riparian areas should be assessed for the first 6 months to assess the success of rehabilitation actions. Any areas that are not progressing satisfactorily must be identified (e.g. on a map) and action must be taken to actively re-vegetate these areas. If natural recovery is progressing well, no further intervention may be required. • Implement IAP control for the first 12 months post-construction to ensure that alien plants are actively managed and eradicated from the site, with adequate monitoring and follow-up measures. This will need to include any disturbed areas created during construction. • The ECO should assess the need / desirability for further monitoring and control after the first 12 months and include any recommendations for further action to the relevant environmental authority (EDTEA). • The use of herbicides in IAP control will require an investigation into the necessity, type to be used, effectiveness and impacts of the agent on aquatic biota. • Any soil erosion in rehabilitated areas must also be addressed through appropriate actions. • There should be low levels of Invasive Alien Plants (<10% IAP cover) • Vegetation cover should be re-instated to >90% cover.

8.3.10 Guidance on Alien Plant Control

Box 3. Guidance Alien Plant Control

There are various means of controlling invasive alien plants in South Africa. The primary methods are discussed below. The suitability of control methods depends on a number of factors, including practical constraints, economic constraints and applicability of methods for particular species of alien plants. It is generally advised that a form of integrated control be implemented; however the final selection of the appropriate methods of control should be based on the following criteria:

- **Species to be controlled:** herbicides are registered for specific species. Selection should be based on "A *Guide to the use of Herbicides*" issued by the Directorate: Agricultural Production Inputs and labels and information brochures provides by herbicide suppliers.
- **Size/age of target plants:**
  - For **seedlings:** hand-pulling or hoeing and foliar applications of herbicides for dense stands.
  - For **saplings:** hand-pulling or hoeing, foliar applications of herbicides for dense stands, basal stem treatments and cut stump treatments recommended.
  - For **mature trees**: ring barking, frilling, basal stem treatments and cut stump treatments recommended.
- **Density of stands:** Overall applications of herbicide can be made to dense stands of seedlings or saplings. Where dense stands of large trees are present, treatment of standing trees may be appropriate to obviate the problem of disposing felled trees.
- **Accessibility of terrain:** In inaccessible areas, methods that rely on the minimum amount of transportation of equipment and chemicals should be given preference.
- **Environmental considerations:** Riparian/wetland areas require a careful approach to treatment/control. Only herbicides approved for use in wetland/riparian areas are to be considered. Washing of equipment or disposal of any chemical substances is prohibited in or near areas where there is a potential risk of contamination of wetlands/riparian areas.
- **Desirable vegetation:** Control methods that will cause the least damage to desirable vegetation must be considered. Selective herbicides or mixes that will not damage other desirable vegetation should be applied where relevant.
- **Disposal of dead vegetation:** Where possible, utilizable wood should be removed after tree felling. This is also the case for trees that could cause the blockage of water courses. Brushwood should be spread rather than stacked to limit soil damage in instances where burning is planned.
- **Cost of application:** the cost of application and re-treatment should be taken into consideration when selecting methods/herbicides, etc.

The **control methods** detailed below have been adapted from the ARC-PPRI (Agricultural Research Commission: Plant Protection Research Institute) Weed Research Programme (online at www.arc.agric.za/arc-ppri/), the DWA Working for Water Programme ((http://www.dwaf.gov.za/wfw/Control/) and eThekwini Municipality's *Practical tips on the management and eradication of invasive alien plants* (EcoFiles Sheet 4. Local Action for Biodiversity).

1. Mechanical control

Mechanical control entails physically damaging or removing the target alien plant. Mechanical control is generally labour intensive and therefore expensive, and can also result in severe soil disturbance and erosion. Different techniques can be applied and include uprooting/hand-pulling, felling, slashing, mowing, ring-barking or bark stripping. This control option is only really feasible in sparse infestations or on a small scale, and for controlling species that do not coppice after cutting. Species that tend to coppice (e.g. *Eucalyptus spp., Melia azedarach)* need to have the cut stumps or coppice growth treated with herbicides following mechanical treatment.

- **Hand pulling/uprooting:** The hand-pulling should be reserved for small plants and shrubs with shallow root systems (not recommended for trees with a stem diameter of more than 10cm). Grip the young plant low down and pull out by hand (using gloves). Uprooting is similar but is undertaken on slightly older individuals with the major drawback being that a relatively large area can be disturbed with the soils being altered and opening the area up to re-infestation.
- **Chopping/ cutting/ slashing:** This method is most effective for plants in the immature stage, or for plants that have relatively woody stems/trunks. An effective method for non re-sprouters or in the case of re-sprouts (coppicing), it must be done in conjunction with chemical treatment of the cut stumps. Cut/slash the stem of the plant as near as possible to ground level. Paint re-sprouting plants with an appropriate herbicide immediately after they have been cut.
- **Strip bark:** Using a bush knife, strip bark away from tree from waist height down to soil. Cambium is stripped with the bark. No herbicide used.
- **Felling:** Large trees can be cut-down in their entirety, however, this is often not recommended unless absolutely necessary as large trees can play a pivot role in soil protection and biodiversity maintenance.
- **Girdling:** Girdling involves cutting a groove or notch into the trunk of a tree to interrupt the flow of sap between the roots and crown of the tree. The groove must completely encircle the trunk and should penetrate into the wood to a depth of at least 1.5 centimetres on small trees, and 2.5 to 4 centimetres on larger trees. The effectiveness of girdling can be increased by using herbicides.

2. Chemical control

Chemical control involves the use of registered herbicides to kill the target weed. The use of herbicide is often essential to the success of an eradication/control programme as it greatly reduces the re-growth potential of alien plants. Unfortunately, if the wrong herbicide is chosen, one can potentially cause more harm than good to the environment. When choosing the most appropriate herbicide, one needs to consider the following:

- **Relative toxicity to humans/animals**
- **Selective vs non-selective herbicides**: There are advantages and disadvantages to using each type. When dealing with light to moderate infestations in grass-dominated veld types, a broad-leaf selective herbicide is recommended so as to reduce the danger that spray drift could kill natural grass. In areas of heavy infestation, a non-selective herbicide is recommended.
- **Residual effect**: Some active ingredients in herbicides will remain in the environment for months, even years, before denaturing. Others start to denature as soon as they enter the soil. If a persistent herbicide is used, ensure that it is not used near any watercourse or area with a high water table (such as wetlands & riparian areas).
- **Is the herbicide registered for the target species:** A list of registered herbicides can be obtained from the Department of Water Affairs: Working for Water Programme – Policy on the Use of Herbicides for the Control of Alien Vegetation (January 2002). Also see http://www.arc.agric.za/arc-ppri/Pages/Weeds%20Research/Specific-IAP-Species-and-their-control-according-to-botanical-names.aspx

Some additional recommendations regarding herbicide use include:

- Herbicides should be applied during the active growing season.
- Always observe all safety precautions printed on the labels and manufacturer's instructions when mixing and applying herbicide.
- Herbicides can be applied in various ways. They can be sprayed onto dense infestations or painted onto the main stem of the plant or cut stump.
- Spraying herbicide on small infestations is not recommended, rather cut and apply herbicide to the stumps either with a brush.
- Spraying should be restricted to windless days when there is less risk of droplets drifting onto non-target species.
- Pressure or flow regulators should be fitted to sprayers for overall application. Spraying should be restricted to plants waist height or lower, but also ensuring there is sufficient foliage to carry the applied herbicide to the root system of the target plant.
- For water-based applications, Actipron Super Wetter should be added where recommended on the herbicide label, at a rate of 1.75/ha for dense-closed stands of alien vegetation.
- For all water-based treatments, a suitable brightly coloured dye should be added to the mix to ensure that all target plants are treated. For diesel-based applications, Sudan Red Dye should be added.
- Chemical control of IAPs is not recommended in aquatic systems due to the risk of water pollution, but may be used in conjunction with cutting or slashing of plants.
- Chemicals should only be applied by qualified personnel.
- Only herbicide registered for use on target species may be used.
- Follow the manufacturer's instructions carefully.
- Appropriate protective clothing must be worn.
- Only designated spray bottles to be used for applying chemicals.
- The number of herbicides for safe use under wet conditions is very limited.

3. Biological control

Biological weed control involves the releasing of natural biological enemies to reduce the vigor or reproductive potential of an invasive alien plant. Research into the biological control of invasive alien plants is the main activity of the Weeds Research Programme of ARC-PPRI and a list of biocontrol agents released against invasive alien plants in South Africa can be downloaded from their website. To obtain biocontrol agents, provincial representatives of the Working for Water Programme or the Directorate: Land Use and Soil Management (LUSM), Department of Agriculture, Forestry and Fisheries (DAFF).

4. Mycoherbicides

A mycoherbicide is a formulation of fungal spores in a carrier, which can be applied to weeds in a similar way as a conventional chemical herbicide (using herbicide application equipment). The spores germinate on the plant, penetrating plant tissues and causing a disease which can eventually kill the plant. Mycoherbicides are indigenous to the country of use and therefore are already naturally present in the environment and do not pose a risk to non-target plants. Under natural conditions they do not cause enough damage to the weed to have a damaging impact and are therefore mass produced and applied in an inundative inoculation, which leads to an epidemic of the disease knocking the weed population down. Mycoherbicides need to be re-applied at regular intervals.

5. Integrated control

It is frequently advisable to use a combination of two or more of the control method mentioned above, which is referred to as *integrated control*. Killing plants without cutting down causes the least disturbance to the soil and is the ideal.

The following integrated control options are available:

- **Basal bark and stem application**: apply recommended herbicide mixed in diesel carrier to the base of the stem of trees (<25cm stem height) and saplings. This method is appropriate for plants with thin bark or stems up to 25cm in diameter. Do not cut the bark. Apply herbicide mix with paintbrushes or using a coarse droplet spray from a narrow angle solid cone nozzle at low pressure. For multi-stemmed plants, each stem must be treated separately.
- **Ring barking**: Invasive trees growing away from any structures or roads can be ring-barked, poisoned and left standing rather than felled. They will slowly collapse over time and can establish habitat for birds, etc. Strip all bark and cambium from a height of 75cm to 100cm down to just below soil level. Cut a ring at the top and pull strips. All bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets should be used for debarking.
- **Frilling:** Using an axe or bush knife, make angled cuts downward into the cambium layer through the bark in a ring. Ensure to effect the cuts around the entire stem and apply herbicide into the cuts.
- **Cut stump treatment**: This is a highly effective and appropriate control method for larger woody vegetation that has already been cut off close to the ground. The appropriate herbicide should be applied to the stump using a paintbrush within 30 min of being cut. Apply recommended herbicide mixture to the cut surface with hand sprayers, a paintbrush or knapsack sprayer at low pressure. Apply only to the cambium or outer layer of large stumps and the entire cut surface of small stumps. Ensure the stumps are cut as low to the ground as practically possible (about 10 – 15 cm or as stipulated on specific herbicide label). Herbicides are applied in diesel or water as recommended for the herbicide. Applications in diesel should be to the whole stump and exposed roots and in water to the cut area as recommended on the label.
- **Scrape and paint**: This method is suitable for large vines and scrambling plants i.e. creepers. Starting from the base of the stem, scrape 20-100cm of the stem to expose the sapwood just below the bark. Within 20 seconds apply the herbicide to the scraped section. Do not scrape around the stem. Stems over 1cm in diameter can be scraped in 2 sides. Leave the vines to die in place to prevent damaging any indigenous plants they may be growing over.
- **Foliar spray:** This is not an advocated method of application by unqualified applicators due to the danger of spraying indigenous species. Should be restricted to droplet application made directly on the leaves on plants that are no higher than knee height. Use a solid cone nozzle that ensures an even coverage on all leaves and stems to the point of runoff. Do not spray just before rain (a rainfall-free period of 6 hours is recommended) or before dew falls. Avoid spraying in windy weather as the spray may come into contact with non-target plants. Spraying dormant or drought stressed plants is not effective as they do not absorb enough of the herbicide.
- **Burning**: Spindly invasive alien plant species, such as Triffid Weed (*Chromolaena odorata*), growing on sandy soils, where there is between 30-40% grass still present, can be eradicated using annual controlled burns. Moderate to low infestations in wetland areas can be treated by controlled burning at the beginning of autumn, followed by mechanical removal or herbicide application in mid spring. ***Note that burning would generally not be acceptable in an urban area due to fire hazard/risk and nuisance.***
- *Note that no heavy machinery should be used to remove invasive alien plants, no matter how high the infestation, without prior authorization from relevant government departments when operating in wetlands and riverine areas.*

6. Disposal of alien plant material

Treated/removed alien plant material will need to be removed from the site and disposed of at a proper/registered receiving area such as a local registered land fill site.

8.3.11 General Guidelines and Restrictions

Before the implementation of any of the proposed mitigation measures/rehabilitation activities outlined in this plan, it is important to understand the following general site guidelines and restrictions:

i. **AN ENVIRONMENTAL CONTROL OFFICER (ECO) MUST BE APPOINTED TO MONITOR ALL CONSTRUCTION WORK (INCLUDING REHABILITATION)** within the freshwater habitats, prior to construction commencing. The ECO must undertake a close-out audit after the monitoring period and sign-off on the success of the rehabilitation.

ii. **INDIGENOUS VEGETATION MAY NOT BE REMOVED DURING REHABILITATION** unless this has been specifically specified for use in vegetation by means of transplanting.

iii. The site is steep and therefore **SLOPES ARE SENSITIVE TO DISTURBANCE**. Site clearing and movement of workers/equipment within the site must therefore be aware of any steep and unstable slopes and restrict movement & activities where necessary.

iv. The use of chemicals/herbicides in alien plant control must be **STRICTLY RESTRICTED TO A CERTIFIED HERBICIDE CONTROL APPLICATOR ONLY.** The application of herbicides will need to take into account the presence of aquatic systems (stream and riparian zone) on site.

v. Where possible, **WATER AND HERBICIDE SOLUTIONS MUST BE USED** instead of diesel and herbicide solutions. Water and herbicide solutions have lower pollution risks when compared to diesel and herbicide solutions.

vi. **THE EDUCATION OF FIELD WORKERS IS VERY IMPORTANT** as they will be primarily responsible for undertaking the rehabilitation work.

vii. **WORKERS MUST BE STRICTLY MONITORED** by a suitable trained site supervisor as they undertake rehabilitation.

viii. All **VEHICLES USED TO ACCESS THE SITE AND TRANSPORT EQUIPMENTN MUST BE RESTRICTED TO EXISTING DISTURBED AREAS ONLY** and should not be permitted to move into undisturbed vegetation or habitat.

ix. **GOOD TIMING AND FOLLOW-UPS ARE VERY IMPORTANT** for a successful rehabilitation process which often generally capital expense in the long-term.

x. **BASIC EQUIPMENT REQUIREMENTS:** all personal working on site must wear the necessary personal protective clothing (PPE) and use appropriate equipment to do the work. This may include the following where relevant:

   a. Long overalls
   b. Eye protection (safety goggles/glasses)
   c. Protective gloves
   d. Safety boots/gum boots
   e. Sun protection hats/caps
   f. Bush knives, machetes, saws, axes, chainsaws, etc.
   g. Registered herbicides and diesel carrier
   h. Paintbrushes, spray jets to apply herbicide
   i. Drinking water

8.3.12 Potential Negative Impacts of Rehabilitation

While the intention of rehabilitation should always to benefit the environment and society through the protection or improvement of freshwater ecosystems and the services that they provide, poorly planned rehabilitation can often cause more harm than good (Armstrong, 2008). Rehabilitation interventions vary considerably in terms of their potential to cause environmental impacts both in terms of the type of impact caused as well as the magnitude of the impact. Thus it is appropriate that all rehabilitation efforts/ projects are scrutinized for their potential to cause unintended, negative environmental impacts (Armstrong, 2008). Potential negative impacts associated with rehabilitation projects are highlighted by Armstrong (2008), most relevant of which to this rehabilitation plan have been summarised in Table 19, below.

It is recommended that these and other potential negative impacts be noted by the Implementing Agent responsible for the rehabilitation and managed on-site according to means of avoidance/ mitigation described in Table 19 and in conjunction with the aquatic ecological impact management and mitigation measures discussed further in Section 8.2.

Table 19. Key potential negative environmental impacts associated with wetland, river and riparian rehabilitation activities and interventions and means of avoiding or mitigating these impacts (after Armstrong, 2008).

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
1	**A weir, earthen plug or sediment fence across a stream channel, artificial drainage channel or erosion gully**	Trapping of bedload and spreading of high flows.	Little that can be done to mitigate.
2	**Sloping of steep slopes and erosion gully head/sides**	Exposure of soils to risk of erosion, which may impact negatively on river/stream and riparian areas and downstream aquatic habitats.	Assess whether bioengineering will be adequate. Ensure revegetation takes place as rapidly as possible. Provide supplementary support (e.g., biomats, ecologs, etc.) to the vegetation, where required.
3	**Infilling of erosion gullies or artificial drainage channels**	Fill material may be washed away, which may impact negatively on the aquatic habitats nearby and downstream aquatic habitats. Obtaining fill will also have associated impacts	Re-vegetate the fill as quickly as possible. Temporarily divert flow, if required, until the fill has become adequately re-vegetated.
4	**Planting of vegetation**	Introduction of alien species that spread beyond the site. Use of plant material of indigenous species that is genetically different to that occurring locally, resulting in 'genetic contamination'.	Do not use species with invasive potential. Use local material only.
5	**Access to the site during rehabilitation by workers and equipment**	Soil compaction and disturbance and vegetation disturbance.	As far as possible, use existing roads and tracks. In very wet areas obtain foot access using boards. Rehabilitate access paths when work is complete (e.g. loosen compacted areas).
6	**Temporary storage of materials**	Disturbance of vegetation. Visual impact.	Remove all material on completion of the work. Rehabilitate site when work is complete.
7	**Mixing of concrete**	Local contamination of the soil.	Confine mixing of concrete to

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
			designated area/s not susceptible to flooding.
8	**Human waste associated with toilets**	Contamination of soil and water.	Locate toilets outside of the delineated watercourses.
9	**Disturbance associated with the noise and presence of workers**	Disturbance of fauna, particularly breeding Red Data species.	Consider timing of activities. Screening with shade-cloth, if required.
10	**Fuel spills or leaks**	Contamination of soil and water.	Maintain any machines (e.g., pumps) being used at the site in good working order, and any stored fuel should be located well outside of the delineated watercourses.
11	**Temporary diversion**	Temporary drying out or redirecting of flows as well as secondary erosion and sediment impacts.	Ensure that the diversion channel or coffer dam is removed and natural flow regimes are restored
12	**Removal of plugs of vegetation from donor sites**	Potential exposure of donor sites to erosion. Disturbance of sensitive habitat.	Remove plugs where the threat of erosion is low and the site is not considered sensitive.
13	**Cutting and filling (e.g. in order to slope a gully head or sides)**	Disturbance of soil and vegetation. Erosion and washing of sediment into downstream habitats.	Where the site is located in water flow paths, particularly where discharges are high, confine activity to the dry season. Divert flow until the intervention is well stabilised. Encourage rapid re-vegetation.
14	**Collection of rocks and material from the local environment**	Loss of habitat from rock removal.	Do not collect rocks or sediments from a stream channel bed.
15	**Collection of local sand**	Disturbance of vegetation, possible increase in risk of erosion.	Collect sand where risk of erosion is low and in areas where pioneer vegetation dominates.
16	**In all cases of disturbance of soil or vegetation, the opportunities for invasive alien species to invade are increased,**	Competition and displacement of native vegetation, loss of biodiversity, increased soil erosion/fire risk, increased water consumption (depending on species of IAPs).	Control alien plants and weeds.

8.3.13 Outstanding Tasks and Way Forward

The outstanding tasks still to be completed as part of the finalization of the rehabilitation planning needs to include the finalization of a detailed freshwater habitat rehabilitation plan for implementation based on these conceptual guidelines that include:

- Accurate location and extent of development footprint including infrastructure and the mapping of areas requiring rehabilitation.
- Finalisation of a site-specific re-vegetation plan including planting method, preferred species, plant spacing and densities, as well as recommended stabilization measures based on slope and soil types.
- Finalisation of the bill of quantities and costs for all rehabilitation interventions required.

8.4 Operation Phase Impact Mitigation Measures

A. Flow and Erosion/ Sedimentation Control

Once the widened bridge infrastructure has been completed and becomes operational, very little can be done to manage instream flow and flow related erosion (scouring) and sedimentation impacts during operation. These impacts can and should be best addressed through careful design of the bridge upgrades that takes into account environmental and ecological considerations. The reader is therefore referred to section 8.1 for bridge design recommendations that will serve to reduce the probability and intensity of operational instream risks and impacts to reasonably low significance levels.

B. Managing for Species Migration

Bridge design already adequately caters for the movement of aquatic biota (fish, amphibians, invertebrates, etc.) between upstream and downstream wetland and river reaches during bridge operation.

C. Alien Plant Monitoring and Control

It is the responsibility of the developer/applicant to eradicate and control alien invasive plants that invade all areas disturbed by the construction and operation of the proposed bridge upgrade. In terms of section 75 of NEMBA, the following applies to the control & eradication of invasive species:

- The control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs;
- Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment; and
- The methods employed to control and eradicate a listed invasive species must also be directed at the offspring, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.
- It is recommended that bi-annual annual alien plant clearing be undertaken by the applicant for the first year post-rehabilitation. Thereafter, alien plant clearing should be undertaken annually until such a time that further risks of alien invasion resulting from disturbance factors are considered negligible.

8.5 Ecological Monitoring Recommendations

Monitoring is required in order to ensure that rivers/streams and riparian areas associated with the proposed development are maintained in their current ecological state or improved but incurring no net loss to condition and functionality as a result of the project. It is recommended that a Monitoring Programme be developed and implemented in accordance with the following guidelines:

A. Responsibilities for Monitoring:

Compliance monitoring will be the responsibility of a suitably qualified/trained ECO (Environmental Control Officer) with any additional supporting EO's (Environmental Officers) having the required competency skills and experience to ensure that monitoring is undertaken effectively and appropriately.

B. Construction Monitoring Objectives:

Key monitoring objectives during the construction-phase should include:

- Ensuring that management and mitigation measure are adequately implemented to limit the potential impact on aquatic resources such as rivers and wetlands; and
- Ensuring that disturbed areas have been adequately to stabilise and rehabilitated to minimise residual impacts to affected water resources.

C. Record keeping:

The ECO shall keep a record of activities occurring on site, including but not limited to:

- Meetings attended;
- Method Statements received, accepted and approved;
- Issues arising on site and cases of non-compliance with the EMPr;
- Corrective actions taken to solve problems that arise;
- Penalties/fines issued; and
- Complaints from interested and affected parties.

D. Construction Phase Monitoring Requirements:

- **During construction:**

This involves the monitoring of construction related impacts as identified in this report. Regular monitoring of the construction activities is critical to ensure that any problems with are picked up in a timeous manner. In this regard, the following potential concerns should be taken into consideration:

- Destruction of habitat outside the construction servitude including 'No Go' areas;
- Erosion of wetlands, river beds and channel banks;
- Erosion of disturbed soils and soil stockpiles by surface wash processes;
- Sedimentation of aquatic habitats (wetlands/rivers) downstream of active work areas;
- Altering the hydrology and through flows to downstream aquatic habitat during construction;
- Pollution of water resource units (with a particular focus on hazardous substances such as fuels, oils and cement products);
- Poorly maintained and damaged erosion control measures (e.g. sand bags, silt fences and silt curtains).

These risks can be monitored visually on-site by the ECO (together with construction staff) with relative ease and should be reported on regularly during the construction process. Any concerns noted should be prioritised for immediate corrective action and implemented as soon as possible.

- **Directly after construction (rehabilitation effectiveness):**

This involves monitoring the effectiveness of rehabilitation activities. Monitoring recommendations for rehabilitated wetland, river and riparian areas have been included in the **'Post Construction Rehabilitation Guidelines'** contained in Section 8.3 of this report.

E. Operation phase monitoring requirements:

This involves annual monitoring of water resource units (wetlands & rivers) affected by the bridges upgrade development in order to ensure that operational impacts are being effectively managed. This can also be achieved through basic visual inspections by the ECO and support staff, documenting issues such as:

- Invasive Alien Plant infestation;
- Scouring and deposition associated with storm water runoff;
- Development of erosion 'headcuts';
- Channel incision downstream of development;
- Blockage/siltation of bridge infrastructure;
- Scouring around infrastructure at wetland and river crossings; and
- Erosion or instability of any artificial embankments.

9 LICENSING & PERMIT REQUIREMENTS

9.1 Water Use Licensing Requirements

Chapter 4 and Section 21 of the National Water Act No. 36 of 1998 lists certain activities for which water use must be licensed, unless its use is excluded. There are several reasons why water users are required to register and license their water use with the Department of Water & Sanitation (DWS), the most important being: (i) to manage and control water resources for planning and development; (ii) to protect water resources against over-use, damage and impacts and (iii) to ensure fair allocation of water among users.

9.1.1 Identified Water Uses

Section 21 water uses associated with the widening of the Bedlane and Dango River bridges are generally "non-consumptive" water uses, as per Table 20, below.

Table 20. Non-consumptive "water uses" associated with the P393 bridges upgrade project.

NWA Section 21 Water Use	Description (DWAF, 2009)	Relevant Activity	Watercourses Affected
21 (a): Taking water from a watercourse	*Abstraction of water from a water resource.*	**Abstraction points and quantities of water to be abstracted from the river for construction purposes is currently unknown and will need to be verified.**	Unknown at this stage
21 (c): Impeding or diverting the flow of water in a watercourse	*This water use includes the temporary or permanent obstruction or hindrance to the flow of water into watercourse by structures built either fully or partially in or across a watercourse; or a temporary or permanent structure causing the flow of water to be re-routed in a watercourse for any purpose.*	**Temporary impoundment/diversion of flows may be necessary to allow for construction to take place within the watercourse during bridge widening.**	1 Bedlane River (R01) 2 Channelled valley bottom wetland (W01) associated with Dango River
21 (i): Altering the bed, banks, course or characteristics of a watercourse	*This water use relates to any change affecting the resource quality of the watercourse (the area within the riparian habitat or 1:100 year floodline, whichever is the greatest).*	**Widening of bridge piers and abutments will result in the alteration of channel banks upstream and downstream of the existing structure.**	

9.1.2 Aquatic Risk Assessment

Water resource screening and risk rating is largely a requirement for all potential water uses as contemplated in the National Water Act No. 36 of 1998 (NWA). Risk can be defined broadly as *'a prediction of the likelihood or probability and impact of an outcome as a result of external or internal vulnerabilities operating on a system and which may be possible to avoid through pre-emptive action'*. The recent General Authorisation (GA) in terms of Section 39 of the National Water Act No. 36 of 1998 for Water Uses as defined in Section 21 (C) or Section 21 (I), (as contained in Government Gazette No. 40229, 26 August 2016) replaces the need for a water user to apply for a license in terms of the National

Water Act No. 36 of 1998, '*provided that the water use is within the limits and conditions of the GA*'. Note that the GA does not apply to:

1. Water use for the rehabilitation of a wetland as contemplated in GA 1198 contained in GG 32805 (18 December 2009).
2. Use of water within the 'regulated area'[2] of a watercourse where the Risk Class is **Medium or High.**
3. Where any other water use as defined in Section 21 of the NWA must be applied for.
4. Where storage of water results from Section 21 (c) and/or (i) water use.
5. Any water use associated with the construction, installation or maintenance of any sewerage pipeline, pipelines carrying hazardous materials and to raw water and wastewater treatment works.

Identification and description of typical risks

The DWS has developed a Risk Assessment Matrix/Tool to assess water risks associated with typical development activities. The DWS Risk Matrix/Assessment Tool (based on the DWS 2015 publication: 'Section 21 c and i water use Risk Assessment Protocol') was applied to the proposed border retaining wall development with emphasis on Section 21 (c) and (i) water uses. The Risk Assessment Matrix/Tool considers the risks posed to watercourses posed by various activities and for different phases of a development (i.e. Construction and Operation in this case). Activities typically give rise to different environmental stressors (or aspects) which manifest in impacts to the receiving aquatic environment and ecosystems. The tool rates the anticipated severity of impacts on the four key drivers of aquatic ecosystem persistence, health and functioning, that being:

1. **Flow Regime**
2. **Water Quality**
3. **Habitat & Vegetation**
4. **Aquatic Biota**

Possible activities, aspects (or stressors) and potential ecological risks identified for the Bedlane and Dango River Bridges widening that could potentially manifest in impacts to the four drivers of wetland/river condition and functioning (as defined by the DWS) are likely to include:

a. Permanent destruction/modification of aquatic habitat and vegetation due to bridge widening;

b. General habitat disturbance leading to the colonisation of adjacent wetland /riparian habitat by alien plants, weeds and other undesirable plant species (post-construction);

[2] The 'regulated area' of a watercourse; for Section 21 (c) or (i) of the Act refers to:

i. The outer edge of the 1:100 year flood line and/or delineated riparian habitat, whichever is greatest, as measured from the centre of the watercourse of a river, spring, natural channel, lake or dam.
ii. In the absence of a determined 1:100 year flood line or riparian area, refers to the area within 100m from the edge of a watercourse (where the edge is the first identifiable annual bank fill flood bench).
iii. A 500m radius from the delineated boundary of any wetland or pan.

c. The risk of reduced water quality and the knock-on effects on aquatic ecology (flora and fauna/biota) as a result of 'accidental' pollution during the construction-phase.

Quantifying ecological risks

For the purposes of this aquatic risk assessment, the DWS "Risk Assessment Matrix" approach, as detailed in the latest General Authorisation in terms of Section 39 of the National Water Act, was applied at a project level in order to identify whether the project will fall within the realm of the GA or whether a full WULA will likely be required and also to dictate what level of risk/impact mitigation will be required for the operational phase of the project to reduce risk to manageable and environmentally acceptable levels.

The spatial scale, duration, frequency of activity and impact, applicable legal issues and ease of detection of impacts were all rated qualitatively using a scale of 1 – 5 (5 being the highest/most significant) and used to automatically calculate significance and provide a risk rating of Low, Moderate or High based on the outcomes of rating the various criteria. In instances where low/moderate risk scores were obtained, risk scores were manually adjusted downwards up to a maximum of 25 points based on the implementation of practical mitigation measures identified.

A broad overview of ratings applied for the development scenario is provided in Table 21, below. This reflects the range of scores associated with operational aspects and impacts with a brief rationale for the scores allocated.

Table 21. Risk criteria rating and rationale.

DWS Risk Rating Criteria	Rating / Score (1-5)	Rationale/Motivation
1 Severity of impact[3]		
a. Flow regime	Insignificant (1)	The risk of impact on wetland/river flow regime is likely to be largely insignificant (short-duration for a limited period during construction, if any at all).
b. Water quality	Insignificant (1)	Water quality risks are considered largely insignificant.
c. Habitat & vegetation	Significant / slightly harmful (3)	Direct impacts to aquatic habitat and vegetation are likely to extend to upstream and downstream during bridge widening, but will be limited to existing impacted areas.
d. Aquatic biota	Insignificant (1)	No aquatic biota of concern were identified in conservation planning datasets or field investigations. Indirect risks of impact are likely to be largely associated with potential water quality impacts which could affect locally common species such as amphibians for example.
2 Spatial scale	Areas specific (1) to Whole site (2)	The extent of impact is likely to be largely restricted to the site and nearby downstream areas, although water quality impacts related to pollution events can potentially migrate a significant distance to reach downstream areas.
3 Duration	From <1month (1)	Impacts are likely to be short-term and mostly limited to the construction phase of the project.
4 Frequency of activity	Annually or less (1) to	Mostly limited to the construction phase activities

[3] Note that ratings here have been assessed on a scale from 1 (Insignificant / non-harmful) to 5 (Disastrous / extremely harmful. Whilst the DWS guidelines suggest that any impacts to a wetland should be rated as a "5", this generates risk scores that are artificially elevated. Following discussions with Dr Wietsche Roots (DWS National), it was agreed that specialists should apply their minds and that the severity rating should rather be assessed on a case by case basis. This approach has therefore been followed for this risk assessment.

DWS Risk Rating Criteria	Rating / Score (1-5)	Rationale/Motivation
	seasonally or 6 monthly (2)	associated with the bridges upgrade project
5 Frequency (probability) of impact	Very seldom (2) to Infrequent (3)	The probability of incurring direct impacts is seldom, with the probability of indirect impacts being slightly more frequent.
6 Legal issues	Full (5)	Impacts to natural watercourses (wetlands & rivers) are regulated under a range of South African legislation (i.e. the National Water Act and National Environmental Management Act).
7 Detection	Immediate (1) to Without much effort (2)	Most impacts can be relatively easily detected.

The results in Table 22 (below) and **Annexure D** indicate that the risks posed by the construction and operation of the proposed bridge widening on water resources (i.e. wetlands and rivers), based on the recommended risk mitigation and impact management contained in this report, will be of **Low to Moderate risk for the construction phase and potentially Low Risk for the operational phase**. This initially suggests that the development would need to be subject to a full Water Use Licence Application in accordance with the conditions of the GA. However, the DWS risk matrix/tool allows for borderline low/moderate risk scores to be "*manually adapted downwards up to a maximum of 25 points from a score of 80, subject to listing of additional mitigation measures considered*". Based on risk and impact mitigation that takes into account the recommendations made by Eco-Pulse (see control measures and mitigation in Table 22 below and Section 8 of this specialist report), the risk class of construction phase activities and stressors can be modified down from a moderate to low risk rating for all activities/stressors. The project can then potentially be authorised under the provisions of the GA.

Table 22. Summary of the DWS Risk Matrix/Tool assessment results applied to the P393 bridges widening.

Phase(s)	Activity	Aspect	Impact	Severity	Consequence	Likelihood	Risk Rating	Control measures	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
Construction	**Demolition and widening of existing bridge structure**	**Site clearing and disturbance of habitat and vegetation**	Direct impacts to river/wetland habitat, vegetation and soils, potentially leading to changes in vegetation composition, structure and habitat for biota as well as the fragmentation of habitat.	**1.75**	**4.75**	**12**	**Moderate**	Onsite BMPs, post-construction rehabilitation	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low
		Temporary impoundment / flow diversion to create a "dry" working area	Temporarily impeding/diverting the flow of water during construction, alteration of natural flow patterns and soil saturation rates, scouring and erosion due to redirection of flows.	**1.5**	**4.5**	**11**	**Low**	Method Statement for flow diversions, onsite BMPs	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low

Phase(s)	Activity	Aspect	Impact	Severity	Consequence	Likelihood	Risk Rating	Control measures	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
		Potential contaminants from construction activities	Water pollution impacts, with resultant consequences for aquatic vegetation and biota.	1.75	5.75	9	Low	Onsite BMPs	Low	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low
Operation	**Operation of the bridge upgrade**	**General habitat disturbance of adjacent areas**	Leading to the colonisation of adjacent wetland habitat by alien plants, weeds and other undesirable plant species affecting habitat integrity and species diversity.	1.5	4.5	12	Low	Post-construction IAP monitoring and clearing	Low	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low

The detailed DWS risk matrix assessment results spreadsheet can be made available to the client by Eco-Pulse on request and are also contained in ***Annexure D.***

The recent GA also includes a number of activities that are generally authorized for State Owned Companies (SOC's) and institutions that are then subject only to compliance with the conditions of the GA (*summarised below under Section 7.2*). Under Appendix D2 of the GA, for SANRAL and the Provincial Departments of Transport or municipalities, the following activities can be authorized under the GA:

- *All maintenance of bridges over rivers, streams and wetlands and the new construction of bridges done according to the SANRAL Drainage Manual or similar norms and standards.*

This essentially replaces the need for the KZN DoT to apply for a full water use license for the widening of the existing P393 Road Bridges and this activity and associated Section 21 c & i water uses can then potentially be authorised under the provisions of the GA subject to compliance with the conditions of the GA. Should additional 'non-consumptive' or 'consumptive' water uses be identified (in addition to Section 21 c and i), a full WULA is likely to be applicable.

9.1.3 Conditions of the GA

Note that conditions set for Section 21 (c) and (i) water use in terms of the GA specify that the water user must ensure that compliance with the following is achieved:

a. Impeding or diverting flow or altering the characteristics of a watercourse does not detrimentally affect other water users, property, health and safety of the general public or the resource quality.

b. The existing hydraulic, hydrologic, geomorphic and ecological functions of the watercourse in the vicinity of the structure is maintained or improved upon.

c. Full financial provision for the implementation of the management measures prescribed in the GA, including an annual financial provision for any future maintenance, monitoring, rehabilitation or restoration works (as may be applicable).
d. Construction camps, storage, washing and maintenance of equipment, storage of construction materials or chemical, sanitation and waste management facilities are located outside of the 1:100yr flood line or riparian habitat of a river, spring, lake, dam or outside any drainage feeding any wetland or pan and is removed within 30 days of completion of any works.
e. The site where water use will occur must not be located on a bend in the watercourse, must avoid high gradient areas, unstable slopes, actively eroding banks, interflow zones, springs and seeps; avoid or minimise realignment of a watercourse, minimise the footprint of alteration and construction footprint.
f. A maximum impact footprint around the works must be established, clearly demarcated, no vegetation cleared or damaged beyond this demarcation and equipment/machinery only operated within the delineated impact footprint.
g. Minimise the duration of disturbance and the footprint of disturbance of the bed and banks of the watercourse.
h. Prevent the transfer of exotic biota to the site.
i. All works must start upstream and proceed in a downstream direction to ensure minimal impact on the water resource.
j. Excavated material from the bed or banks of a watercourse must be stored appropriately and returned to the original locations upon completion of the works.
k. Adequate erosion control measures are to be implemented at and near all alterations, with an emphasis on erosion control on steep slopes and drainage lines.
l. Alteration or hardened surfaces must be structurally stable, not induce sedimentation, erosion or flooding, not cause a detrimental change in the quantity, velocity, pattern, timing, water level, water quality, stability or geomorphological structure of a watercourse, or cause nuisance or health or safety hazards.
m. Measures are undertaken to protect the breeding, nesting or feeding patterns of aquatic biota (including migratory species), allow for the continued movement of biota up and downstream and prevent a decline in the composition and diversity of indigenous and endemic aquatic biota.
n. Ensure that no substance or material that can potentially cause pollution of the water resource is being used in works.
o. Measures are undertaken to prevent increased turbidity, sedimentation and detrimental chemical changes to the composition of the water resource.
p. Instream water quality is to be measured on a <u>weekly basis</u> during construction (includes pH, EC/TDS, TSS/Turbidity, DO) both upstream and downstream of the works.
q. In-stream flow is to be measured on an on-going basis by means of instruments and devices certified by the SABS, with a baseline measurement at least one week prior to initiation of the works.

r. One or more photographs or video-recordings must be taken of the watercourse and its banks at least 20m upstream and 20m downstream from the structure/works. These must be taken on a daily basis, starting one week before commencement of any works and continuing of one month upon completion.

Furthermore:

- Rehabilitation[4] authorised in terms of the GA (i.e. where risk is deemed "Low") must be conducted in terms of a rehabilitation plan, with implementation overseen by a suitably qualified SACNASP registered Pr.Sci.Nat.
- Upon completion of construction activities, a systematic rehabilitation programme must be undertaken to restore the watercourse to its condition prior to the commencement of the water use. All disturbed areas must be re-vegetated with indigenous vegetation suitable to the area.
- Active alien invasive plant control measures must be implemented to prevent invasion buy exotic and alien vegetation within the disturbed area.
- Upon completion of any works, during any annual inspection to determine the need for maintenance at any impeding or diverting structure, disturbed areas are to be cleared of construction debris/blockages, alien invasive vegetation, must be re-shaped to free-draining and non-erosive contours and r re-vegetated with indigenous vegetation suitable to the area.
- Upon completion of any works, the hydrological functionality and integrity of the watercourse (bed, banks, riparian habitat and aquatic biota) must be equivalent or exceed that which existed before commencing with the works.
- The water user must establish and implement monitoring programmes to measure the impact on resource quality to ensure water use remains within the parameters in terms of water quality and quantity (maintaining instream flow).
- Baseline monitoring to be undertaken to determine 'present day values' for water resource quality before commencement of water use.
- Upon completion of construction activities, an Environmental Rehabilitation structures must be inspected regularly for the accumulation of debris, blockages, instabilities and erosion with remedial and maintenance actions where required.
- Audit is to be undertaken annually for three years to ensure that the rehabilitation is stable.

[4] 'Rehabilitation' means the process of reinstating natural ecological driving forces within part or the whole of a degraded watercourse to recover former or desired ecosystem structure, function, biotic composition and associated ecosystem services.

10 CONCLUSION

The findings of the Specialist Freshwater Wetland and Aquatic Habitat Assessment undertaken by Eco-Pulse Environmental Consulting Services have been presented in this specialist report to inform the Basic Assessment and Water Use License Application (WULA) processes being undertaken by RHDHV on behalf of the KwaZulu-Natal Department of Transport (KZN DoT) who is planning to widen two existing bridges located on the Bedlane and Dango Rivers (both tributaries of the Mhlathuze River) associated with the upgrading of the Provincial P393 road (R24) between Eshowe and Melmoth towns, in the uMhlathuze Local Municipality, KwaZulu-Natal.

Wetlands and rivers assessed as being at moderate to high risk (i.e. that stand to be negatively affected by the development project) and which qualify as a Water Use in terms of Section21 of the National Water Act No. 36 of 1998, were subject to further detailed delineation and functional assessment in the field and included the following two (2) watercourses:

Water Resource Unit	HGM Type	Extent	PES	EIS	Location	GPS Coordinates
Bedlane River R01	Transitional River	N/A	C: fair	Low	Associated with the Bedlane River at the existing bridge site	28◦ 43' 17.30" S 31◦ 33' 18.44" E
Wetland W01	Channelled valley bottom (CVB) wetland	~7.8 ha	D: poor	Moderate	Associated with the Dango River at the existing bridge site	28◦ 43' 28.49" S 31◦ 34' 3.61" E

Section 21 (c) and (i) "non-consumptive" water use has been identified for both watercourses to be impacted by the proposed bridge widening:

NWA Section 21 Water Use	Relevant Activity
21 (c): *Impeding or diverting the flow of water in a watercourse*	Temporary impoundment/diversion of flows may be necessary to allow for construction to take place within the watercourse during bridge widening.
21 (i): *Altering the bed, banks, course or characteristics of a watercourse*	Widening of bridge piers and abutments will result in the alteration of channel banks upstream and downstream of the existing structure.

Possible activities, aspects (or stressors) and potential ecological risks identified for the P393 bridge widening project that could potentially manifest in impacts to the four drivers of wetland or river condition/functioning as defined by the DWS are likely to include the following (regarded as low risk activities in general):

- Permanent destruction/modification of aquatic habitat and vegetation due to bridge widening;
- General habitat disturbance leading to the colonisation of adjacent wetland /riparian habitat by alien plants, weeds and other undesirable plant species (post-construction); and

- The risk of reduced water quality and the knock-on effects on aquatic ecology (flora and fauna/biota) as a result of 'accidental' pollution during the construction-phase.

Due to the risk of activities and related stressors considered to be low, the project would essentially qualify for licensing under a General Authorisation (GA). The recent GA also includes a number of activities that are generally authorized for State Owned Companies (SOC's) and institutions that are then subject only to compliance with the conditions of the GA, which includes Provincial Department of Transport engaging in the "*maintenance of bridges over rivers, streams and wetlands and the new construction of bridges done according to the SANRAL Drainage Manual or similar norms and standards*."

The most significant ecological impact is likely to be associated with bridge widening during the construction phase, during which piers and abutments will be lengthened in both an upstream and downstream direction, resulting in the destruction of potential aquatic habitat beyond the existing bridge footprint. However, due to the small extent of the planned bridge widening and the already disturbed nature of the watercourses and habitat at each bridge crossing site, impact significance is likely to be moderately-low and generally acceptable from an aquatic environmental perspective. Other more indirect impacts are likely to be of low significance and can be easily mitigated on-site through a range of practical measures recommended in Section 8 of this report, with the principal recommendations including:

- Bridge design recommendations;
- Construction-phase impact mitigation measures;
- Operation-phase impact mitigation measures;
- Post-construction rehabilitation guidelines; and
- Ecological monitoring recommendations.

No protected tree or plant species were recorded within the portions of the wetland/river to be impacted by bridge widening, hence permits for protected plant rescue and translocation will not be required for this project.

Should you have any queries regarding the findings and recommendations in this Specialist Wetland Assessment report, please contact Eco-Pulse Consulting directly.

Yours faithfully,

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12 ANNEXURES

ANNEXURE A: Detailed Assessment Methods.

A1 Wetland delineation

The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' (DWAF, 2005). Three specific wetland indicators were used in the detailed field delineation of wetlands, which include:

- **Terrain unit indicator**

A practical index used for identifying those parts of the landscape where wetlands are likely to occur based on the general topography of the area.

- **Wetland vegetation indicator**

Vegetation in an untransformed state is a useful guide in finding the boundary of a wetland as plant communities generally undergo distinct changes in species composition as one proceeds along the wetness gradient from the centre of a wetland towards adjacent terrestrial areas. An example of criteria used to classify wetland vegetation and inform the delineation of wetland zones is provided in Table 23. A hydric status was allocated for each plant species sampled based on the field experience of the assessor and using available literature, including:

- *A practical field procedure for the identification and delineation of wetlands and riparian areas (DWAF, 2005);*
- *Easy identification of some South African Wetland Plants: Grasses, Resticios, Sedges, Rushes, Bulrushes, Eriocaulons and Yellow-eyed grasses (Van Ginkel et al., 2011);*
- *Guide to grasses of Southern Africa (Van Oudtshoorn, 2006);*
- *Field Guide to Trees of Southern Africa (Van Wyk & Van Wyk, 2007);*
- *Pooley, E., 2005. A field guide to Wildflowers of KZN and the Eastern Region (Pooley, 2005); and*
- *Problem Plants and Alien Weeds of South Africa (Bromilow, 2010).*

Table 23. Criteria used to inform the delineation of wetland habitat based on wetland vegetation (adapted from Macfarlane *et al.*, 2008 and DWAF, 2005).

Vegetation	Temporary wetness zone	Seasonal wetness zone	Permanent wetness zone
Herbaceous	Mixture of non-wetland species and hydrophilic plant species restricted to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Emergent plants including reeds and bulrushes; floating or submerged aquatic plants
Woody	Mixture of non-wetland and hydrophilic species restricted to wetland areas	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species restricted to wetland areas with morphological adaptations to prolonged wetness (e.g.: prop roots)
SYMBOL	**HYDRIC STATUS**	**DESCRIPTION/OCCURRENCE**	
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but	

Vegetation	Temporary wetness zone	Seasonal wetness zone	Permanent wetness zone
		occasionally found in non-wetland areas	
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas	
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)	
D	Dryland species	Almost always grow in drylands	

- **Soil wetness indicator**

According to the wetland definition used in the National Water Act (NWA, 1998), vegetation is the primary indicator which must be present under normal circumstances. However, in practice the soil wetness indicator (informed by investigating the top 50cm of wetland topsoil) tends to be the most important, and the other three indicators are used to refine the assessment. The reason for this is that vegetation responds relatively quickly to changes in soil moisture and may be transformed by local impacts; whereas the soil morphological indicators are far more permanent and will retain the signs of frequent saturation (wetland conditions) long after a wetland has been transformed/drained (DWAF, 2005). Thus the on-site assessment of wetland indicators focused largely on using soil wetness indicators, determined through soil sampling with a soil auger, with vegetation and topography being a secondary indicator. A Munsell Soil Colour Chart was used to ascertain soil colour values including hue, colour value and matrix chroma as well as degree of mottling in order to inform the identification of wetland (hydric) soils. Soil sampling points were recorded using a GPS (Global Positioning System) and captured using Geographical Information Systems (GIS) for further processing. An example of soil criteria used to assess the presence of wetland soils is provided below in Table 24 while Figure 10 provides a conceptual overview of soil and vegetation characteristics across the different wetness zones.

Table 24. Soil criteria used to inform wetland delineation using soil wetness as an indicator (after DWAF, 2005).

Soil depth	Temporary wetness zone	Seasonal wetness zone	Permanent wetness zone
0 – 10cm	**Matrix chroma**: 1- 3 (Grey matrix <10%) **Mottles**: Few/None high chroma mottles **Organic Matter**: Low **Sulphidic**: No	**Matrix chroma**: 0- 2 (Grey matrix >10%) **Mottles**: Many low chroma mottles **Organic Matter**: Medium **Sulphidic**: Seldom	**Matrix chroma**: 0- 1 (Prominent grey matrix) **Mottles**: Few/None high chroma mottles **Organic Matter**: High **Sulphidic**: Often
30 – 50cm	**Matrix chroma**: 0 – 2 **Mottles**: Few/Many	As Above	As Above

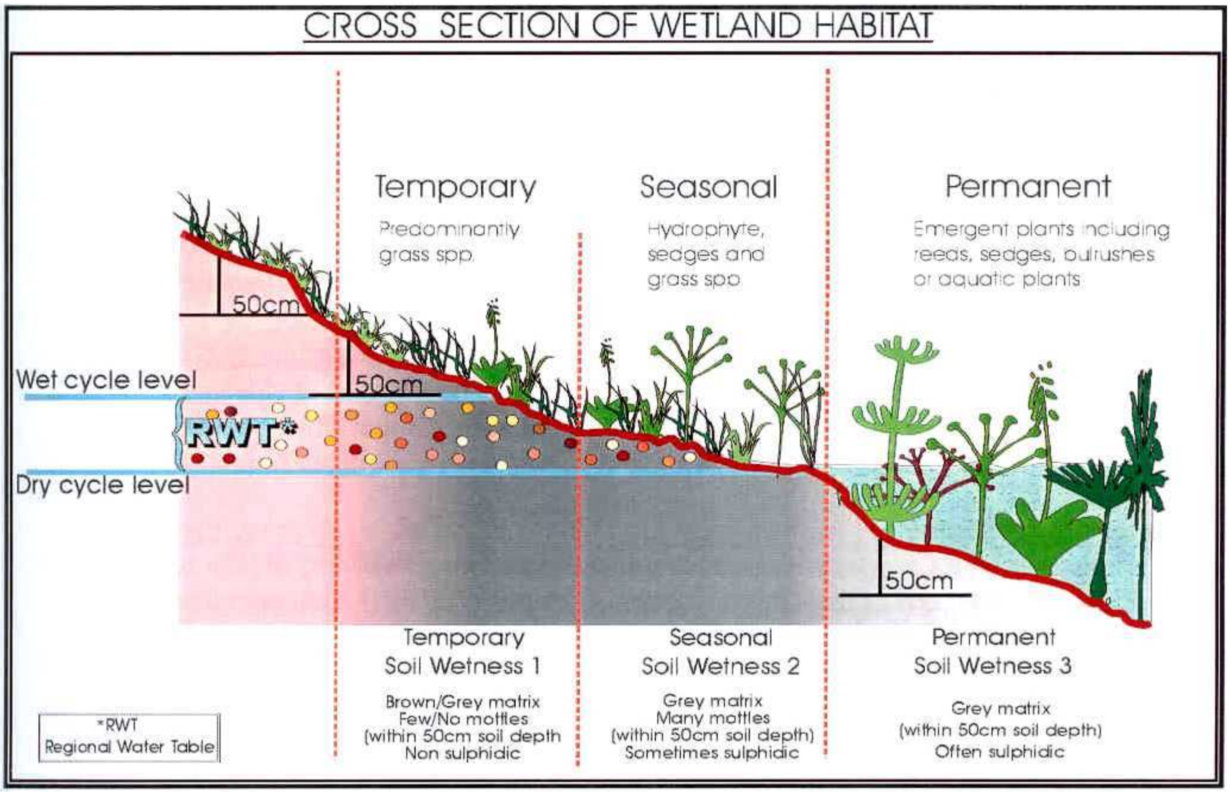


Figure 10 Diagram representing the different zones of wetness found within a wetland (DWAF, 2005).

- **Delineation of riparian areas**

The location of drainage features and boundary of any riparian areas (also known as the riparian zone) was delineated according to the methods in the Department of Water Affairs wetland delineation manual '*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas*' *(*DWAF, 2005). Like wetlands, riparian areas have their own unique set of indicators required in order to delineate these features. In the absence of typical wetland features, riparian area indicators were used instead to identify and delineate the edge of riparian areas, in accordance with the DWAF delineation manual, which included:

- **Alluvial soils and deposited material**: this includes relatively recently deposited sand, mud, etc. deposited by flowing water that can be used to confirm the topographical and vegetation indicators.
- **Channel morphology/topography associated with the watercourse**: the outer edge of the macro-channel bank associated with a river/stream provides a rough indication of the outer edge of a riparian area.
- **Vegetation composition & structure**: unlike the delineation of wetland areas where hydromorphic soils are the primary indicator, the delineation of riparian areas relies primarily on vegetation indicators. Using vegetation, the outer boundary of a riparian area must be adjacent to a watercourse and can be defined as the zone where a distinctive change occurs with respects to:

o Species composition relative to adjacent terrestrial areas; and

o Changes in the physical structure such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas (growth from refers to the health, compactness, crowding, size, structure and numbers of individual plants).

Note that the sole reliance on one indicator can be misleading (e.g. many species of plants can successfully grow both in and out of wet areas) and a combination of all three indicators should therefore be used to provide for a logical, defensible (higher level of confidence) and technical basis for riparian area delineation

A2 Classification of wetlands and rivers

For the purposes of this study, wetlands were classified according to HGM (hydro geomorphic) type (Level 4A classification level) using the National Wetland Classification System which was developed for the South African National Biodiversity Institute (Ollis *et al.*, 20013) as outlined in Table 25, below.

Table 25. Wetland classification (after Ollis *et al.*, 2013).

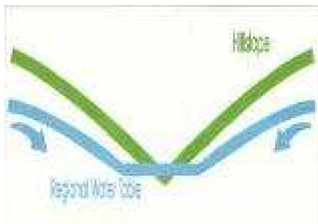
LEVEL 3	LEVEL 4A	
Landscape Setting	**HGM Type**	**Description**
SLOPE	Channel (river)	*Areas of channelled flow including rivers and streams where water is largely confined to a main channel during low flows. Flood waters may over top the banks of the channel and spread onto an adjacent floodplain*
	Hillslope seep	*Wetlands on slopes formed mainly by the discharge of sub-surface water.*
VALLEY FLOOR	Channel (river)	*River channels in a valley floor setting.*
	Channelled valley-bottom wetland	*Valley floors with one or more well-defined stream channels, but lacking characteristic floodplain features.*
	Unchannelled valley-bottom wetland	*Valley floors with no clearly defined stream channel.*
	Floodplain wetland	*Valley floors with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbows and natural levees.*
	Depression	*Basin-shaped areas that allow for the accumulation of surface water, an outlet may be absent (e.g. pans).*
	Valleyhead seep	*Seeps located at the head of a valley, often the source of streams.*
PLAIN	Channel (river)	*River channels in a plain landscape setting.*
	Floodplain wetland	*Floodplain wetlands as above but in a plain landscape setting.*
	Unchannelled valley-bottom wetland	*Unchannelled valley bottom type wetlands as above but in a plain landscape setting.*
	Depression	*Depression type wetlands as above but in a plain landscape setting.*
	Flat	*Extensive areas characterised by level, gently undulating or uniformly sloping land with a very gentle gradient.*
BENCH (HILLTOP / SADDLE / SHELF)	Depression	*Depression wetlands located on a bench.*
	Flat	*Flat wetlands located on a bench.*

River/stream channels were mapped in GIS using a combination of digital satellite imagery in conjunction with GPS points and data captured in the field. The classification of channels was based on the size of channels (Table 26) and the nature of flows through the channel (Table 27).

Table 26. Classification of channels according to channel size.

CHANNEL WIDTH	RESOURCE DESCRIPTION
>10 m	**Major Rivers**
2 – 10 m	**Rivers**
<2 m	**Streams**

Table 27. Classification of channels according to nature of flows.

	CHANNEL SECTION (CLASS)		
	"A" type	**"B" type**	**"C" type**
	Ephemeral systems	**Weakly ephemeral to seasonal systems**	**Perennial systems**
DESCRIPTION	A water-course that has no riparian habitat and no soil hydromorphy (ie. strongly ephemeral systems). Signs of wetness rarely persist in the soil profile	A water-course with riparian vegetation/habitat and intermittent base flow (ie. weakly ephemeral to non-perennial/seasonal systems). These channels show signs of wetness indicating the presence of water for significant periods of time.	A water-course with permanent-type riparian vegetation/habitat, permanent base flow and permanent inundation (ie. perennial systems).
HYDROLOGY	A-section channels are situated well above the zone of saturation (no direct contact between surface water system and ground water system) and hence do not carry base-flows . They do however carry storm water runoff following intense rainfall events (ephemeral), but this is generally short-lived.	Channel bed situated within the zone of the seasonally fluctuating regional water table (ie. intermittent base flow depending on water table). Periods of no flow may be experienced during dry periods, with residual pools often remaining within the channel.	Water course is situated within the zone of the permanent saturation, meaning flow is all year round except in the case of extreme drought.
TOPOGRAPHICAL POSITION	Valley head (upper reaches of catchments). Channel type also linked to steep slopes which are responsible for water leaving the system rapidly.	Mid-section of valley (middle reaches of catchments).	Valley bottom areas (middle to lower reaches of catchments).
DIAGRAM			

A3 WET-Health Assessment: Wetland Present Ecological State

The Level 1 (rapid) WET-Health tool (Macfarlane *et al*, 2008) provides an appropriate framework for assessing the baseline condition or PES (Present Ecological State) of wetland ecosystems that could be impacted by the proposed development. The assessment also helps to identify specific impacts thereby highlighting issues that should be addressed through mitigation and rehabilitation activities. While this is a rapid assessment, we regard it as adequate to inform an assessment of existing impacts on wetland condition. This approach relies on a combination of desktop and on-site indicators to assess various aspects of wetland condition, including:

- ***Hydrology***: defined as the distribution and movement of water through a wetland and its soils.
- ***Geomorphology***: defined as the distribution and retention patterns of sediment within the wetland.
- ***Vegetation***: defined as the vegetation structural and compositional state.

Each of these modules follows a broadly similar approach and is used to evaluate the extent to which anthropogenic changes have impacted upon wetland functioning or condition. While the impacts considered vary considerably across each module, a standardized scoring system is applied to facilitate the interpretation of results (Table 28). Scores range from 0 indicating no impact to a maximum of 10 which would imply that impacts had totally destroyed the functioning of a particular component. The reader is encouraged to refer back to the tables below to help interpret the results presented in the site assessment.

Table 28. Guideline for interpreting the magnitude of impacts on wetland integrity (after Macfarlane *et al.,* 2008).

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

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table 29, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table 29. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane *et al.*, 2008).

PES CATEGORY	DESCRIPTION	RANGE
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9
C	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9
D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9
E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9
F	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10

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

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

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

It should be noted that the rapid assessment tool that relies on qualitative information and expert judgment. The methodology is still being tested and will be refined in the near future.

A4 Riverine Present Ecological State (PES) – Index of Habitat Integrity (IHI)

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

The IHI (Index of Habitat Integrity)1996, version 2 (Kleynhans, 2012) was used to assess habitat integrity and is based on an interpretation of the deviation from the reference condition for the river reach assessed and is approached from both an instream and riparian zone perspective. Specification of the reference state is followed by an impact-based approach, whereby the extent and intensity of anthropogenic impacts are interrogated to interpret the level of modification to the primary drivers of river health, namely hydrology, geomorphology and physic-chemical conditions. Naturally, the severity of impacts on habitat integrity will vary according to the natural characteristics of different rivers, with particular river types being inherently more sensitive to certain types of impacts than others. The IHI assessment involved the assessment and rating of a range of criteria for instream and riparian habitat (see Box 2, below) scored individually (using an impact magnitude rating scale from 0-10) using Table 30 as a guide. This assessment is informed by a site visit to a specific section or reach of the river but is refined based on a desktop review of reach and catchment-scale impacts based on available aerial photography and land cover information.

Table 30. Rating table used to assess impacts to river systems.

Impact Class	Description	Score
A: Natural	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 - 0.9
B: Good	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 – 1.9
C: Fair	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	2 – 3.9
D: Poor	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	4 – 5.9
E: Seriously modified	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.	6 – 7.9
F: Critically modified	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.	8 - 10

Box 2. *Criteria assessed in the Index of Habitat Integrity* (after Kleynhans, 1996).

- ***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.
- ***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).
- ***Bed modification:*** This has a direct bearing on the amount and availability of substrate characteristics of available habitats. Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included.
- ***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.
- ***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. Any densification of woody exotic species would lead to channel shape change through increased sediment deposits. This has serious implications for more extensive bank over-topping during flood events with increased scouring along outer edges of the Dry Bank. It is the extremes, i.e. drought or very wet events, which are particularly crucial sensitive periods to be considered.
- ***Water quality:*** 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 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.
- ***Vegetation removal:*** Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river. Refers to physical removal for farming, firewood and overgrazing. Includes both exotic and indigenous vegetation.
- ***Exotic vegetation:*** Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone.
- ***Connectivity:*** Relates to changes that influence the movement of aquatic biota, both laterally onto adjacent floodplain areas and longitudinal movement upstream and downstream. These modifications can affect the life-history stage requirements and recolonization options for instream biota.

A5 Assessment of wetland functional importance: ecosystem goods and services

The effectiveness and importance of wetlands in providing ecosystem goods and services was rated using the WET-Ecoservices (Kotze *et al.*, 2009) tool, a method suited for assessing the functioning of South African wetlands. Common wetland ecosystem goods and services that were evaluated using WET-Ecoservices are described in Table 31, below.

Table 31. Descriptions of common wetland ecosystem goods and services (after Kotze *et al.*, 2009).

ECOSYSTEM SERVICE	Description
Flood Attenuation	*Refers to the effectiveness of wetlands at spreading out and slowing down storm flows and thereby reducing the severity of floods and associated impacts.*
Stream Flow Regulation	*Refers to the effectiveness of wetlands in sustaining flows in downstream areas during low-flow periods.*
Sediment Trapping	*Refers to the effectiveness of wetlands in trapping and retaining sediments from sources in the catchment.*
Nutrient & Toxicant Retention and Removal	*Refers to the effectiveness of wetlands in retaining, removing or destroying nutrients and toxicants such as nitrates, phosphates, salts, biocides and bacteria from inflowing sources, essentially providing a water purification benefit.*
Erosion Control	*Refers to the effectiveness of wetlands in controlling the loss of soil through erosion.*
Carbon Storage	*Refers to the ability of wetlands to act as carbon sinks by actively trapping and retaining carbon as soil organic matter.*
Biodiversity Maintenance	*Refers to the contribution of wetlands to maintaining biodiversity through providing natural habitat and maintaining natural ecological processes.*
Water Supply	*Refers to the ability of wetlands to provide a relatively clean supply of water for local people as well as animals.*
Harvestable Natural Resources	*Refers to the effectiveness of wetlands in providing a range of harvestable natural resources including firewood, material for construction, medicinal plants and grazing material for livestock.*
Cultivated Foods	*Refers to the ability of wetlands to provide suitable areas for cultivating crops and plants for use as food, fuel or building materials.*
Food for Livestock	*Refers to the ability of wetlands to provide suitable vegetation as food for livestock.*
Cultural significance	*Refers to the special cultural significance of wetlands for local communities.*
Tourism & Recreation	*Refers to the value placed on wetlands in terms of the tourism-related and recreational benefits provided.*
Education & Research	*Refers to the value of wetlands in terms of education and research opportunities, particularly concerning their strategic location in terms of catchment hydrology.*

The level of predicted importance of ecosystem services provided by wetlands was rated according to the rating table found in Table 32, below. This was informed by wetland characteristics that affect the ability of wetlands to supply benefits and local and catchment context that affects the demand placed on wetlands to provide goods and services.

Table 32. Rating table used to rate level of ecosystem supply.

Rating	Importance or level of supply of ecosystem services
Low	The wetland is not considered to be important for providing this service/benefit.
Moderately-Low	The importance of the wetland in providing ecosystem goods and services is regarded as moderately low.

Moderate	The wetland is considered important for providing this particular ecosystem service to a moderate degree.
Moderately-High	The wetland is considered important for providing this particular ecosystem service to a high degree.
High	The wetland is considered very important for providing this particular ecosystem service to a high degree.

The WET-Ecoservices tool has however been updated by Eco-Pulse Environmental Consulting Services to provide a more robust assessment of the importance value of different wetland functions. This involved separately scoring demand for and supply of each function considered and then integrating these scores into a composite importance score. The level of predicted importance of ecosystem services provided by wetlands was classified according to the rating table found in Table 33, below. This was informed by wetland characteristics that affect the ability of wetlands to supply benefits and local and catchment context that affects the demand placed on wetlands to provide goods and services.

Table 33. Rating table used to rate the importance of ecosystem goods and services based on joint consideration of supply and demand (mid-points of classes used here for illustrative purposes).

	Demand				
Supply	**Low**	**Moderately-Low**	**Moderate**	**Moderately-High**	**High**
Low	Low	Low	Low	Low	Moderately-Low
Moderately-Low	Low	Moderately-Low	Moderately-Low	Moderately-Low	Moderate
Moderate	Low	Moderately-Low	Moderate	Moderate	Moderately-High
Moderately-High	Low	Moderately-Low	Moderate	Moderately-High	High
High	Moderately-Low	Moderate	Moderately-High	High	High

A6 Wetland Ecological Importance and Sensitivity (EIS)

The outcomes of the WET-Health and WET-Ecoservices functional assessment were used to inform an assessment of the importance and sensitivity of wetland systems using a Wetland EIS (Ecological Importance and Sensitivity) assessment tool developed by Eco-Pulse Consulting (2015). The Eco-Pulse Wetland EIS tool includes an assessment of the following components:

- Biodiversity support;
- Landscape scale importance;
- Functional importance (hydrological and direct benefits); and
- Sensitivity of the wetland to flow modification, sediment/erosion and water quality changes.

The maximum score for these components was taken as the importance rating for the wetland which is rated using Table 34, below.

Table 34. Rating table used to rate EIS (Eco-Pulse, 2015).

Rating	**Explanation**
Very Low/None, Rating: 0 – 0.5	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play a limited functional role in the landscape.
Low,	

Rating	Explanation
Rating: 0.6 – 1.5	
Moderate, Rating: 1.6 -2.7	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small functional role in the landscape.
High, Rating: 2.8 – 3.5	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They generally play a large functional role in the landscape.
Very high, Rating: >3.5	Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They generally play a major functional role in the landscape.

A7 River Ecological Importance and Sensitivity (EIS) Assessment

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 local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007). For the purposes of this assessment, the EIS assessment for riparian areas was based on rating the following criteria using the scheme in Table 35:

- **Riparian & in-stream biota**: referring to the presence and status of biota (*including fauna & flora).* This includes aspects of species richness/diversity, the presence of rare/endangered species, unique species/endemics, species that are sensitive to changes in flows/water quality.
- **Riparian & in-stream habitat:** including the diversity of habitat types within the in-stream and riparian zones, the sensitivity of habitats to changes in flow/water quality and the importance of riparian areas as migration routes/ecological corridors as well as the conservation importance of areas.

Table 35. Rating scheme used to rate EIS for riparian areas.

CRITERIA	RATING SCORE				
	0	1	2	3	4
Presence of rare/endangered species **Presence of unique/endemic species** **Presence of species considered intolerant/sensitive to changes in flows/water quality**	None	Low	Moderate	High	Very High
Diversity of habitat types **Presence of refugia/Refuge value of habitat types** **Habitat sensitivity to changes in flow** **Habitat sensitivity to changes in water quality** **Importance in terms of migration routes/ecological corridors**	Very Low	Low	Moderate	High	Very High
Conservation importance	None	Low (Local level)	Moderate (Provincial level)	High (National level)	Very High (National/ International level)

The scores assigned to the criteria in Table 35 were used to rate the overall EIS of each mapped unit according to Table 36, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane *et al*., 2008).

Table 36. EIS classes used to inform the assessment (after Kleynhans & Louw, 2007).

EIS Score	EIS Rating	General Description
0	None/ Negligible	Features that are highly transformed and have no ecological importance at any scale. Such features have a very low sensitivity to anthropogenic disturbances.
1	Very Low	Features are not ecologically important and sensitive at any scale. The biodiversity of these areas is typically ubiquitous with low sensitivity to anthropogenic disturbances and play an insignificant role in providing ecological services.
2	Low	Features regarded as somewhat ecologically important and sensitive at a local scale. The functioning and/or biodiversity features have a low-medium sensitivity to anthropogenic disturbances. They typically play a very small role in providing ecological services at the local scale.
3	Medium	Features that are considered to be ecologically important and sensitive at a local scale. The functioning and/or biodiversity of these features is not usually sensitive to anthropogenic disturbances. They typically play a small role in providing ecological services at the local scale.
4	High	Features that are considered to be ecologically important and sensitive at a regional scale. The functioning and/or biodiversity of these features are typically moderately sensitive to anthropogenic disturbances. They typically play an important role in providing ecological services at the local scale.
5	Very High	Features that are considered ecologically important and sensitive on a national or even international level. The functioning and/or biodiversity of these features are usually very sensitive to anthropogenic disturbances. This includes areas that play a major role in providing goods and services at a local or regional level.

A8 Impact significance assessment

Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact (or resource being affected), and the likelihood / probability of the impact occurring. In light of this understanding, significance can only be assessed if one knows the importance or value of the environmental change/impact. Thus, end point or eventual impacts that can be valued like impacts to water resources, ecosystem services and biodiversity conservation can only be assessed in terms of significance and are referred to as ultimate consequences of an activity or a suite of impacts. Put another way, the significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed.

For the purposes of this assessment, the assessment of potential impacts was undertaken using an "Impact Assessment Methodology for EIAs" adopted by Eco-Pulse (2015). This assessment was informed by baseline aquatic information contained in this report relating to the sensitivity of habitats and potential occurrence of protected species as well as information on the proposed development provided by the client and experience in similar projects in South Africa. The approach adopted is to identify and predict all potential primary and secondary/indirect impacts resulting from an activity from origin (e.g. catchment land hardening) to end point (e.g. loss of ecosystem services as a result of erosion). Thereafter, the approach is to rate intensity as the realistic worst case consequence (end-point / ultimate) of an activity (according to Table 37, below) and then assess the likelihood of this consequence occurring as well as the extent and duration of the impact.

Impact significance = (impact intensity + impact extent + impact duration) x impact likelihood.

This formula is based on the basic risk formula: **Risk = consequence x probability**

Table 37. Criteria and numerical values for rating environmental impacts.

Score	Rating	Description
Intensity (I) – defines the magnitude and importance of the impact		
16	**High**	Loss of human life. Deterioration in human health. High impacts to water resources: · Critical / severe local scale (or larger) ecosystem modification/degradation and/or collapse. · Critical / severe local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. <u>Critical / severe ecosystem impact description:</u> Impact affects the continued viability of the systems/components and the quality, use, integrity and functionality of the systems/components permanently ceases and are irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible, rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation. · Extinction of habitat type or serious impact to future viability of a critically endangered habitat type. · Extinction of species or serious impact to survival of critically endangered species.
8	**Moderately-High**	· Loss of livelihoods. · Individual economic loss. Moderately-high impacts to water resources: · Large local scale (or larger) ecosystem modification/degradation and/or collapse. · Large local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. <u>Large ecosystem impact description:</u> Impact affects the continued viability of the systems/components and the quality, use, integrity and functionality of the systems/components are severely impaired and may temporarily cease. High costs of rehabilitation and remediation, but possible. · Measurable reduction in extent of endangered and critically endangered habitat types. · Measurable reduction in endangered and critically endangered floral and faunal populations.
4	**Moderate**	Moderate impacts to water resources: · Moderate local scale (or larger) ecosystem modification/degradation and/or collapse. · Moderate local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. <u>Moderate ecosystem impact description:</u> Impact alters the quality, use and integrity of the systems/components but the systems/ components still continue to function but in a moderately modified way (integrity and functionality impaired but major key processes/drivers somewhat intact / maintained). · Measurable reduction in vulnerable habitat types. · Measurable reduction in non-threatened habitat types resulting in an up-listing to threatened status. · Measurable reduction in near-threatened and vulnerable floral and faunal populations. · Measurable reduction in non-threatened floral and faunal populations resulting in an up-listing to threatened status.

Score	Rating	Description
2	**Moderately-Low**	Moderately-low impacts to water resources: · Small but measurable local scale (or larger) ecosystem modification / degradation. · Small but measurable local scale (or larger) modification (reduction in level) of ecosystem services and/or loss of ecosystem services. Small ecosystem impact description: Impact alters the quality, use and integrity of the systems/components but the systems/ components still continue to function, although in a slightly modified way. Integrity, function and major key processes/drivers are slightly altered but are still intact / maintained. · Reduction in non-threatened endangered habitat types with no up-listing to threatened status. · Reduction in non-threatened floral and faunal populations with no up-listing to threatened status.
1	**Low**	Negative change to onsite characteristics but with no impact on: · Human life · Human health · Local water resources, local ecosystem services and/or key ecosystem controlling variables · Threatened habitat conservation/representation · Threatened species survival
Extent (E) – relates to the extent of the Impact Intensity		
5	**Global**	The scale/extent of the impact is global/worldwide.
4	**National**	The scale/extent of the impact is applicable to the Republic of South Africa
3	**Regional**	Impact footprint includes the greater surrounding area within which the site is located (e.g. between 20-200km radius of the site).
2	**Local**	Impact footprint extends beyond the cadastral boundary of the site to include the areas adjacent and immediately surrounding the site (e.g. between a 0-20km radius of the site).
1	**Site**	Impact footprint remains within the cadastral boundary of the site.
Duration (D) – relates to the duration of the Impact Intensity		
5	**Permanent**	The impact will continue indefinitely and is irreversible.
4	**Long-term**	The impact and its effects will continue for a period in excess of 30 years. However, the impact is reversible with relevant and applicable mitigation and management actions.
3	**Medium-term**	The impact and its effects will last for 10-30 years. The impact is reversible with relevant and applicable mitigation and management actions.
2	**Medium-short**	The impact and its effects will continue or last for the period of a relatively long construction period and/or a limited recovery time after this construction period, thereafter it will be entirely negated (3 – 10 years). The impact is fully reversible.
1	**Short-term**	The impact and its effects will only last for as long as the construction period and will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 3 years). The impact is fully reversible.
Probability (P) – relates to the likelihood of the Impact Intensity		
1	**Definite**	More than 75% chance of occurrence. The impact is known to occur regularly under similar conditions and settings.
0.75	**Highly Probable**	The impact has a 41-75% chance of occurring and thus is likely to occur. The impact is known to occur sporadically in similar conditions and settings.
0.5	**Possible**	The impact has a 10-40% chance of occurring. This impact may/could occur and is known to occur in low frequencies under the similar conditions and settings.
0.2	**Unlikely**	The possibility of the impact occurring is low with less than 10% chance of occurring. The impact has not been known to occur under similar conditions and settings.
0.1	**Improbable**	The possibility of the impact occurring is negligible and only under exceptional circumstances.

Table 38. Impact significance categories and definitions.

Impact Significance	Impact Significance Score Range	Definition
High	**18 - 26**	Unacceptable and fatally flawed. Impact should be avoided and limited opportunity for offset/compensatory mitigation. The proposed activity should only

		be approved under special circumstances.
Moderately High	**13 – 17.9**	Generally unacceptable unless offset/compensated for by positive gains in other aspects of the environment that are of critically high importance (i.e. national or international importance only). Strict conditions and high levels of compliance and enforcement are required. The potential impact will affect a decision regarding the proposed activity require that the need and desirability for the project be clearly substantiated to justify the associated ecological risks.
Moderate	**8 – 12.9**	Impact has potential to be significant but is acceptable provided that there are strict conditions and high levels of compliance and enforcement. If there is reasonable doubt as to the successful implementation of the strict mitigation measures, the impact should be considered unacceptable. The potential impact should influence the decision regarding the proposed activity and requires a clear and substantiated need and desirability for the project to justify the risks.
Moderately Low	**5 – 7.9**	Acceptable with moderately-low to moderate risks provided that specific/generic mitigation applied and routine inspections undertaken. The potential impact may not have any meaningful influence on the decision regarding the proposed activity.
Low	**0 – 4.9**	The potential impact is very small or insignificant and should not have any meaningful influence on the decision regarding the proposed activity. Basic duty of care must be ensured.

A confidence rating was also given to the impacts rated in accordance with the table below:

Table 39. Confidence ratings used when assigning impact significance ratings.

Level of confidence	Contributing factors affecting confidence
Low	A low confidence level is attributed to a low-moderate level of available project information and somewhat limited data and/or understanding of the receiving environment.
Medium	The confidence level is medium, being based on specialist understanding and previous experience of the likelihood of impacts in the context of the development project with a relatively large amount of available project information and data related to the receiving environment.
High	The confidence level is high, being based on quantifiable information gathered in the field.

ANNEXURE B: Review of applicable environmental legislation.

Relevant environmental legislation pertaining to the protection and use of aquatic ecosystems (i.e. wetlands and rivers) in South Africa:

South African Constitution 108 of 1996	This includes the right to have the environment protected through legislative or other means.
National Environmental Management Act 107 of 1998	This is a fundamentally important piece of legislation and effectively promotes sustainable development and entrenches principles such as the 'precautionary approach', 'polluter pays', and requires responsibility for impacts to be taken throughout the life cycle of a project.
Environmental Impact Assessment (EIA) Regulations	New regulations have been promulgated in terms of Chapter 5 of NEMA and were published on 4 December 2014 in Government Notice No. R. 32828. In addition, listing notices (GN 983-985) lists activities which are subject to an environmental assessment.
The National Water Act 36 of 1998	This Act imposes 'duty of care' on all landowners, to ensure that water resources are not polluted. The following Clause in terms of the National Water Act is applicable in this case: **19 (1)** "*An owner of land, a person in control of land or a person who occupies or uses the land on which (a) any activity or process is or was performed or undertaken; which causes, has caused or likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring*" Chapter 4 of the National Water Act is of particular relevance to wetlands and addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use water. Water use is defined very broadly in the Act and effectively requires that any activities with a potential impact on wetlands (within a distance of 500m upstream or downstream of a wetland) be authorized.
General Authorisations (GAs)	These have been promulgated under the National Water Act and were published under GNR 398 of 26 March 2004. Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a license which should be obtained from the Department of Water and Sanitation (DWS).
National Environmental Management: Biodiversity Act No. 10 of 2004	The intention of this Act is to protect species and ecosystems and promote the sustainable use of indigenous biological resources. It addresses aspects such as protection of threatened ecosystems and imposes a duty of care relating to listed invasive alien plants.
Conservation of Agricultural Resources Act 43 of 1967	The intention of this Act is to control the over-utilization of South Africa's natural agricultural resources, and to promote the conservation of soil and water resources and natural vegetation. This includes wetland systems and requires authorizations to be obtained for a range of impacts associated with cultivation of wetland areas.

Other pieces of legislation that may also be of some relevance include:

- The National Forests Act No. 84 of 1998;
- The Natural Heritage Resources Act No. 25 of 1999;
- The National Environmental Management: Protected Areas Act No. 57 of 2003;
- Minerals and Petroleum Resources Development Act No. 28 of 2002;
- Nature and Environmental Conservation Ordinance No. 19 of 1974; and
- The Mountain Catchments Areas Act No. 62 of 1970.

ANNEXURE C: Impact significance assessment results summary.

Impact Significance Assessment: Construction Phase								
IMPACT SIGNIFICANCE: 'Poor" Mitigation Scenario								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Physical destruction and/or modification of aquatic habitat**	Negative	Site	Moderate	Permanent	Definite	**Moderately-Low**	High
2	**Flow modification and erosion/sedimentation impacts**	Negative	Surrounding Area	Moderate	Medium-term	Highly Probable	**Moderately-Low**	Medium
3	**Water quality impacts**	Negative	Surrounding Area	Moderately-Low	Long-term	Possible	**Low**	Medium
IMPACT SIGNIFICANCE: 'Best Practical' Mitigation Scenario								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Physical destruction and/or modification of aquatic habitat**	Negative	Site	Moderate	Permanent	Definite	**Moderately-Low**	High
2	**Flow modification and erosion/sedimentation impacts**	Negative	Surrounding Area	Moderate	Short-term	Possible	**Low**	Medium
3	**Water quality impacts**	Negative	Surrounding Area	Moderately-Low	Short-term	Unlikely	**Low**	Medium

Impact Significance Assessment: Operational Phase								
IMPACT SIGNIFICANCE: 'Poor" Mitigation Scenario								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Physical destruction and/or modification of aquatic habitat**	Negative	Surrounding Area	Moderate	Long-term	Highly Probable	**Moderately-Low**	Medium
2	**Flow modification and erosion/sedimentation impacts**	Negative	Surrounding Area	Moderate	Medium-term	Probable	**Low**	Medium
3	**Water quality impacts**	Negative	Surrounding Area	Moderately-Low	Long-term	Possible	**Low**	Medium
IMPACT SIGNIFICANCE: 'Best Practical' Mitigation Scenario								
No.	**IMPACT**	**Status**	**Extent**	**Intensity**	**Duration**	**Probability**	**Significance**	**Confidence**
1	**Physical destruction and/or modification of aquatic habitat**	Negative	Site	Moderate	Medium-term	Probable	**Low**	Medium
2	**Flow modification and erosion/sedimentation impacts**	Negative	Surrounding Area	Moderate	Long-term	Possible	**Low**	Medium
3	**Water quality impacts**	Negative	Surrounding Area	Moderately-Low	Long-term	Possible	**Low**	Medium

ANNEXURE D: Aquatic Risk Assessment Matrix for Section 21 c & i water use licensing.

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I Water Use Risk Assessment Protocol)

Project Name: P393 Bridges Widening

Date: 28-Jun-17 Version 1.3

Name of Assessors: Mr. Adam Teixeira-Leite (Pr.Sci.Nat.) **SACNASP Registration No.** 400332/13

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

Phase(s)	Activity	Aspect	Impact	Flow Regime	Physico & chemical (water Quality)	Habitat (Geomogh & Vegetation)	Biota	Severity	Spatial Scale	Duration	Consequence	Frequency of Activity	Frequency of Impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control measures	Revised Risk Rating	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
Construction	**Demolition and widening of existing bridge structure**	**Site clearing and disturbance of habitat and vegetation**	Direct impacts to river/wetland habitat, vegetation and soils, potentially leading to changes in vegetation composition, structure and habitat for biota as well as the fragmentation of habitat.	1	2	3	1	**1.75**	1	2	**4.75**	1	5	5	1	**12**	**57**	**Moderate**	80 %	Onsite BMPs, post-construction rehabilitation	32	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low
		Temporary impoundment / flow diversion to create a "dry" working area	Temporarily impeding/diverting the flow of water during construction, alteration of natural flow patterns and soil saturation rates,	2	1	1	2	**1.5**	2	1	**4.5**	1	4	5	1	**11**	**49.5**	**Low**	70 %	Method Statement for flow diversions, onsite BMPs	24.5	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS

Phase(s)	Activity	Aspect	Impact	Flow Regime	Physico & chemical (water Quality)	Habitat (Geomogh & Vegetation)	Biota	Severity	Spatial Scale	Duration	Consequence	Frequency of Activity	Frequency of Impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence Level	Control measures	Revised Risk Rating	Borderline LOW / MODERATE Rating Classes	PES & EIS of Affected Watercourse
			scouring and erosion due to redirection of flows.																				= Low
		Potential contaminants from construction activities	Water pollution impacts, with resultant consequences for aquatic vegetation and biota.	1	3	1	2	**1.75**	2	2	**5.75**	1	2	5	1	**9**	**51.75**	**Low**	70 %	Onsite BMPs	26.75	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low
Operation	**Operation of the bridge upgrade**	**General habitat disturbance of adjacent areas**	Leading to the colonisation of adjacent wetland habitat by alien plants, weeds and other undesirable plant species affecting habitat integrity and species diversity.	1	1	2	2	**1.5**	1	2	**4.5**	2	3	5	2	**12**	**54**	**Low**	70 %	Post-construction IAP monitoring and clearing	29	**Low**	Wetland W01: PES = D ; EIS = Moderate River R01: PES = C ; EIS = Low