Client

City of Cape Town (Bulk Water)

AQUATIC ECOSYSTEM ASSESSMENT FOR THE EXISTING ATLANTIS WATER RESOURCE MANAGEMENT SCHEME (AWRMS) INFRASTRUCTURE

INPUT INTO A MAINTENANCE MANAGEMENT PLAN

DRAFT REPORT

May 2025

Submitted to:

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Table of Contents

DECLARATION OF SPECIALIST INDEPENDENCE

I, Philip Frenzel, as a junior aquatic ecologist at Freshwater Consulting cc and primary author of this report, hereby confirm my independence as a specialist and declare that I do not have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for work performed, specifically in connection with the assessment of the area potentially affected by the proposed maintenance activities associated with the existing Atlantis Water Resource Management Scheme within the City of Cape Town.

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STATEMENT OF COMPETENCE

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Experience in study area: Freshwater specialist on a number of assessments across City of Cape Town, including mapping and delineation as well as assessment of impacts, ecological condition and importance of wetlands and rivers.

SACNASP details: Registered Professional Natural Scientist (Reg No 123620) in the field of Ecological Science

A short CV is provided in Section 10 (Appendix A).

DECLARATION OF SPECIALIST INDEPENDENCE

I, Kate Snaddon, as a senior aquatic ecologist at Freshwater Consulting cc and reviewer of this report, hereby confirm my independence as a specialist and declare that I do not have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for work performed, specifically in connection with the assessment of the area potentially affected by the proposed maintenance activities associated with the existing Atlantis Water Resource Management Scheme within the City of Cape Town.

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STATEMENT OF COMPETENCE

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Position: Member and freshwater specialist at Freshwater Consulting cc

Qualification(s): BSc, BSc Hons, BSc Masters in Zoology

Experience: 26 years in freshwater ecosystems

Experience in study area: Freshwater specialist on a number of assessments across City of Cape Town, including mapping and delineation as well as assessment of impacts, ecological condition and importance of wetlands and rivers.

SACNASP details: Registered Professional Natural Scientist (Reg No 400225/06) for Ecological Science

A short CV is provided in Section 10 (Appendix A).

1 INTRODUCTION

1.1 Background

The City of Cape Town has implemented its New Water Programme (NWP) in an effort to diversify and expand Cape Town's water supply sources to meet the growing water demands of an increasing population. Various water augmentation projects (e.g., sea water desalinisation, water re-use, and ground water abstraction) fall under the New Water Programme – one of which includes upgrading of the Atlantis Water Resource Management Scheme (AWRMS). The AWRMS is a managed aquifer recharge scheme where treated wastewater and storm water is diverted to large basins where it infiltrates into a sandy aquifer, whereafter it is abstracted and reused for municipal supply of water (DWS, 2010).

Construction of the AWRMS was completed by 1979. In short, this scheme consists of basins which allow for the infiltration of stormwater, and treated wastewater to recharge the sandy Atlantis aquifer, which acts as an underground water reservoir. A portion of the water is diverted towards coastal recharge basins, which maintain a high-water table along the coast to prevent the intrusion of sea water into the aquifer. Water from the aquifer is abstracted from boreholes in the Witzand and Silwerstroom wellfields and is pumped to a water treatment plant before being distributed into the municipal supply system. The basins, wellfields and water treatment plants are currently in the process of being repaired and upgraded in order to further augment the water supply within the region.

Given the proximity of the proposed maintenance activities to a number of inland aquatic ecosystems, some of the proposed maintenance activities will constitute Section 21 (c) and (i) 'water uses' in terms of Section 39 of the National Water Act (1998), Act 36 of 1998, thus requiring Water Use Authorisation (WUA) from the Department of Water and Sanitation (DWS) and requiring specialist input from a freshwater ecologist. Freshwater Consulting cc was contracted by Zutari (Pty) Ltd to undertake an assessment of the potential impacts and risks to inland aquatic ecosystems associated with maintenance activities of the existing AWRMS infrastructure as input to a Maintenance Management Plan (MMP), developed by Zutari (Pty) Ltd, for submission to Department of Forestry, Fisheries and the Environment (DFFE).

1.2 Terms of Reference

Specifically, Freshwater Consulting was contracted to:

- Undertake a desktop assessment of historic and current aerial imagery of the study area, to determine the presence and extent of any wetlands/rivers potentially impacted by maintenance activities associated with the AWRMS.
- Undertake a site visit to verify and delineate the extent of any affected inland aquatic ecosystems, and to classify and assess their condition and ecological importance and sensitivity.

- Identify, predict and describe potential impacts on the affected inland aquatic ecosystems based on the proposed maintenance activities.
- Identify and describe mitigation measures to minimise negative impacts, including recommendations for rehabilitation to restore disturbed habitats, if applicable.
- Undertake an assessment of risks to inland aquatic ecosystems based on the Risk Assessment Matrix (RAM) in accordance with GN 4167 December 2023 for identifying and assessing the level of risk to inland aquatic ecosystems of water uses as defined in Section 21 (c) and (i) of the National Water Act (NWA) subject to General Authorisations (GA).
- Compile an Aquatic Ecosystem Assessment report for input into the development of a Maintenance Management Plan with recommendations for mitigating impacts during maintenance activities.

The following approach was followed to meet these Terms of Reference:

- A desktop assessment of spatial information within and around the study area. In particular, information contained in the latest spatial biodiversity plans for the region was sourced, including the National Freshwater Ecosystem Priority Area (NFEPA), National Biodiversity Assessment (NBA) and the Western Cape Biodiversity Spatial Plan (Pool-Stanvliet *et al.* 2017), as a basis for understanding conservation status and associated management guidelines.
- Perusal of available historic and current aerial imagery supplied by Google Earth, City of Cape Town imagery and the National Geo-spatial Information (NGI) database.
- A three-day site visit on 1, 2 and 11 October 2024 (spring) and an additional one-day trip on 21 February 2025 (summer) to:
  - Verify the presence and extent of rivers and wetlands in terms of the Department of Water and Sanitation's (DWAF 2008) Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas.
  - Classify identified inland aquatic ecosystems in accordance with the 'National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al.* 2013).
  - Assess Present Ecological State (PES), and ecological importance and sensitivity (EIS) of identified and delineated inland aquatic ecosystems using national protocols.
- Assess landscape and topographical features to inform the determination of suitable ecological buffers based on the use of the Buffer Zone Guidelines for Rivers, Wetlands and Estuaries (MacFarlane and Bredin 2017).
- Describe and assess the impacts associated with the proposed maintenance activities.
- Identify mitigation and recommend management measures to reduce the severity of the negative impacts and enhance any positive impacts.
- Undertake an assessment of residual risks to inland aquatic ecosystems by completing the Risk Assessment Matrix (RAM) in accordance with GN 4167 December 2023 for identifying and assessing the level of risk to inland aquatic ecosystems of water uses as defined in Section 21 (c) and (i) of the National Water Act (NWA).
- Provide input into Method Statements (where relevant and required)

- Compile an Aquatic Ecosystem Assessment report detailing the above, and advising on the type of water use authorisation required.

1.3 Definition of inland aquatic ecosystems

All reference to wetlands and watercourses in this document is based on the following definitions of wetlands and water courses, as stipulated in the National Water Act (NWA) (Act 36 of 1998):

“watercourse'' *means -*

(a) a river or spring;

(b) a natural channel in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be watercourse, and a reference to a watercourse includes, where relevant, its bed and banks;

“wetland'' *means -*

land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Essentially, this means that wetlands are areas where water is the primary driving force. Therefore, wetlands develop in areas where water is present for prolonged periods of time but soils are saturated or inundated with water for varying lengths of time and at different frequencies.

“Riparian habitat” *means -*

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 (see Figure 1.1).

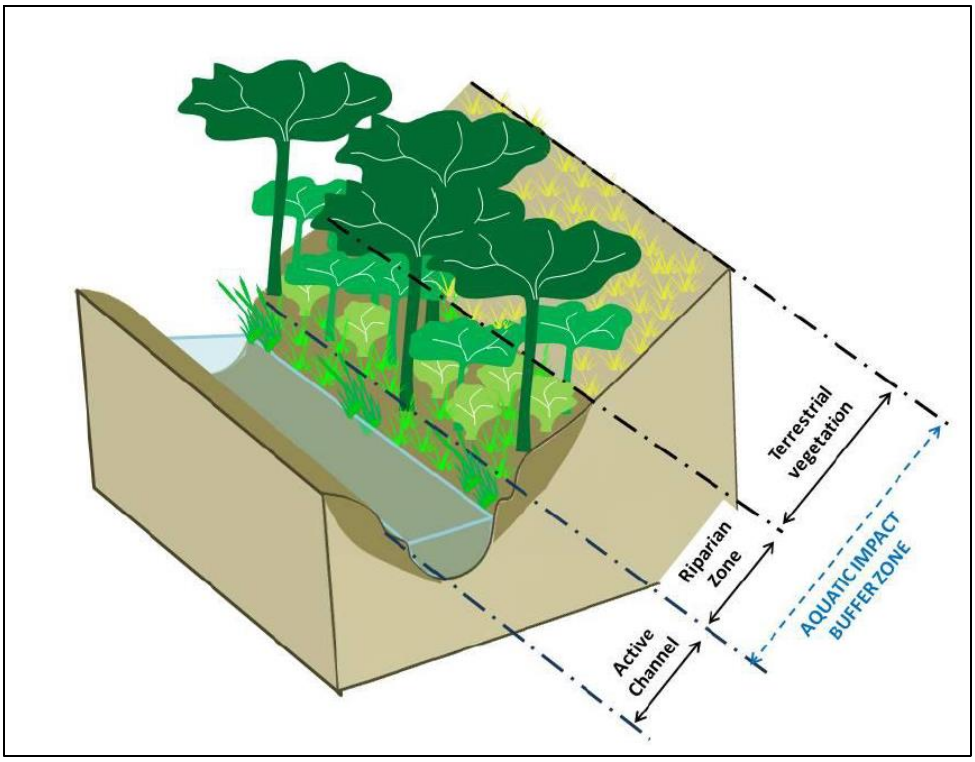

Figure 1.1: Schematic diagram indicating the boundary of active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone (MacFarlane and Bredin, 2017). The buffer (measured from the edge of the active channel) protecting watercourse must include the riparian zone, and can extend into terrestrial vegetation.

1.4 Assumptions and limitations of the assessment

Mapping was done with a hand-held GPS in order to save time and costs. Accuracy is estimated as being approximately 2-3m. Delineation of wetlands and riparian areas was done using the indicators described in the DWAF (2008) guidelines for delineation. No primary data (such as macroinvertebrates and water quality) were collected from inland aquatic ecosystems found on site. The infrastructure that was included as part of this assessment is outlined in Section 3.1. Considering that some of these pipelines were constructed more than 40 years ago, the exact placement of all pipeline routes within the map is not entirely accurate. Thus, as a safety precaution, when identifying which inland aquatic ecosystems may potentially be impacted by the proposed maintenance activities, it is assumed that the actual pipelines in the ground may be within 15m on either side of the mapped pipeline routes.

1.5 Use of this Report

This report reflects the professional opinion of its author. It is the policy of Freshwater Consulting that the full and unedited contents of this report should be presented to the client, and that any summary of the findings should only be produced in consultation with the author.

1.6 Declaration of Independence

This is to confirm that **Philip Frenzel** and **Kate Snaddon**, the specialist consultants who are responsible for undertaking this study and preparing this report, are independent, and have no vested interests, financial or otherwise, in the activities under consideration.

1.7 Specialist Details

Philip Frenzel, the author of this report, is an independent specialist consultant with 6 years of experience in the field of freshwater ecology. Kate Snaddon, the reviewer of this report, is also an independent freshwater specialist with 26 years of experience in the field. Both specialist consultants are registered as professional scientists (Pr Sci Nat) with the South African Council for Natural Scientific Professions (registration numbers: 123620 [PF] and 400225/06 [KS]).

1.8 Study area

The study area in which the Atlantis Water Resource Management Scheme (AWRMS) infrastructure spans across three quaternary catchments (i.e. G21B, G21A and G21D), with the vast majority falling within the G21B quaternary catchment. The AWRMS infrastructure spans from Melkbosstrand in the south, Silwerstroom in the west, Mamre in the north and Atlantis in the east (Figure 1.2).

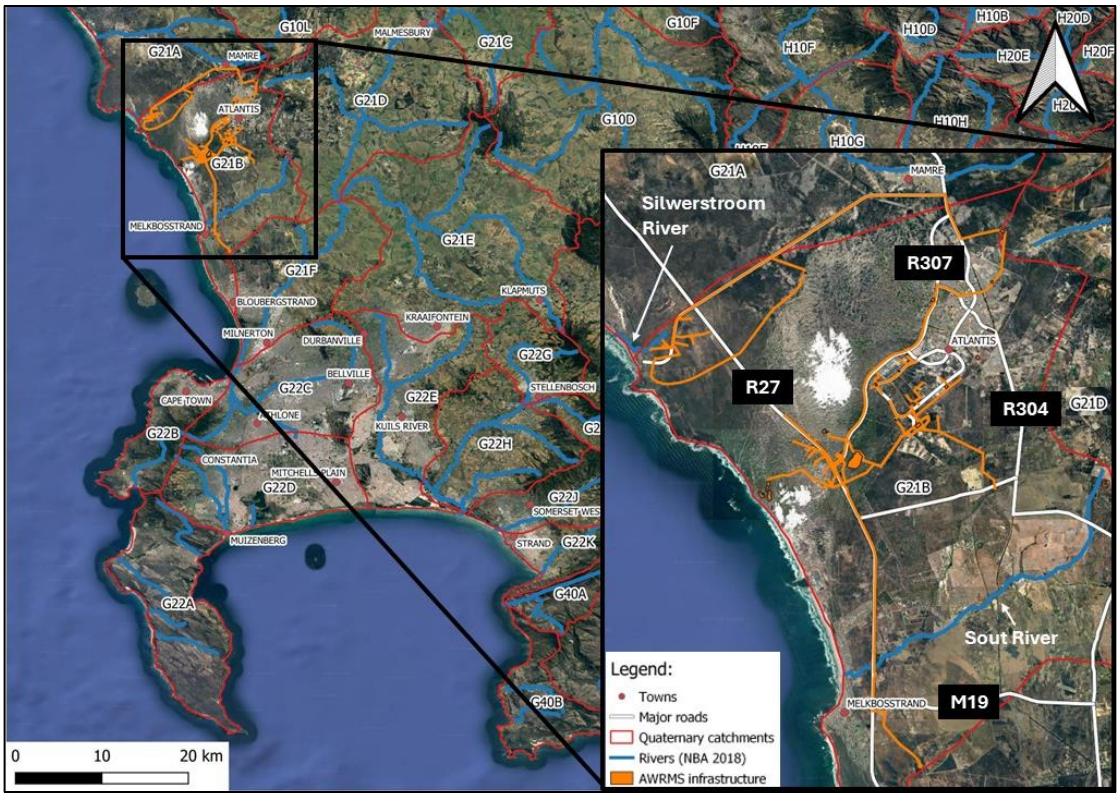

Figure 1.2: Map showing the general location of the study site and the associated AWRMS infrastructure.

2 SITUATION ASSESSMENT

2.1 Catchment context from a desktop perspective

The existing AWRMS infrastructure spans across the G21B, G21A and G21D quaternary catchments in the Berg-Olifants Water Management Area (WMA) and the lower Berg sub-WMA (Figure 1.2). The vast majority of the AWRMS infrastructure falls within the G21B quaternary catchment, which is dominated by plains and moderate relief terrain. Within the G21B quaternary catchment in particular, a significant portion of the area within which the AWRMS infrastructure is situated is protected formally and is thus largely pristine in nature. The three conservation areas are the Atlantis Aquifer Nature Reserve, Koeberg Nature Reserve and the Ganzekraal Conservation Area (Figure 2.1). Furthermore, the AWRMS infrastructure falls within the greater Cape West Coast Biosphere Reserve.

Other areas on the outskirts of the town of Atlantis are utilised for subsistence farming (largely livestock) and many areas are invaded by alien trees such as Acacias, Eucalyptus and Pine species. Although impacted, they are still classified as Ecological Support Areas (ESA) or Critical Biodiversity Areas (CBA) according to the City of Cape Town Biodiversity Network (Figure 2.1). The main town of Atlantis within which a portion of the AWRMS infrastructure is situated, comprises residential and industrial landuses.

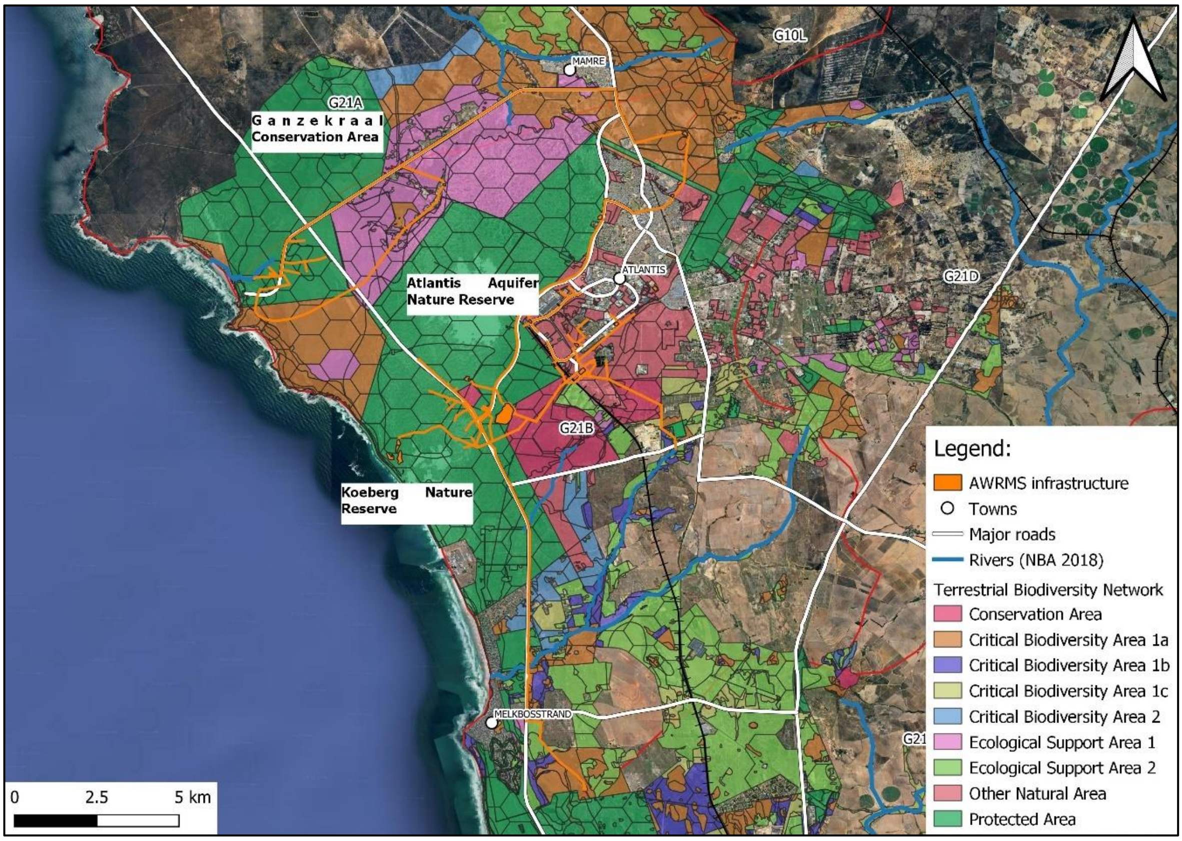

Figure 2.1: Map showing the City of Cape Town Biodiversity Network within the study area.

The study area lies within the South Western Coastal Belt Level 1 ecoregion – which is characterised by features provided in Table 2.1. According to the National Vegetation Map (Skowno *et al.*, 2019), the AWRMS infrastructure crosses numerous vegetation types – with the dominant vegetation type being Cape Flats Dune Strandveld and Atlantis Sand Fynbos. Two other vegetation types, namely Cape Flats Sand Fynbos and Swartland Shale Renosterveld, occur within the study area too but to a much lesser extent (Figure 2.2). Specific details on their extent, pressures and threats, etc. can be found in the botanical assessment prepared by Emms (2024). The ecosystem threat status of the four vegetation types is as follows (Skowno *et al.*, 2019):

- Cape Flats Dune Strandveld (endangered)
- Atlantis Sand Fynbos (endangered)
- Cape Flats Sand Fynbos (critically endangered)
- Swartland Shale Renosterveld (critically endangered)

Table 2.1: Main attributes of the South Western Coastal Belt Ecoregion Level 1 that intersects with the study area (from Kleynhans *et al*., 2005). The dominant features are in bold.

Ecoregion	Terrain morphology	Dominant vegetation types	Altitude (mamsl)	Mean Annual Precipitation (mm)	Rainfall seasonality
South Western coast belt	Plains; Low Relief; **Plains Moderate Relief**; Closed Hills; Mountains; Moderate and High Relief	Sand Plain Fynbos; Mountain Fynbos; **West Coast Renosterveld;** Dune Thicket; Strandveld Succulent Karoo	0-300; 300-900 limited	0 to 1500 (300-500 within the study area)	Winter

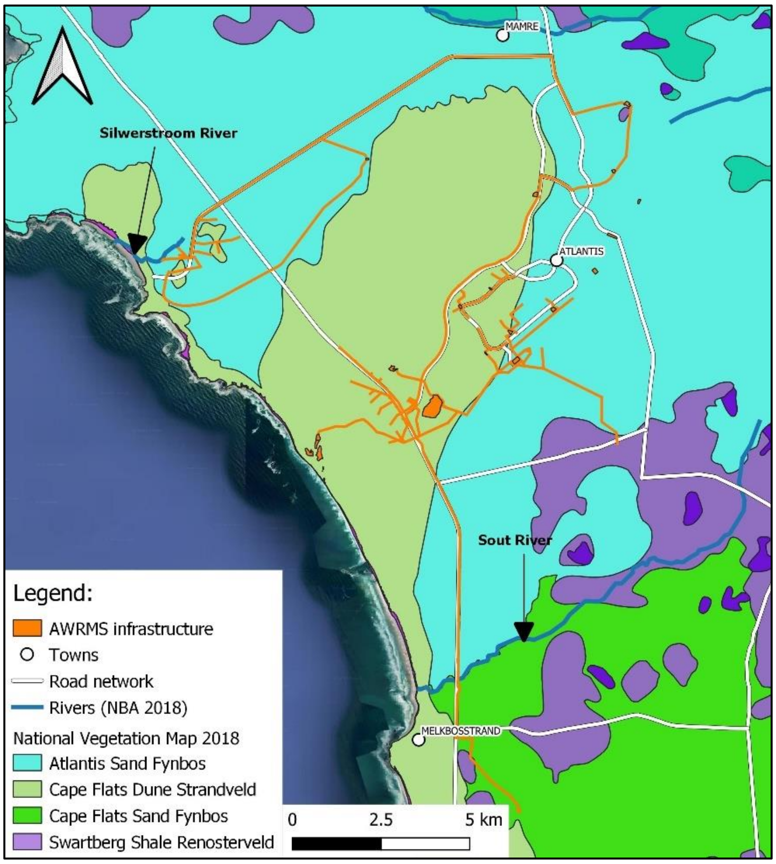

Figure 2.2: Map showing the vegetation types found within the study area based on the National Vegetation Map (Skowno *et al.,* 2019). Note: only the four vegetation types which the AWRMS infrastructure cross have been included within the legend.

2.2 Description of inland aquatic ecosystems in the study area from a desktop perspective

Various spatial datasets have mapped numerous rivers and wetlands within the study area (Figure 2.3). These spatial datasets include: National Wetlands Map 5 (Van Deventer *et al.* 2019 from NBA 2018), National Freshwater Ecosystem Priority Area (NFEPA), City of Cape Town wetlands, City of Cape Town Open Watercourses and the National Biodiversity Assessment River layer. The aquatic ecosystems mapped within the DWS 500m regulated area of the AWRMS infrastructure were ground-truthed during the site visits. More detail on the verified aquatic ecosystems is provided in Section 2.4.

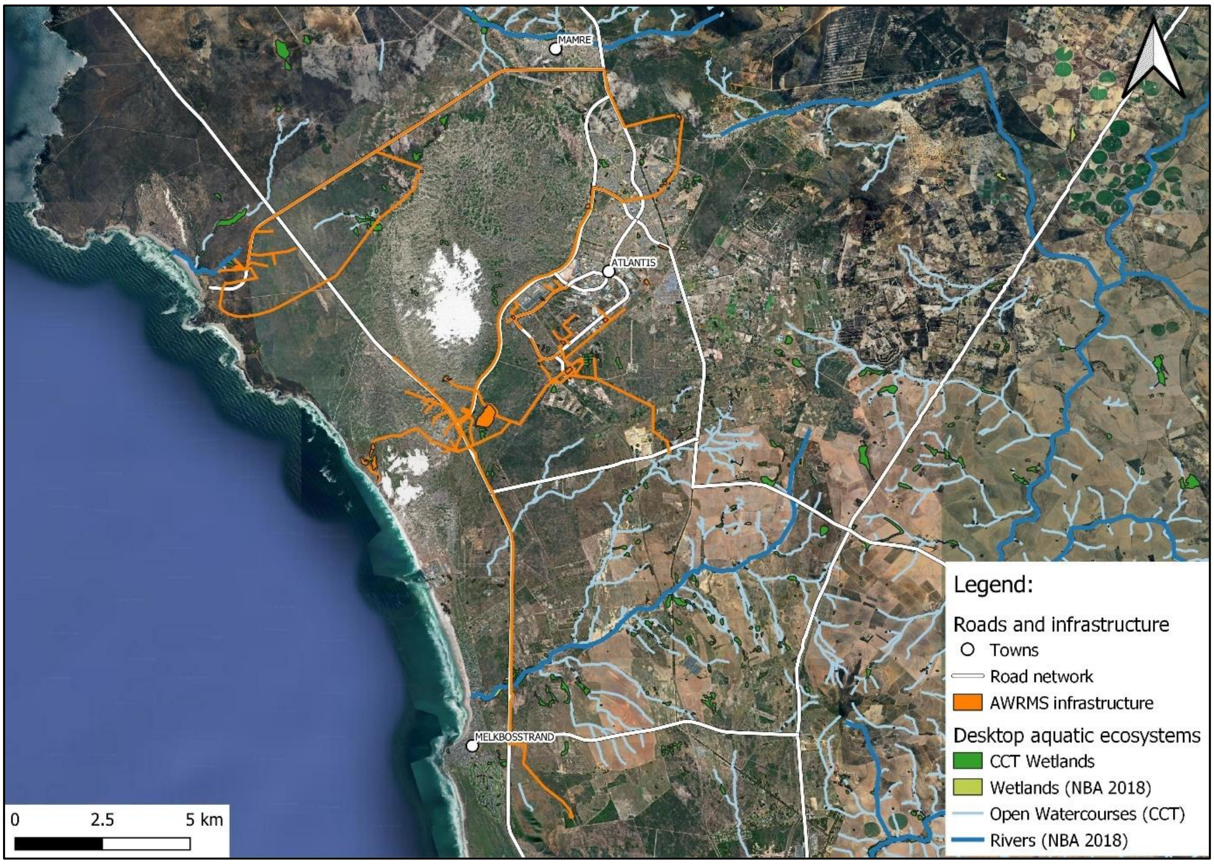

Figure 2.3: Map showing the desktop-mapped aquatic ecosystems within the study area.

From an aquatic biodiversity perspective, the AWRMS falls within areas that are classified as both low and very high sensitivity according to the National Screening Tool (Figure 2.4). The reason for the very high sensitivity classification is because of the presence of inland aquatic ecosystems that are mapped as:

- Aquatic CBA 1 (see Box 1 for further explanation)
- Aquatic CBA 2 (degraded) (see Box 1 for further explanation)
- Aquatic ESA1 (see Box 1 for further explanation)
- FEPA sub-catchment (see Box 2 for further explanation)
- Rivers B and D
- Depression, floodplain and seep wetlands within the Southwest Fynbos Bioregion
- Depression and seeps within the West Coast Renosterveld Bioregion
- Depression wetlands within the West Strandveld Bioregion

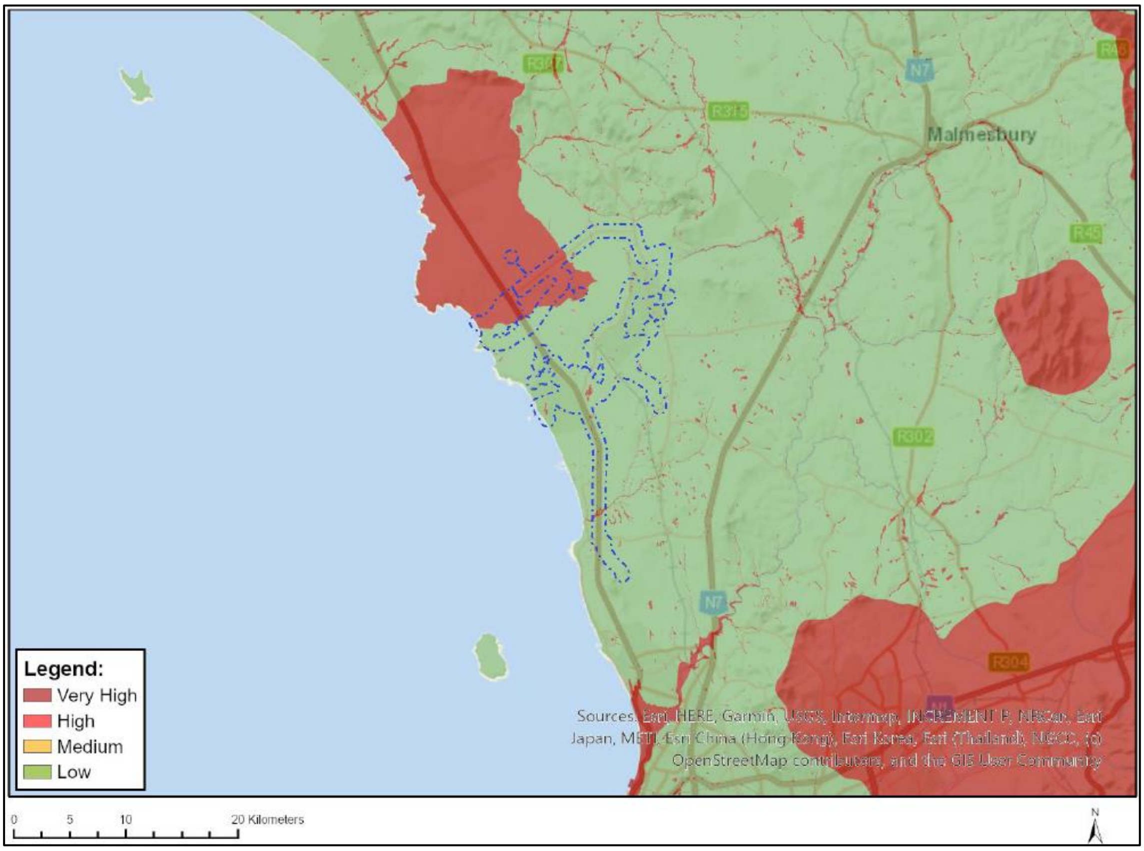

Figure 2.4 Map showing the aquatic biodiversity sensitivity of areas where the AWRMS infrastructure is located, as extracted from the Department of Forestry, Fisheries and Environment's EIA Screening Tool. The dashed blue line is the DWS-regulated area (500m) around the existing AWRMS infrastructure that was assessed for this study.

Box 1: Summary of the Western Cape Biodiversity Spatial Plan and the associated desired management objectives (Pool-Stanvliet *et al.* 2017).

BSP MAP CATEGORIES AND DESIRED MANAGEMENT OBJECTIVES

PROTECTED AREA: Must be kept in a natural state, with a management plan focused on maintaining or improving the state of biodiversity. A benchmark for biodiversity.

CRITICAL BIODIVERSITY AREA 1: Maintain in a natural or near-natural state, with no further loss of habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.

CRITICAL BIODIVERSITY AREA 2: Maintain in a functional, natural or near-natural state, with no further loss of natural habitat. These areas should be rehabilitated.

ECOLOGICAL SUPPORT AREA 1: Maintain in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised.

ECOLOGICAL SUPPORT AREA 2: Restore and/or manage to minimise impact on ecological infrastructure functioning; especially soil and water-related services.

ONA: Natural to Near-Natural – Minimise habitat and species loss and ensure ecosystem functionality through strategic landscape planning. Offers flexibility in permissible land uses, but some authorisation may still be required for high-impact land uses.

NO NATURAL REMAINING: Manage land use in a biodiversity-friendly manner, aiming to maximise ecological functionality. In old lands, stabilise ecosystems and manage them to restore ecological functionality, particularly soil carbon and water-related functionality, using indigenous plant cover. Old lands should be burnt and grazed appropriately.

Box 2: Context of the FEPA prioritisation and classification

FEPAs (Freshwater Ecosystem Priority Areas) are strategic priorities for conserving freshwater ecosystems and supporting the sustainable use of water resources (Nel *et al.* 2011). They were developed as part of the National Freshwater Ecosystem Priority Areas (NFEPA) programme. FEPAs have been determined for different river and wetland types throughout South Africa, on the basis of a number of criteria that included ensuring that there an adequate extent of different river and wetland ecosystem types is conserved, that they represent adequate habitats to support threatened fish species and their migration corridors; that free-flowing rivers (i.e. rivers without major dams) are prioritised for conservation, that water supply areas in high-water yielding sub-quaternary catchments are maintained and that ecological connectivity between systems is maintained as far as possible. The NFEPA data was used in this assessment to establish whether or not any potentially affected aquatic ecosystems were afforded FEPA status as a basis for assessing condition and importance at a desktop level.

In terms of the AWRMS study area (Figure 2.5), portions of the pipeline infrastructure fall within catchments that are classified as FEPAs and Upstream Management Areas. The FEPA status indicates that these systems should remain in good condition in order to contribute to the biodiversity goals of the country (Nel *et al*. 2011). Upstream Management Areas are catchments in which human activities need to be managed to prevent the degradation of downstream River FEPAs and/or Fish Support Areas (FSA).

Although not relevant to this study, Nel *et al.* (2011) further classify catchments as Phase 2 FEPAs or Fish migration corridors. Phase 2 FEPAs contain rivers in moderately modified (C) rivers and should not degrade further as they may, in future, be considered for rehabilitation once good condition FEPAs (in an A or B ecological category) are considered fully rehabilitated. Fish migration corridors provide links between certain habitats necessary for the migration of threatened migratory fish species.

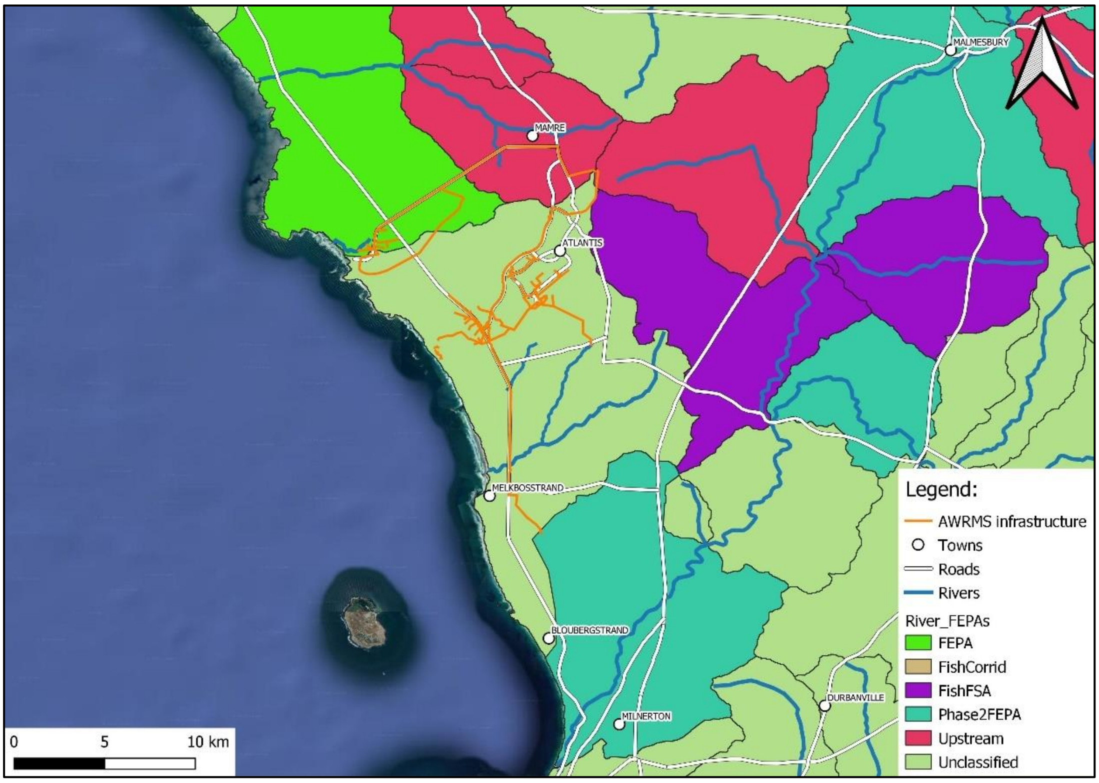

Figure 2.5: Map showing the FEPA status of aquatic ecosystems within the study area.

Considering that the existing AWRMS infrastructure crosses over a number of inland aquatic ecosystems (see Section 2.4), the aim of the maintenance activities must take into account the overarching objective of not leading to any further degradation of the environment – especially near the areas that are classified to be of very high aquatic sensitivity.

2.3 Description of the study area

2.3.1 Landscape topography

As described in Emms (2024), the landscape and topography vary across the extensive study area and have the following features associated with the main areas:

- **Silwerstroom Wellfield**: Sand-dominated, vegetated (stable) dunes with gently undulating to flat topography.
- **Witsands Wellfield, Witsands Aquifer Nature Reserve, and Koeberg Nature Reserve (including the Coastal Recharge Basins)**: Vegetated (stable) dunes.
- **Atlantis Industrial and outskirts**: Sandy, gently undulating to flat topography.
- **R27**: Sandy, gently undulating to flat topography.
- **Blouberg Hill lower slopes**: Sandy flats and lower slopes of Blouberg Hills with sandy, slightly loamy soils containing a small clay content but predominantly sandy.

2.3.2 Historic land use changes

Historic imagery was consulted to determine whether any major changes in land uses (and subsequent ecological condition) were noted within the broader AWRMS study area (Figure 2.6). Large parts of the study have remained largely natural, however, along infrastructure routes (pipelines and roads) disturbances can clearly be noted. The areas around the towns of Atlantis, Mamre and Melkbos have experienced urban encroachment into areas that were largely natural, as visible in the earliest available imagery. Agricultural fields were already visible in 1938 along portions of the southern sections of the AWRMS infrastructure.

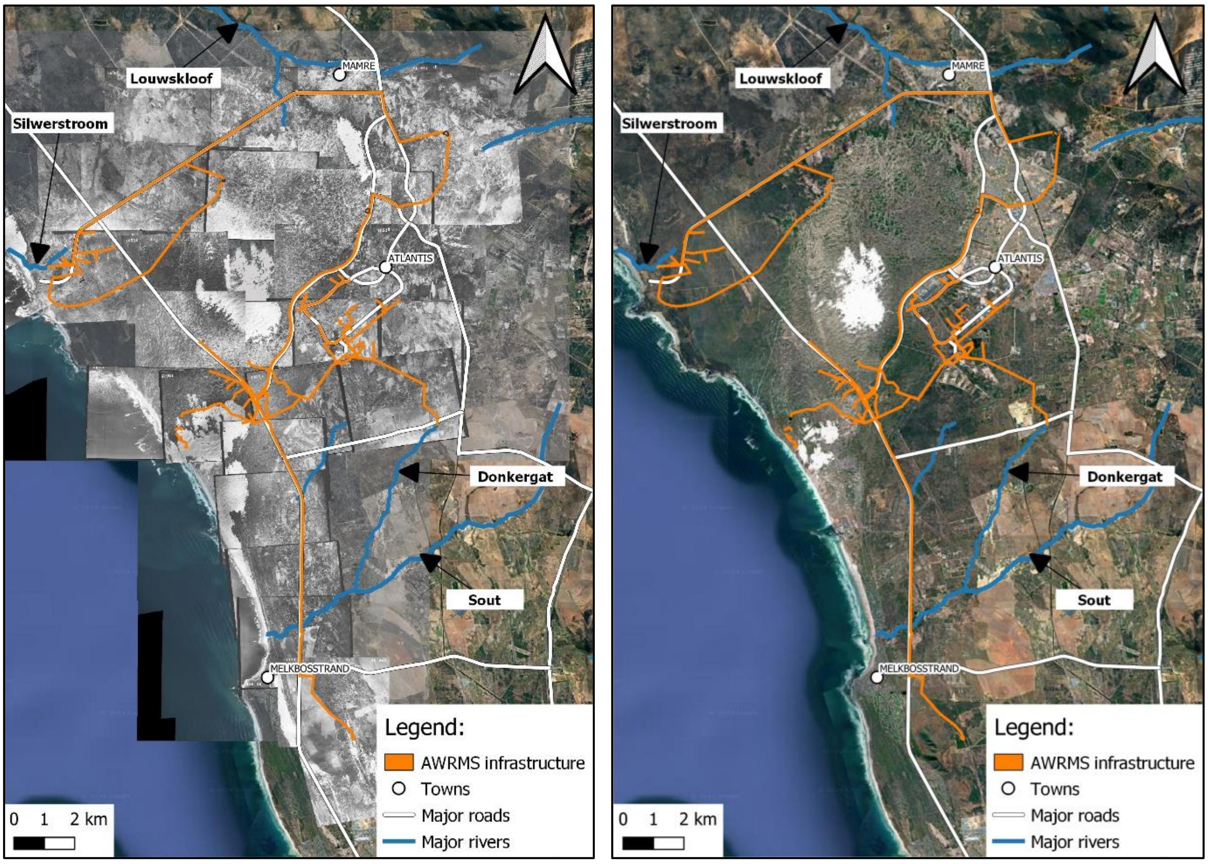

Figure 2.6: Aerial imagery from 1938 (left) and 2024 (right) which shows changes to the landscape within the study area.

2.3.3 Background groundwater quality

An extensive water quality dataset containing data from 2017 to 2024 was received from Umvoto (Pty) Ltd, who have been involved in water quality monitoring of the AWRMS for several years. The dataset details the extensive list of parameters that are routinely monitored across a wide borehole (groundwater) monitoring network as well as at strategic surface water locations associated with the pipelines and discharge locations. The dataset includes numerous parameters relating to macro chemistry (e.g. pH, electrical conductivity, various nutrients, etc.), inorganics, total and dissolved metals (e.g. aluminium, arsenic, copper, cyanide, etc.), microbes (e.g. *Escherichia coli*, total coliform bacteria, microcystins etc.), pathogens (e.g. clostridium, parasites, coliphages, etc.) and contaminants of emerging concern (e.g. herbicides, pesticides, pharmaceuticals, hydrocarbons, etc.).

The purpose of including this section in this report is to provide context on the environmental conditions of the study area. This is to ascertain the baseline conditions as a means to determine the significance of impacts (specifically relating to water quality impairment) expected to be associated with the maintenance activities outlined and discussed here.

The range in specific water quality parameters was determined by looking at the minimum and maximum data points across the dataset in comparison with DWAF 1996 water quality guidelines for aquatic ecosystems. It must be noted that these water quality guidelines are limited to a set number of parameters for which target ranges, and chronic- and acute effect values have been determined. Some of the parameters being monitored as part of the AWRMS are not included in the 1996 DWS water quality guidelines, so it should be noted that their ranges may (or may not) exceed thresholds which are detrimental to aquatic biota. Based on an analysis of the AWRMS data, the following parameters exceeded water quality thresholds at some monitoring points between 2017 and 2024:

- Dissolved aluminium
- Dissolved copper
- Dissolved cyanide
- Dissolved zinc
- Total cadmium
- Total cyanide
- Total selenium
- Counts of pathogens and microbiological parameters as well as Nitrogen and Phosphorus concentrations

It must be noted that the geology of the Sout River catchment contributes to the naturally brackish nature of the water, with high concentrations of dissolved salts (EC/TDS) and metals such as aluminium, iron and strontium occurring naturally (CCT 2023).

Therefore, it should be noted that the groundwater quality within the broader AWRMS study area varies and is not pristine (due to natural as well as artificial reasons) and thus, relative to the status quo, inland aquatic ecosystems (as outlined in Section 2.4) may be variably impacted from a water quality perspective based on their proximity to recharge areas receiving treated effluent. This was considered for the assessment of impacts within Section 5.

2.4 Delineation and description of inland aquatic ecosystems within the study site

The Department of Water and Sanitation's wetland and riparian zone delineation manual (DWAF 2008) was used to identify and delineate inland aquatic ecosystems within the study area. The manual describes the indicative characteristics that can be used to distinguish between wetlands or riparian zones and the surrounding terrestrial landscape. These indicators are:

- **Vegetation**: the presence, or at least occasional presence, of plants adapted to or tolerant of saturated soils (hydrophytes) or alluvial soils. These plants are known as either obligate or facultative wetland plants (Corry 2012) which means they are found most often in wetlands;
- **Soils**: in the case of wetlands, the presence of wetland (hydromorphic) soils that display characteristics (soil colour, mottles[1], organic streaking or gleying[2]) resulting from prolonged saturation, and for riparian areas, the presence of alluvial soils and / or deposited material. Hydromorphic soils must display signs of wetness within 50 cm of the soil surface, as it has been shown that regular saturation of the top 50 cm of soil is necessary to support hydrophytic vegetation;
- **Hydrology**: a high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil;
- **Terrain**: the position in the landscape that allows for retention of water and the development of wetlands, or for riparian areas, association with a watercourse.

The outcome of the site verification in October 2024 and February 2025 resulted in the identification of numerous kinds of aquatic features within the DWS-regulated area of 500m. These are broadly categorised in Table 2.2 and visualised within this section. Figure 2.7 provides an overview map of the area – with subsequent maps providing a close-up of various sections of the AWRMS (Figures 2.8 to 2.20). It must be noted that not all of these aquatic features will be impacted by the proposed maintenance activities outlined in this document. Those that will be impacted will be discussed in more detail in Section 4.1.

[1] These are orange, yellow or reddish-brown splotches that appear in mineral soils that are alternately wet and dry and therefore indicative of seasonal wetland habitat.

[2] Gleying occurs when iron deposits in the soil are converted from an oxidized to a reduced state due to extended periods of saturation and low oxygen conditions.

Table 2.2: Summary and descriptions of the various kinds of aquatic features that were identified during the fieldwork for this study.

Aquatic feature	Description	Photographic Examples	
Artificial basins (Basin 1, 2, 3, 4, 5, 6, 8, 9, 10, 11)	These artificially excavated basins primarily store stormwater runoff from residential and/or industrial areas originating from the town of Atlantis.	 Photo of Basin 5 in the town of Atlantis	 Photo of Basin 11 in the town of Atlantis
Recharge wetlands (Basin 7 and 12)	These modified, yet likely natural wetlands are used as the primary recharge areas of the AWRMS. They receive a mixture of treated effluent and stormwater and are typically permanently saturated and inundated. The seasonal edges are dominated by weedy species (e.g. *Sonchus* spp and *Xanthium* spp) and sedges (*Scirpoides holoschoenus*)	 Photo of Basin 7	 Photo of Basin 12

Aquatic feature	Description	Photographic Examples	
Recharge wetlands (coastal recharge basins)	It is unclear whether these coastal recharge basins were historically natural dune slack wetlands, however, they currently store and allow for the infiltration of treated industrial effluent as a means to prevent saltwater intrusion.	 Photo of the desilting basin as part of the Coastal Recharge Basin network	 Photo of one of several infiltration ponds as part of the Coastal Recharge Basin network
Dune slack wetlands	**Type 1:** These natural depression wetlands are associated with higher periods of saturation (and likely inundation) due to their close proximity to recharge wetlands described above. The presence of *Typha capensis* stands within their core is indicative of permanently saturated and seasonally inundated conditions.	 Photo taken of a wetland near Basin 7	 Photo taken of a wetland near Basin 7

Aquatic feature	Description	Photographic Examples	
Dune slack wetlands	**Type 2:** These natural depression wetlands are typically located further away from recharge basins and are assumed to be largely isolated (hydrologically) from AWRMS activities. The plant communities are distinctly different to Type 1 in that they are grass-dominated with sedges such as *Ficinia* spp and *Scirpoides holoschoenus.*	 Photo of a dune slack wetland in Koeberg Nature Reserve (near borehole AT-P09/W34006)	 Photo of a dune slack wetland near electricity infrastructure (near Brakkefontein Road)
	Various other dune slack wetlands (similar to those described here) are located within the Witzands Nature Reserve, but are dominated by alien invasive, Coastal Wattle (*Acacia cyclops*), but do support wetland sedges (*Ficinia* and *Juncus* spp) and grasses (e.g. Cogon Grass (*Imperata cylindrica*).	 Photo of a dune slack wetland in Witzand Nature Reserve (near borehole AT-EX18)	 Photo of a dune slack wetland in Witzand Nature Reserve (near borehole AT-EX18)

Aquatic feature	Description	Photographic Examples	
Perched depression wetlands	**Type 1**: These natural depression wetlands are protected within nature reserves and are largely unimpacted. They do however lie adjacent to dirt roads that allow for access to various boreholes. They are situated on a clay lens and receive runoff from overland flow. They are dominated by various kinds of grasses as well as clumps of sedges (e.g. *Ficinia* spp and *Scirpoides holoschoenus*).	 Photo of a perched wetland in the Koeberg Nature Reserve between boreholes AT-MON24 and AT-S01	 Photo of a perched wetland in the Koeberg Nature Reserve between boreholes AT-MON24 and AT-S01
Perched depression wetlands	**Type 2**: These natural depression wetlands are not protected within nature reserves and are largely located within subsistence farming communities where they experience overgrazing by goats, horses and cattle. Similarly, these systems are located on a clay lens and fed by overland runoff.	 Photo of a depression wetland along Silwerstream Road	 Photo of a depression wetland along Silwerstream Road

Aquatic feature	**Description**	**Photographic Examples**	
Silwerstroom channelled valley bottom wetland	This natural wetland is mainly fed by lateral ingress of groundwater from the surrounding dunes via two main springs as well as surface water runoff. The wetland is dominated by *Phragmites australis* within its midsections whereas further upstream, other indigenous plants include *Senecio halimfolius*, *Cyperus rotundus, Imperata cylindrica, Ficinia nodosa, Helichrysum sp.* and *Morella cordifolia.* Some alien plants include Watercress (*Nasturtium* spp) and Duckweed (*Lemna*).	 Photo of the wetland upslope of the in-channel dam	 Photo of the wetland immediately downstream of the Silwerstroom weir and pump house
Seeps	These wetlands occur immediately adjacent to the Witsand dunes and are likely fed by daylighting groundwater. Although situated in an area that is utilised by subsistence farming communities, they support dense and diverse stands of indigenous vegetation including *Senecio halimifolius*, *Cliffortia* spp, *Carpha glomerata* and *Isolepis prolifera*. Some invasion of *Acacia cyclops* was observed in some parts.	 Photo of a seep wetland situated west of the Witzands Aquifer Nature Reserve along the Silwerstroom pipeline route	 Photo of an extensive seep wetland situated west of the Witzands Aquifer Nature Reserve along the Silwerstroom pipeline route

Aquatic feature	Description	Photographic Examples	
Seepage from Wesfleur WWTW	An artificial wetland that has originated due to seepage from the unlined maturation ponds. Closest to the maturation pond, large swathes of *Typha capensis* and *Phragmites australis* are present. Beyond these swathes and towards the edge of the temporary wetland habitat, the vegetation community is dominated by alien plants (e.g. *Acacia saligna* and *Cenchrus clandestinus*) as well as indigenous plant species (e.g. *Osteospermum incanum* and the *Ficinia nodosa*. Further downstream, it is heavily affected by sand mining activities.	 Photo of the artificial wetland immediately south of the Wesfleur WWTW maturation ponds	 Photo of the artificial wetland further downstream of the Wesfleur WWTW maturation ponds
Unchanneled valley bottom wetland below a chicken farm	This wetland originates below a chicken farm and is likely fed by daylighting groundwater (Kobus Prinsloo, geohydrologist at Umvoto). At its core, it is dominated by the indigenous sedge, *Bolboschoenus maritimus*. The plant community changes to comprise *Cenchrus clandestinus, Rumex crispus, Senecio* spp and *Lolium* spp further downstream. The wetland edges are starting to become invaded by *Acacia cyclops* and *Acacia saligna*.	 Photo of the start of the wetland system immediately south of the chicken farm	 Photo of the wetland system further downstream of the chicken farm

Aquatic feature	Description	Photographic Examples	
Koerasie unchanneled valley bottom wetland	This wetland is heavily grazed – especially near its midsections where a subsistence farming community resides. The vegetation community is comprised largely of overgrazed grasses (e.g. *Cynodon dactylon*) and sedges as well as alien trees (*Acacia cyclops* and *Acacia saligna*).	 Photo of the wetland system along Silverstream Road (looking downstream)	 Photo of the wetland system along Silverstream Road (looking downstream)
Temporary wetlands	Various temporary wetlands were identified and are likely sustained by overland flow from their upper catchments. These wetlands are dominated by grasses and stands of *Scirpoides holoschoenus*.	 Photo of temporary wetland habitat upslope of the pipeline that carries water from borehole W34018/W34020 within the Silwerstroom Wellfield	 Photo of temporary wetland habitat – with a dense stand of sedges immediately downslope of the darker vegetation in the background.

Aquatic feature	**Description**	**Photographic Examples**	
Sout River channelled valley bottom wetland	The Sout River is a perennial river system which receives inputs of treated effluent within its lower catchment, which alters the hydrological regime as well as impairs its water quality. The two major point sources include the Donkergat River (linked to the AWRMS) as well as the Melkbos WWTW (near West Coast Road). Within the river's lower reaches (near the WWTW), a large channelled valley bottom wetland exists and is dominated by *Phragmites australis.*	 Photo of the Sout River taken from the bridge crossing West Coast Road (looking upstream)	 Photo of the Sout River taken from the bridge crossing West Coast Road (looking downstream)
Rivers (Langwater-spruit and the Brakkefont-ein Road stream)	These river systems are non-perennial in nature and are fed by overland flow during periods of high rainfall. They flow through areas which are impacted by agricultural and mining activities. They support largely weedy species, such as grasses and alien *Acacia* trees.	 Photo of the Langwaterspruit River along Silverstream Road (looking downstream)	 Photo of the Brakkefontein Road River along West Coast Road (looking upstream)

Aquatic feature	Description	Photographic Examples	
Donkergat River channelled valley bottom wetland	The wetland habitat associated with the Donkergat River is dominated by kweek grass (*Cynodon dactylon*), Curley Dock (*Rumex crispus*), alien *Acacia* trees and kikuyu grass (*Cenchrus clandestinus*). The channel section receives treated effluent as part of the AWRMS system and is dominated by bullrushes (*Typha capensis*). Alien *Acacias* have established well on the channel banks.	 Photo of the wetland habitat upslope of the discharge point into the channel	 Photo of the Donkergat River wetland near the discharge point into the channel (looking downstream)
Unchanneled valley bottom wetland in Ganzekraal Conservation Area	This wetland is well grazed with evidence of livestock trampling within the wetland, and minor excavations to allow for the accumulation of water for stock watering. The vegetation community is comprised largely of plants such as *Isolepis prolifera*, *Juncus lomatophyllus* and pockets of *Typha capensis* within the wet core, which are surrounded by grasses such as *Cynodon dactylon* as well as alien trees (*Acacia cyclops* and *Acacia saligna*).	 Unchanneled valley bottom wetland within the Ganzekraal Conservation Area	 Unchanneled valley bottom wetland within the Ganzekraal Conservation Area

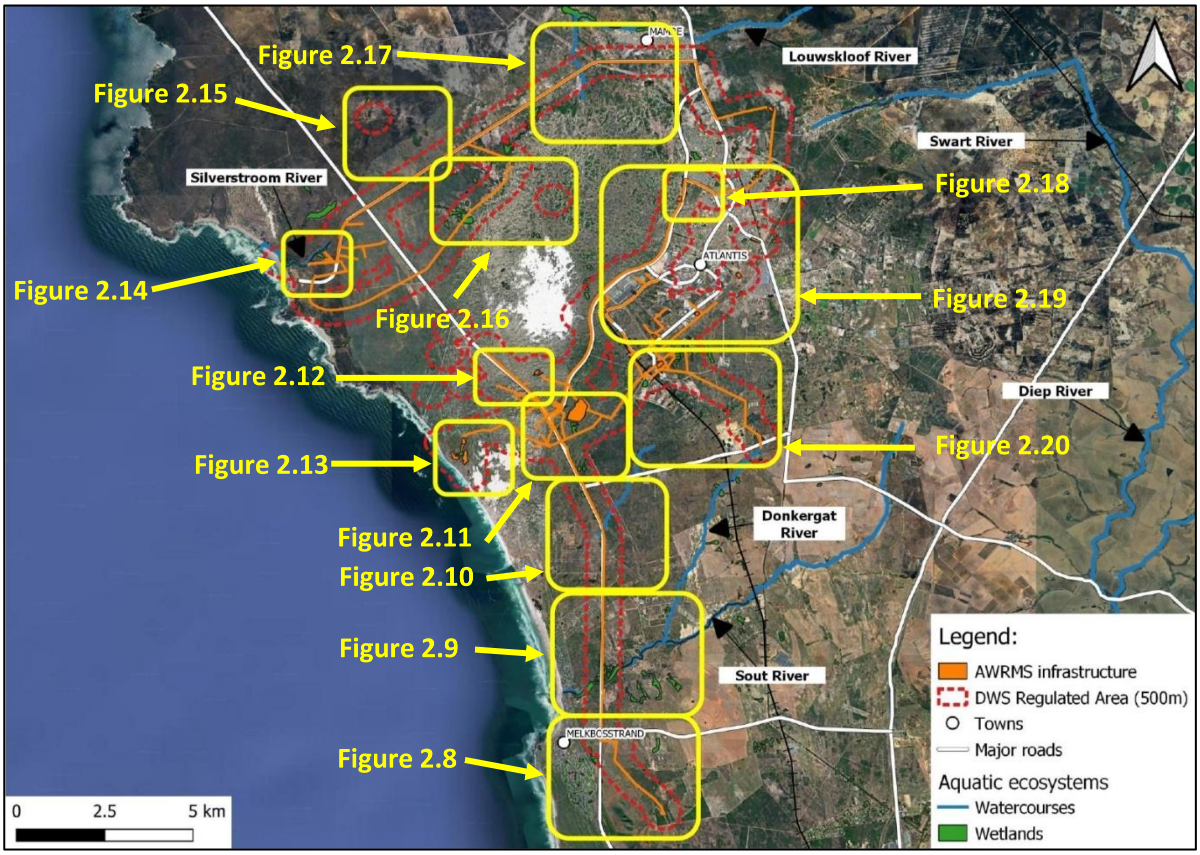

Figure 2.7: Map showing the entire AWRMS infrastructure route with yellow polygons showing the extent of the below series of zoomed-in maps of verified inland aquatic ecosystems.

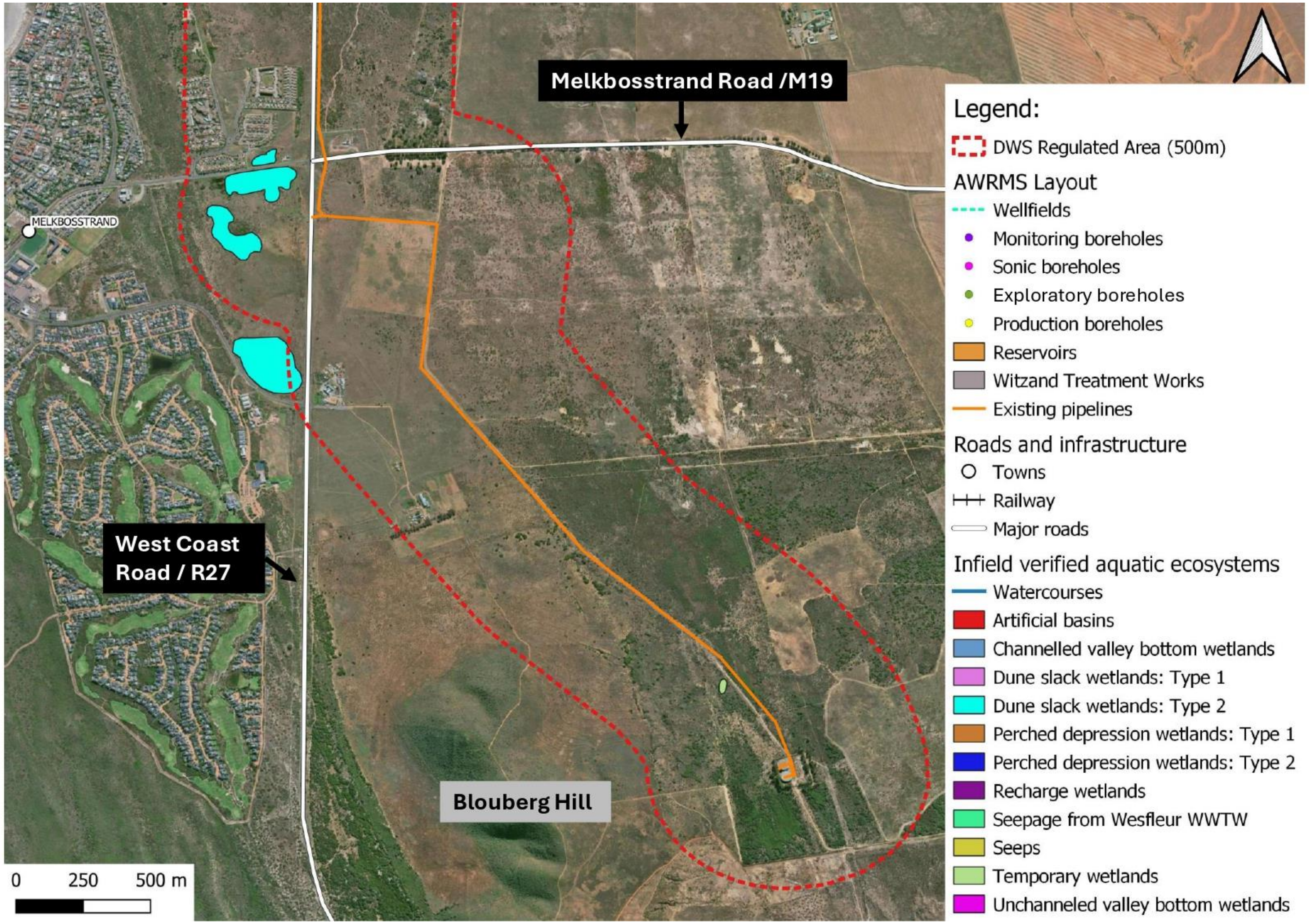

Figure 2.8: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

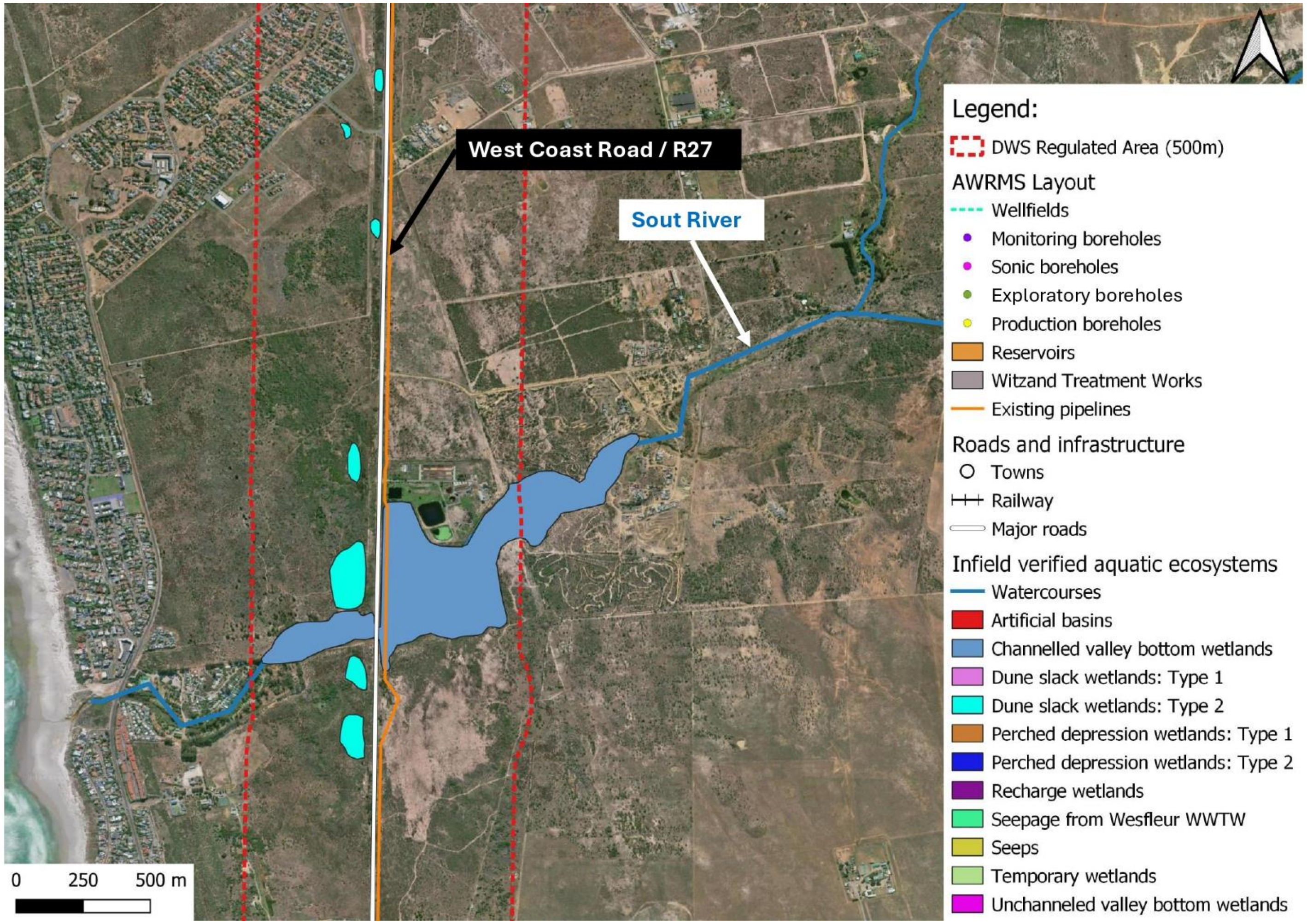

Figure 2.9: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

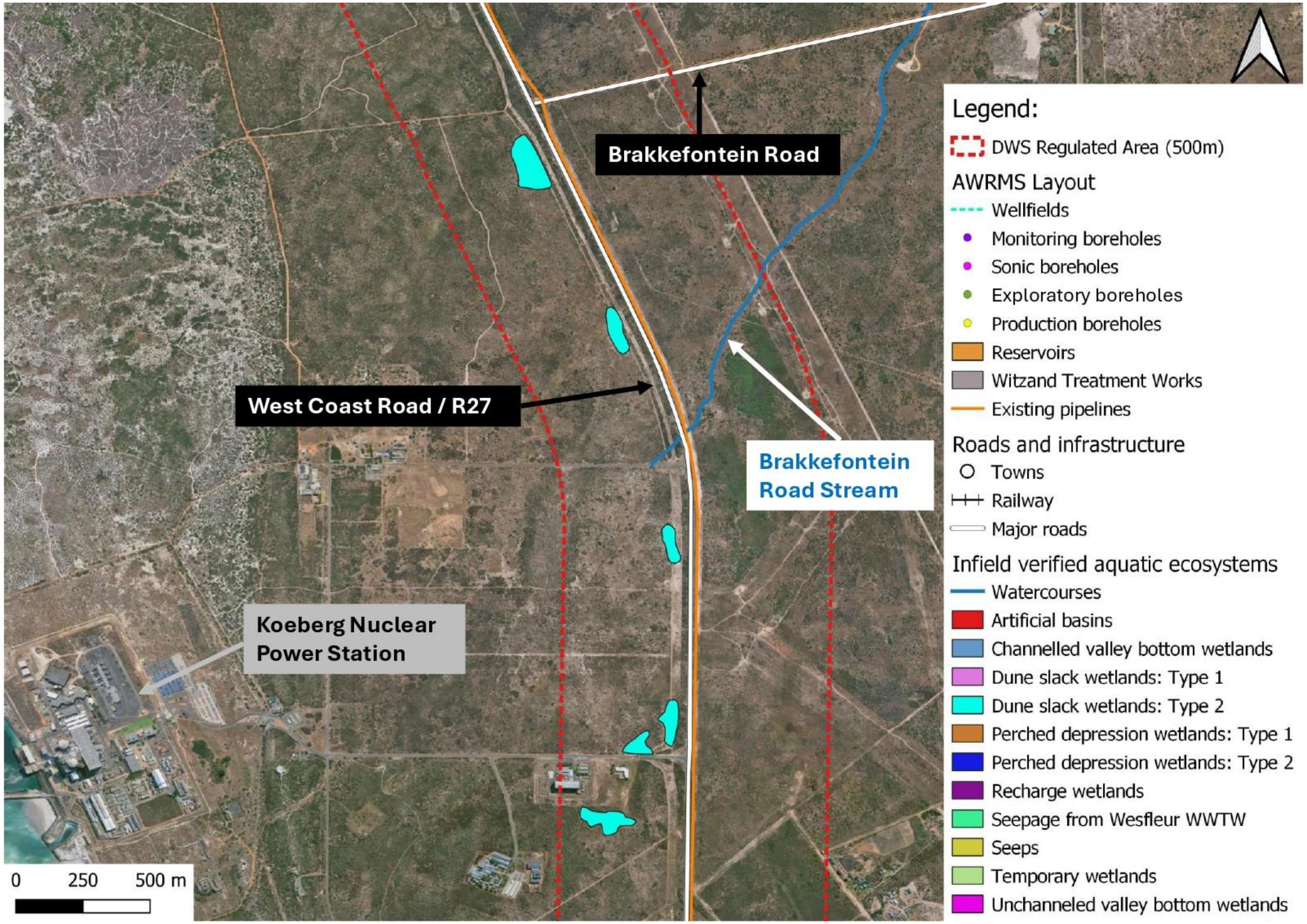

Figure 2.10: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

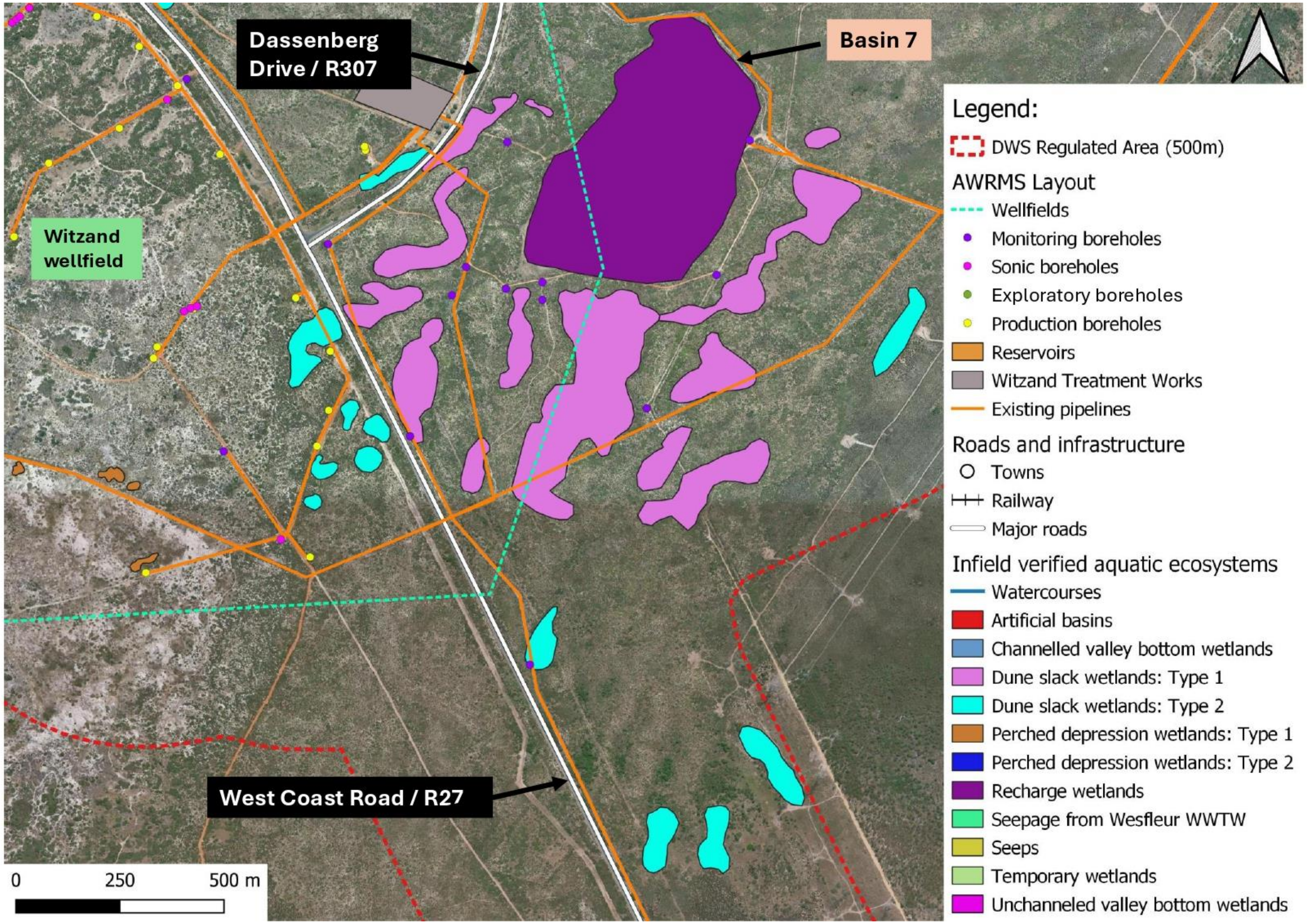

Figure 2.11: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

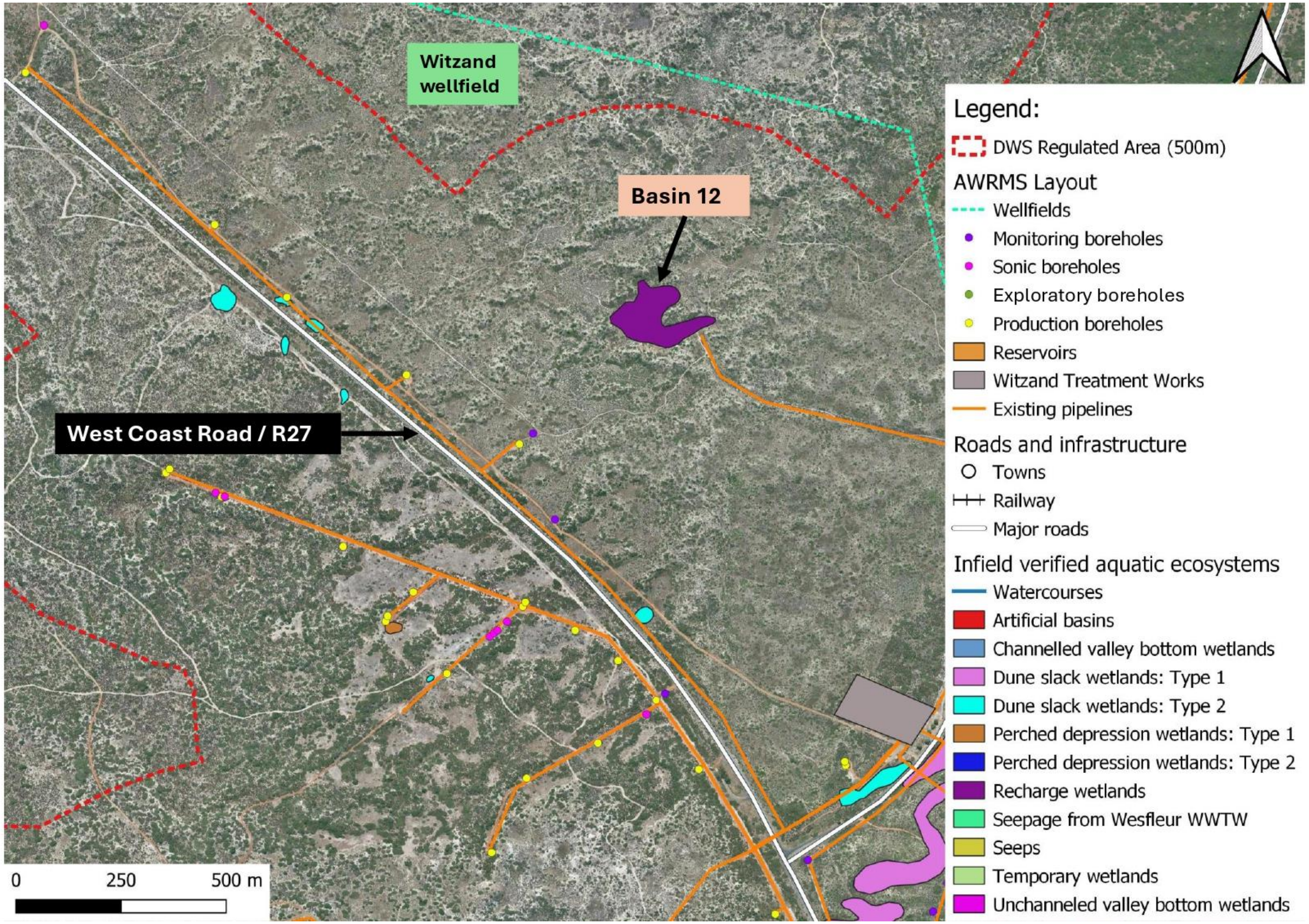

Figure 2.12: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

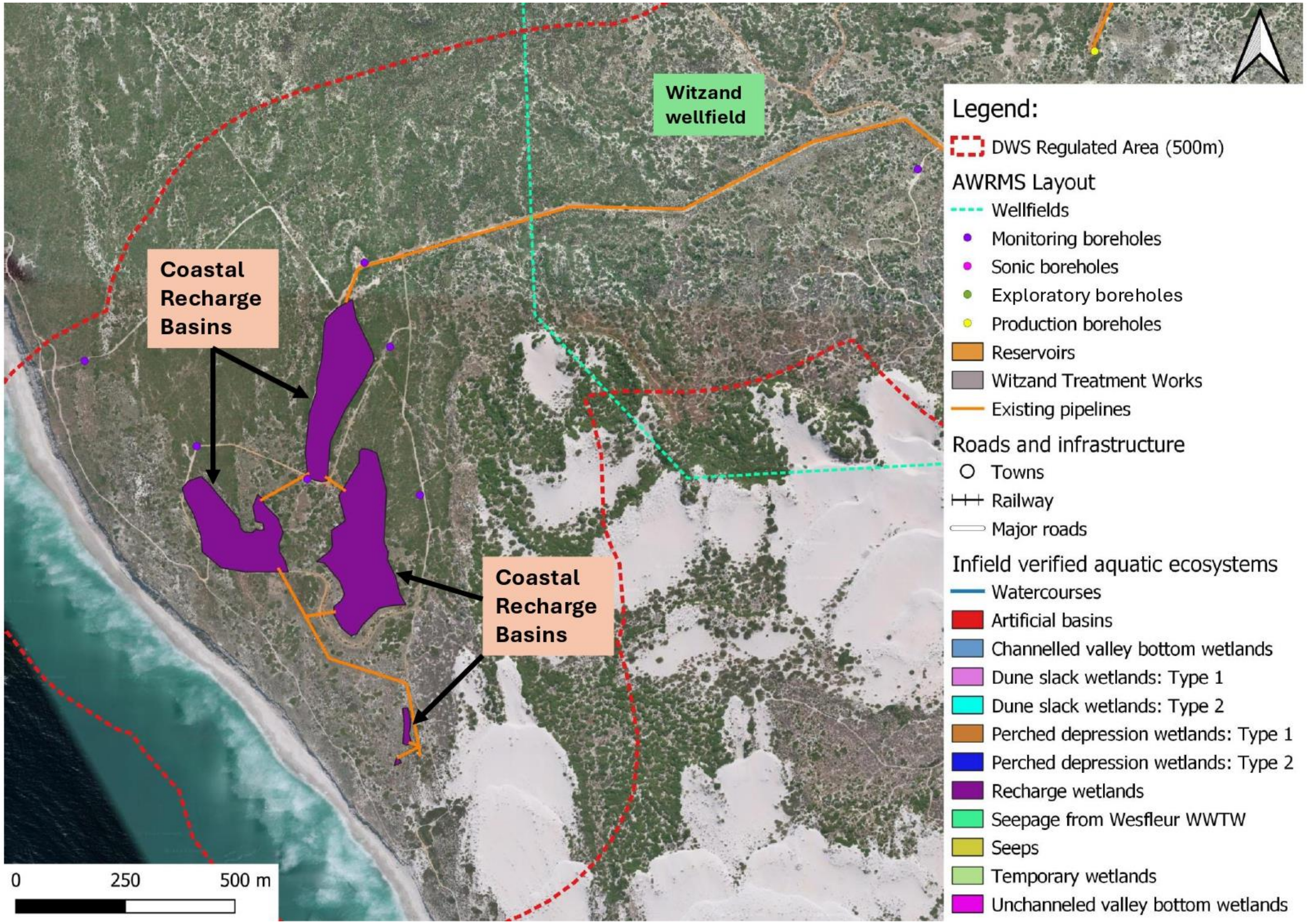

Figure 2.13: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

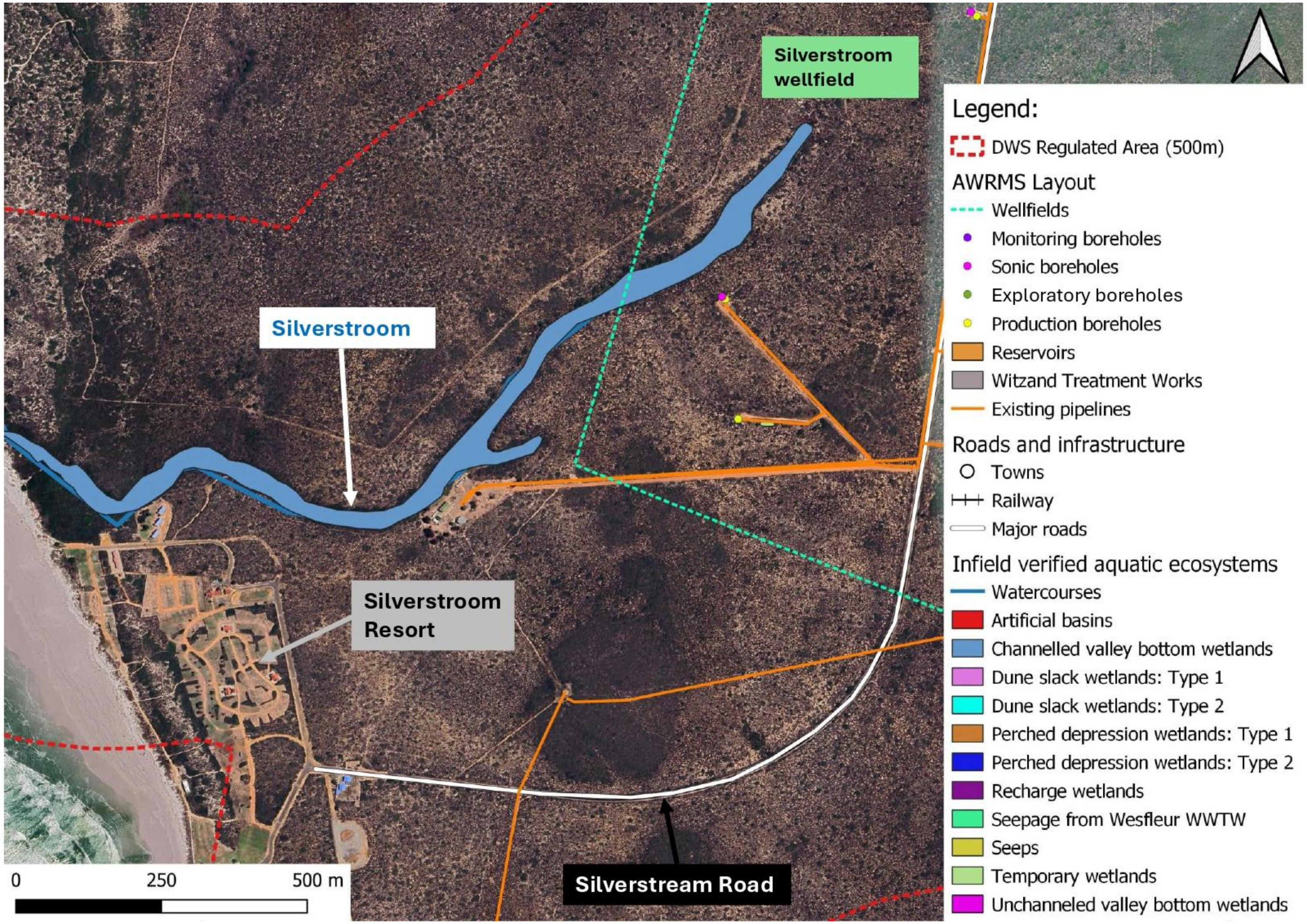

Figure 2.14: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

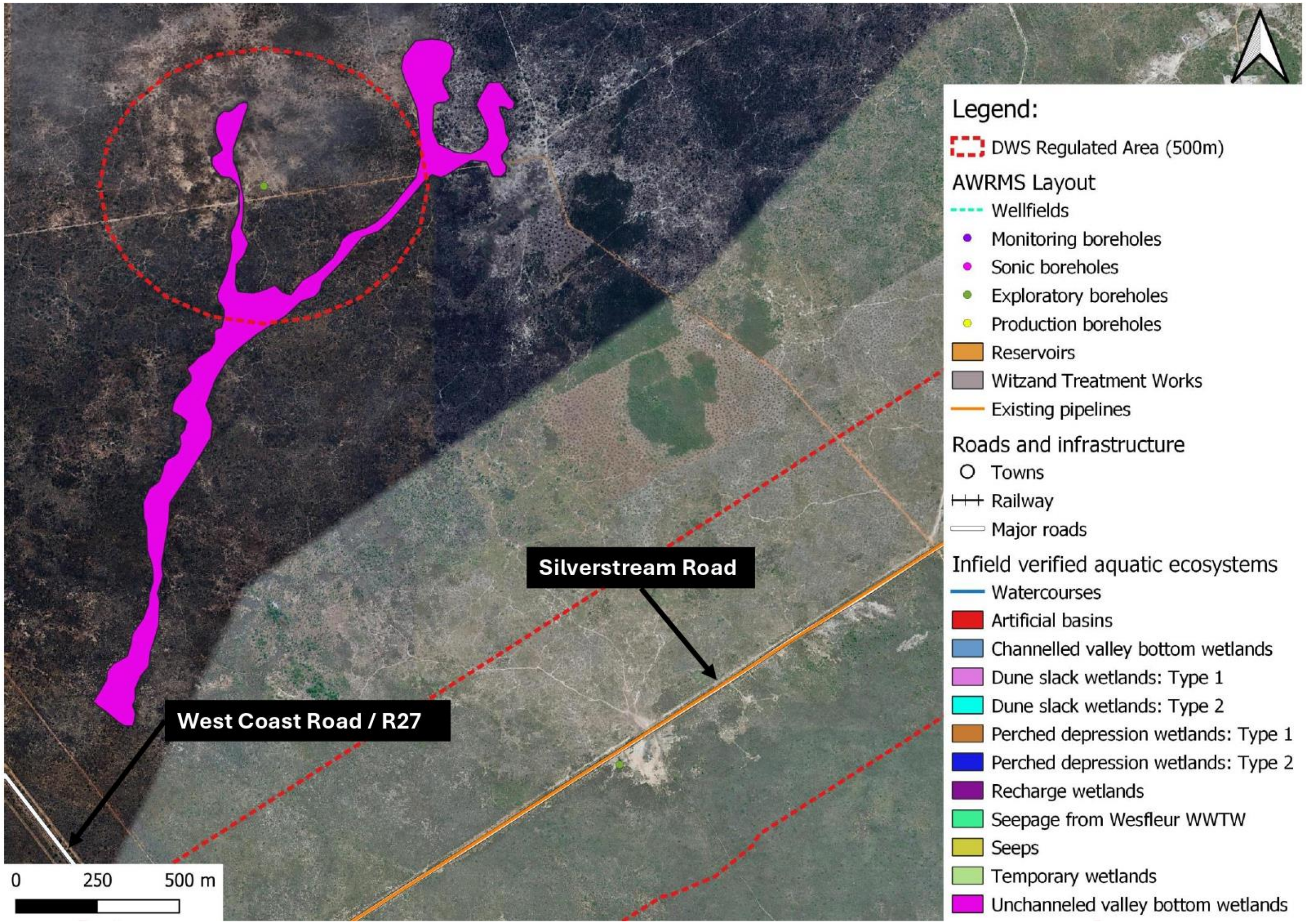

Figure 2.15: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

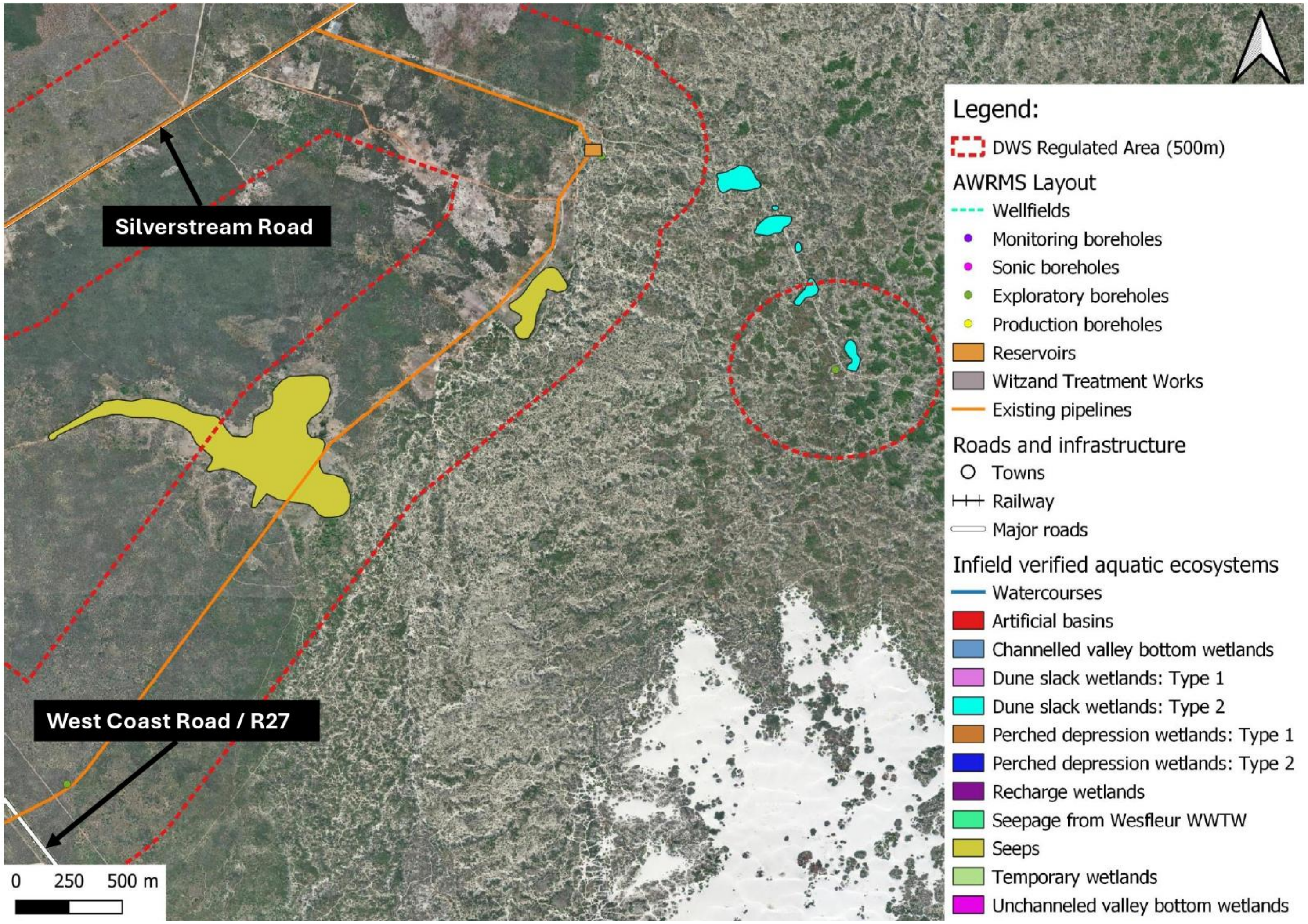

Figure 2.16: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

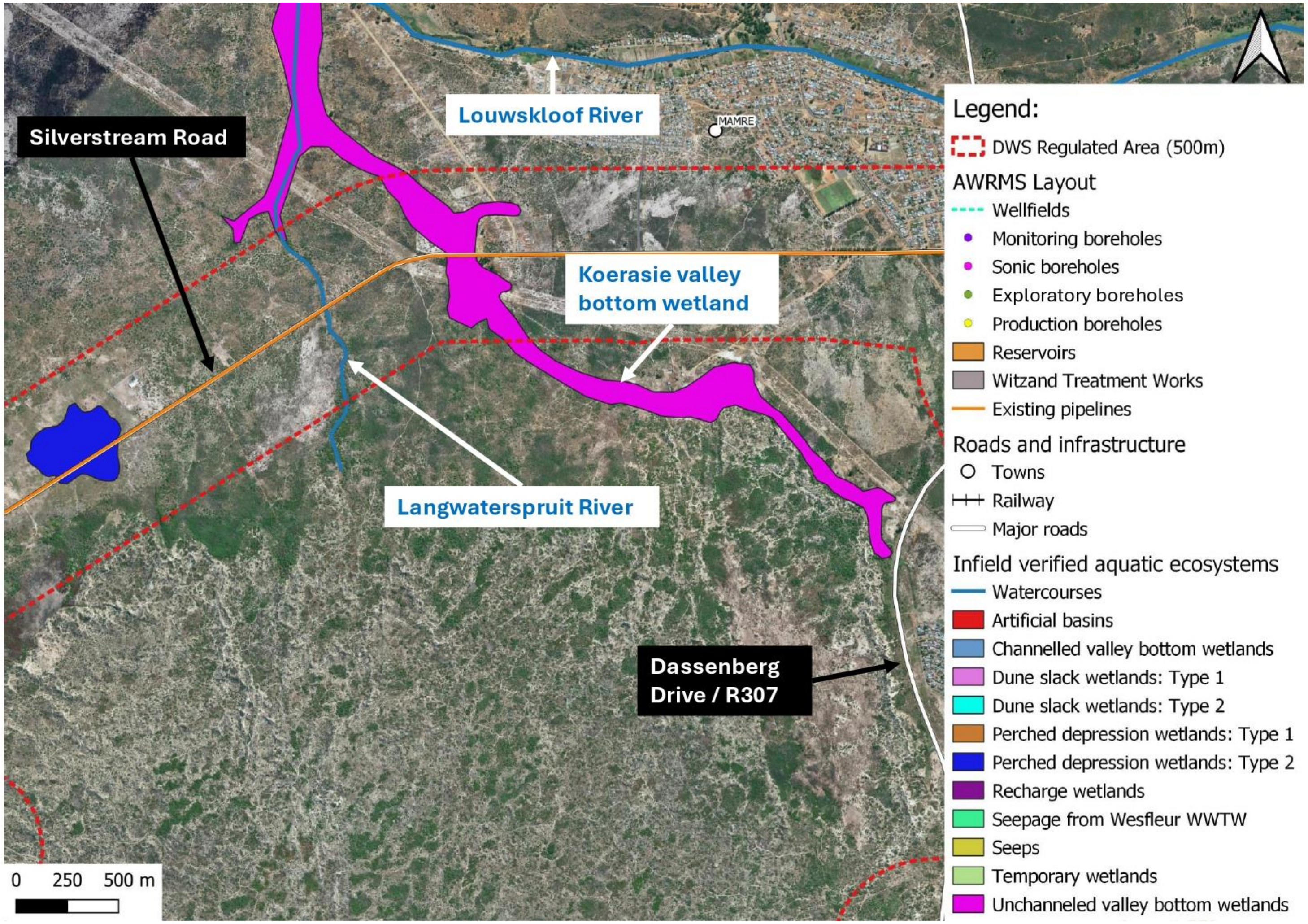

Figure 2.17: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

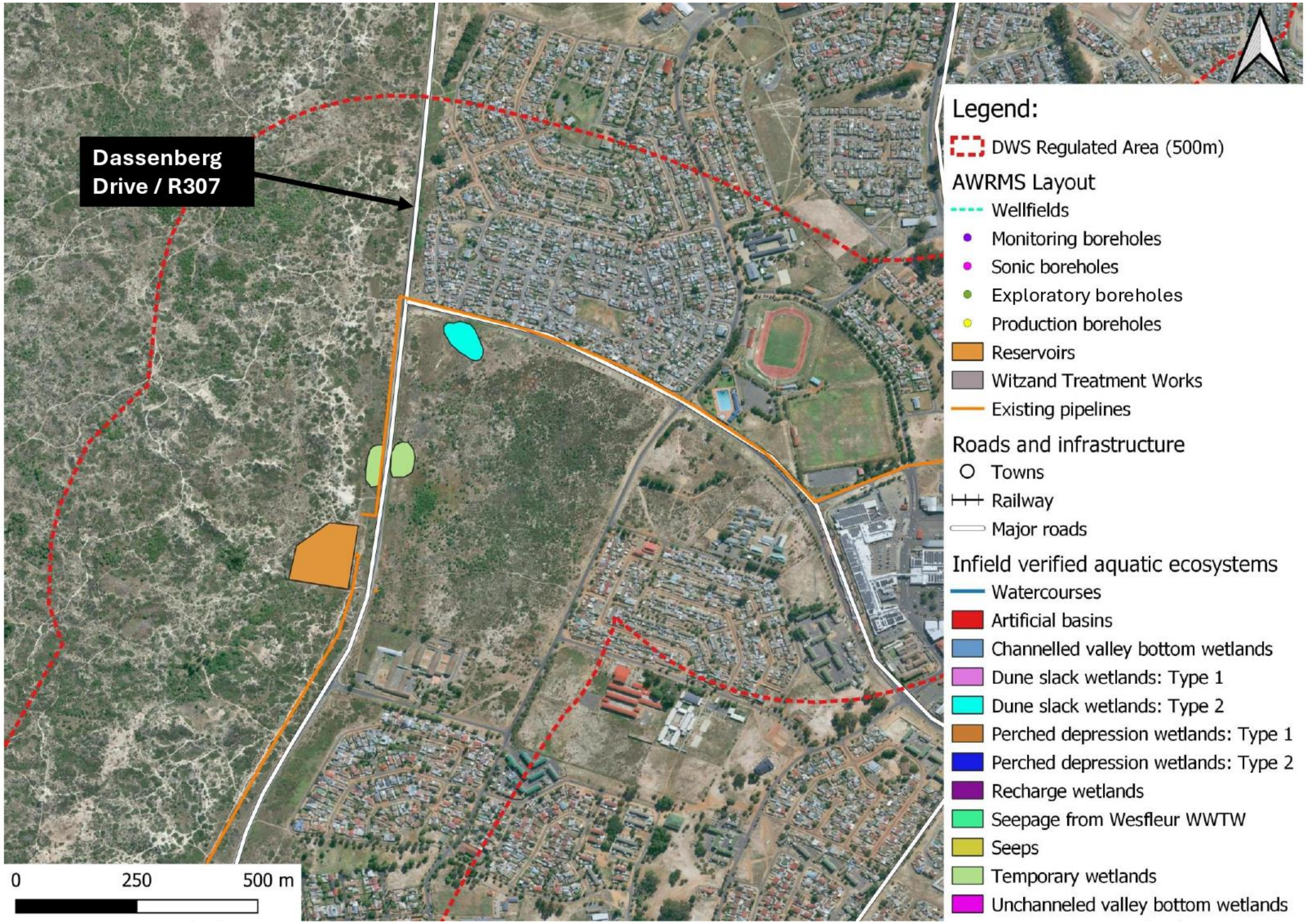

Figure 2.18: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

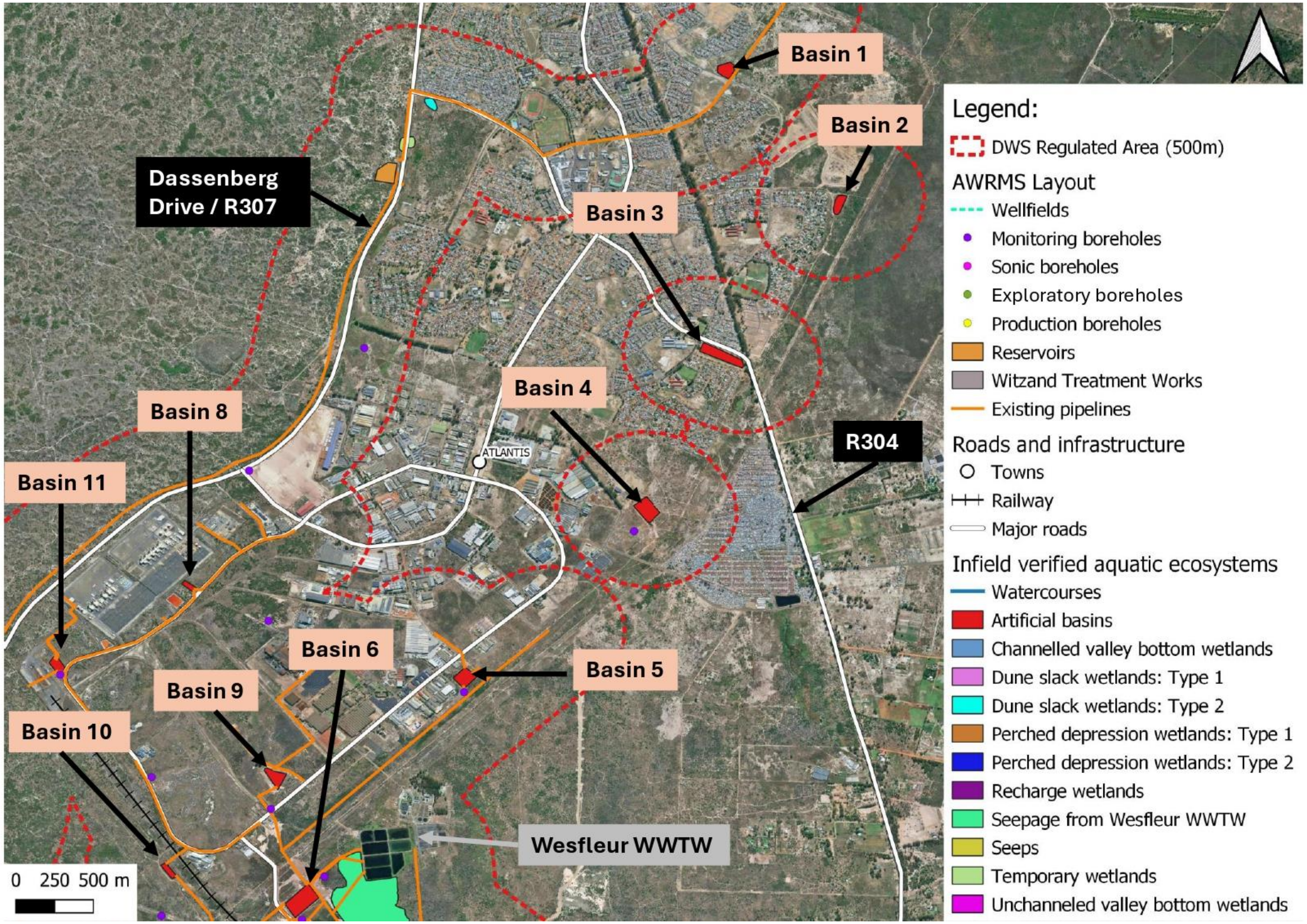

Figure 2.19: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

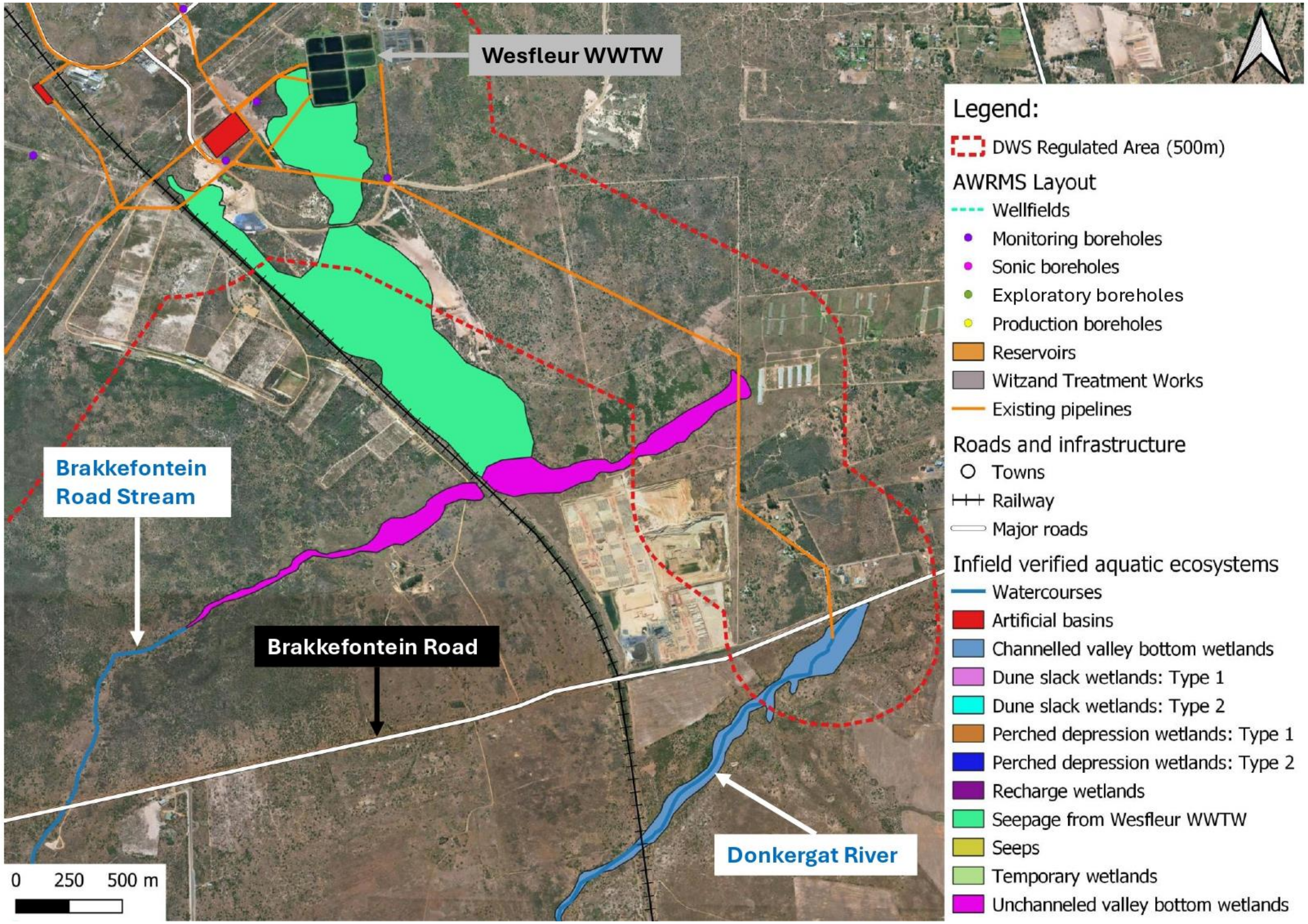

Figure 2.20: Map showing infield delineated inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 2.7.

3 AWRMS INFRASTRUCTURE

3.1 Existing infrastructure

The existing AWRMS infrastructure includes a variety of components (Figure 3.1 and Figure 3.2). These include:

- Below-ground pipelines transporting industrial effluent, domestic effluent, stormwater, groundwater or potable water (or a combination thereof)
- Wesfleur Wastewater Treatment Works and Witzand Water Treatment Plant/Works
- Production, monitoring and sonic boreholes
- Recharge basins with inlets, outlets and weirs
- Stormwater detention ponds
- Detention and polishing ponds (i.e. Basin 6)
- Reservoirs, pump stations, return flow chambers and outflows
- Road network (including bridge crossings and culverts) linking the above infrastructure

Any new infrastructure not included here would require environmental due diligence before an amendment is required to the MMP for which this report is being generated.

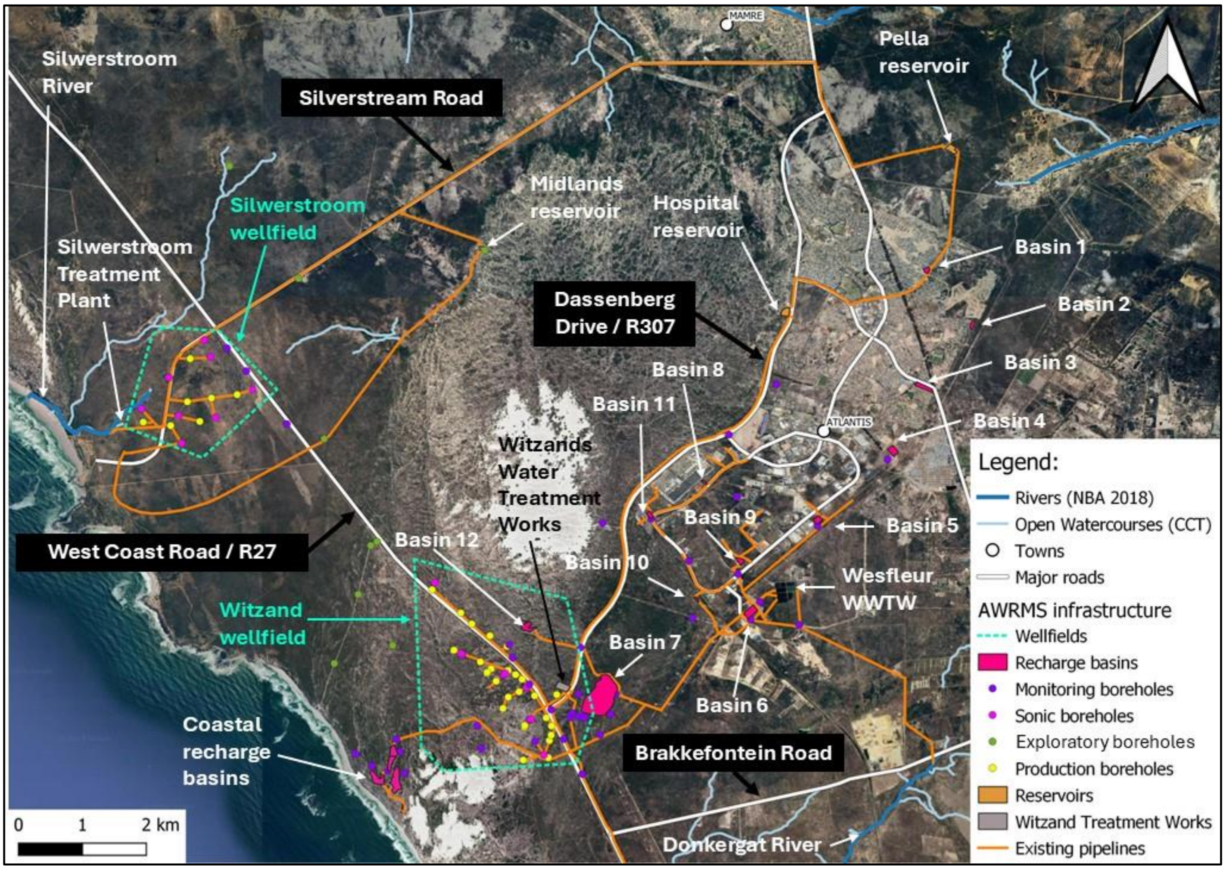

Figure 3.1: Map showing the northern portions of the existing infrastructure of the Atlantis Water Resource Management Scheme that was included in this assessment. Note: no field-verified inland aquatic ecosystems have been included on this map as they would make the map too cluttered.

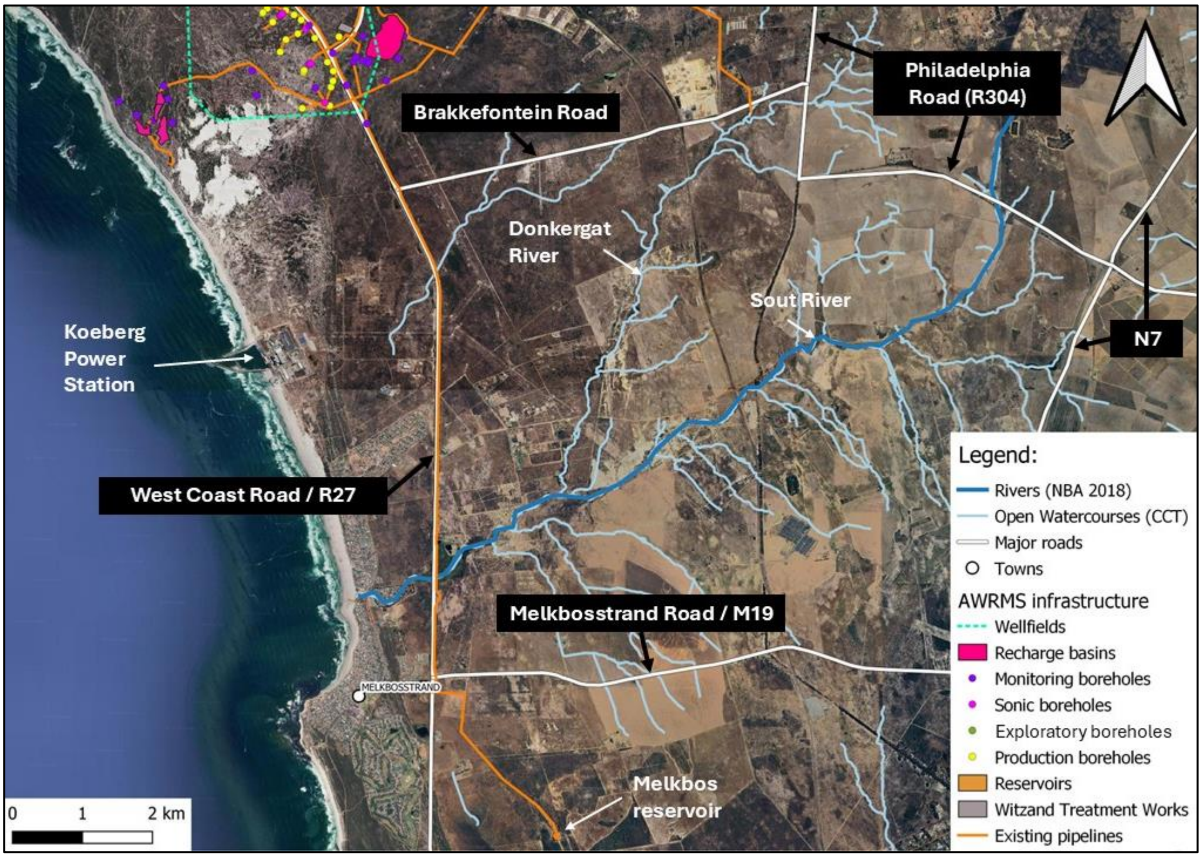

Figure 3.2: Map showing the southern portions of the existing infrastructure that has been built as part of the Atlantis Water Resource Management Scheme that was included in this assessment. Note: no field-verified inland aquatic ecosystems have been included on this map as they would make the map too cluttered.

Note: Considering that some of these existing pipelines were constructed more than 40 years ago, the exact placement of all pipeline routes on the maps provided in this report is not always accurate. Thus, as a safety precaution, when identifying which inland aquatic ecosystems may potentially be impacted by the proposed maintenance activities, it was assumed that the actual pipelines in the ground may be within 15m on either side of the mapped pipeline route.

3.2 Comment on water quality in pipelines and boreholes

The AWRMS pipeline network carries water of varying quality from various sources and discharges it into numerous storage facilities/basins, recharge areas and the Donkergat River (Figure 3.3). It must be noted that while most pipelines can be shut off during maintenance activities, some pipelines cannot be switched off. These include pipelines going into and coming out of the Wesfleur WWTW as well as those carrying stormwater. While most stormwater pipelines discharge into Basin 6 (which is currently being upgraded to increase its capacity), stormwater pipelines from the noxious industrial trade area (to the coastal recharge basins) cannot be shut off.

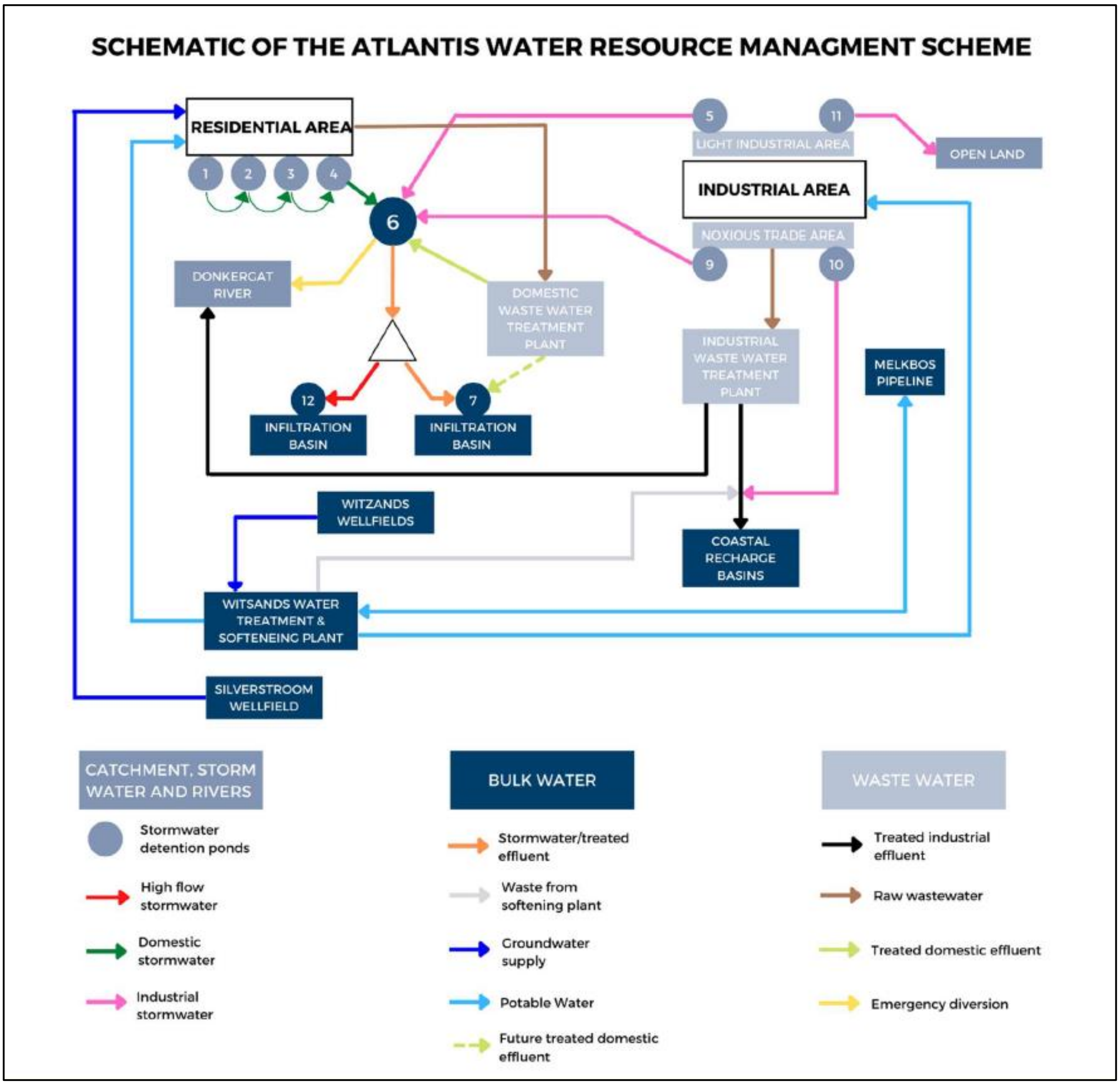

Figure 3.3: Schematic showing the conceptual flow (via pipelines) of various treated effluent types between different locations within the AWRMS. Sourced from City of Cape Town (2021).

The water quality data from various pipelines and manholes were interrogated to ascertain the main parameters for which water quality thresholds have been exceeded over the past few years (relative to the South African water quality guidelines – DWAF 1996), and may result in the deterioration of inland aquatic ecosystems in close proximity to these pipelines in the event that these pipelines are damaged, leak or flows cannot be stopped during maintenance activities (Table 3.1).

Table 3.1: Summary of the main water quality parameters that occasionally or regularly exceed thresholds that may negatively impact inland aquatic ecosystems. Note: in the determination of this list, some data points were below the laboratory's detection limit and thus the detection limit was halved and compared to water quality guidelines for inland aquatic ecosystems. This may inadvertently place an analysed parameter on this list even if the true concentration at the time of the sampling event may indeed be lower. Also, some parameters only had one or two data points – which may skew the overall results.

Pipeline routes	Main water quality parameters that occasionally/regularly exceed thresholds that may negatively impact inland aquatic ecosystems
Basin 10 to coastal recharge basins carries industrial stormwater from the noxious trade area in Atlantis	Cyanide, Selenium, Total Dissolved Solids, Total Suspended Solids, Aluminium, Copper, Iron, Zinc, Nitrogen and Orthophosphates
Basin 6 to Basin 7 and 12 carries a mix of stormwater (from the industrial area and residential area) as well as treated domestic effluent	Cyanide, Cadmium, Selenium, Total Dissolved Solids, Total Suspended Solids, Aluminium, Copper, Iron, Zinc, Nitrogen and Orthophosphates
Basin 6 to Donkergat River carries a mix of stormwater (from the industrial area and residential area) as well as treated domestic and industrial effluent	Cyanide, Cadmium, Selenium, Total Dissolved Solids, Total Suspended Solids, Aluminium, Copper, Iron, Zinc, Nitrogen and Orthophosphates
Silwerstroom to residential carries treated potable water	Cyanide, Cadmium, Iron, Zinc, Copper, Aluminium
Witzand Treatment Works to Melkbos Reservoir carries treated potable water	Cyanide, Cadmium, Iron, Zinc, Copper, Aluminium

4 ECOLOGICAL ASSESSMENT OF AFFECTED ECOSYSTEMS

4.1 *Potentially impacted aquatic ecosystems*

It must be noted that although numerous inland aquatic ecosystems were identified within the DWS-regulated area (500m) of the existing AWRMS infrastructure (see Section 2.4), only a subset of rivers and wetlands are regarded as potentially affected aquatic ecosystems (Figure 4.1). This is because they exist upslope of infrastructure or they are hydrologically isolated from the proposed maintenance activities i.e. there is a barrier (e.g. an impermeable road or dune) between the inland aquatic ecosystem and where the maintenance activity will be taking place. The potentially affected aquatic features that will be impacted by the proposed maintenance activities have been numbered on the series of maps below (Figure 4.2 to Figure 4.12), and the ecological assessment includes only these inland aquatic features.

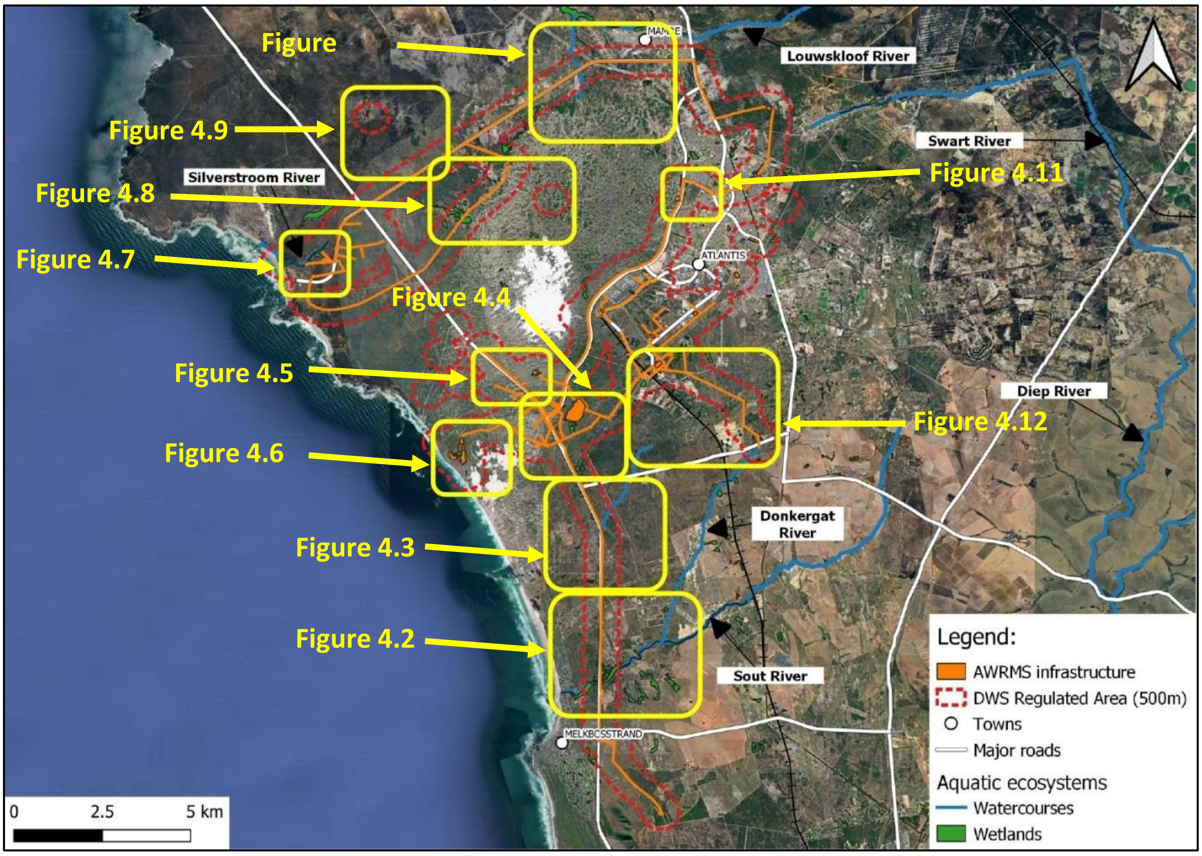

Figure 4.1: Map showing the entire AWRMS infrastructure route with yellow polygons showing the extent of the series of zoomed-in maps below of verified inland aquatic ecosystems.

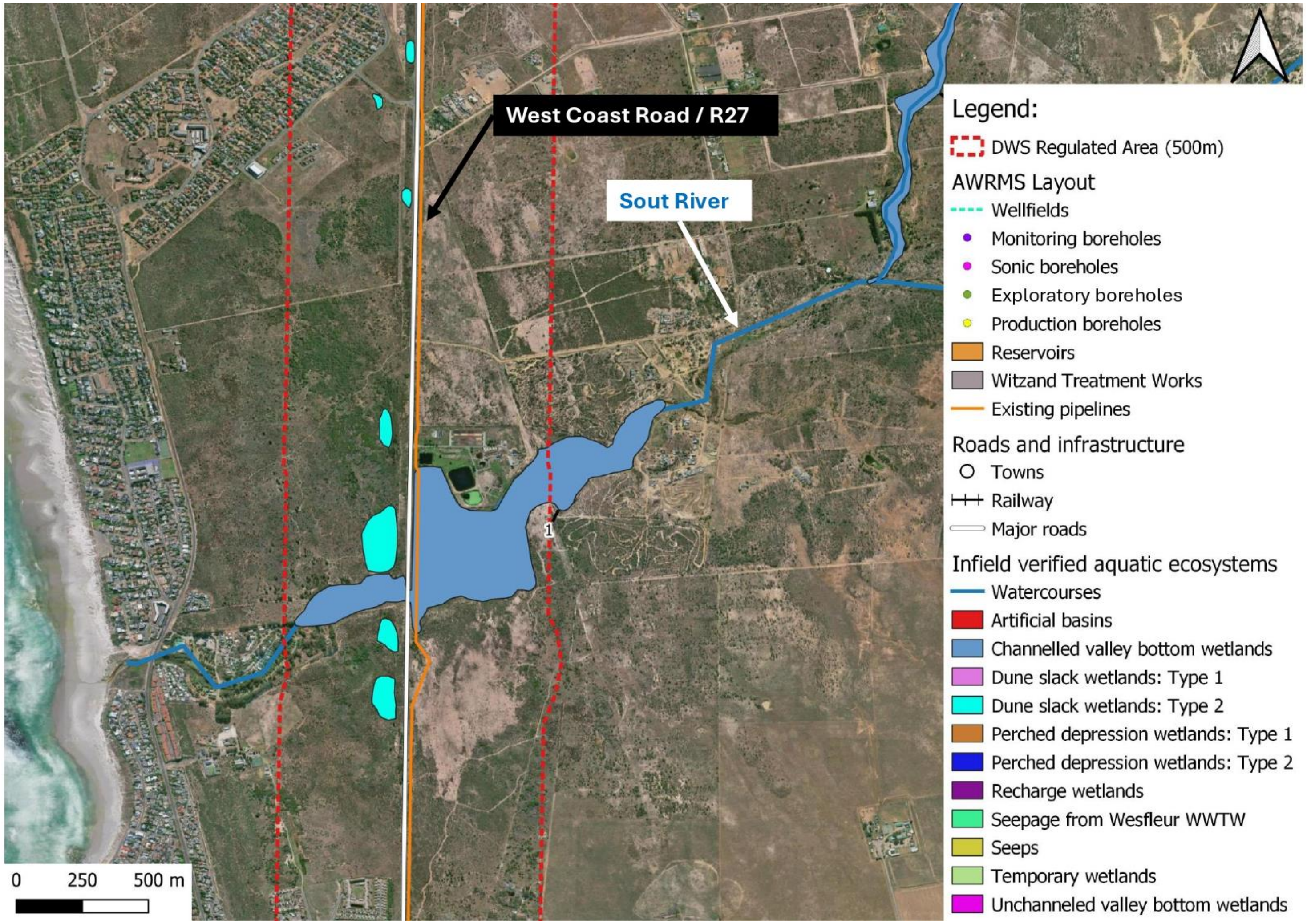

Figure 4.2: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

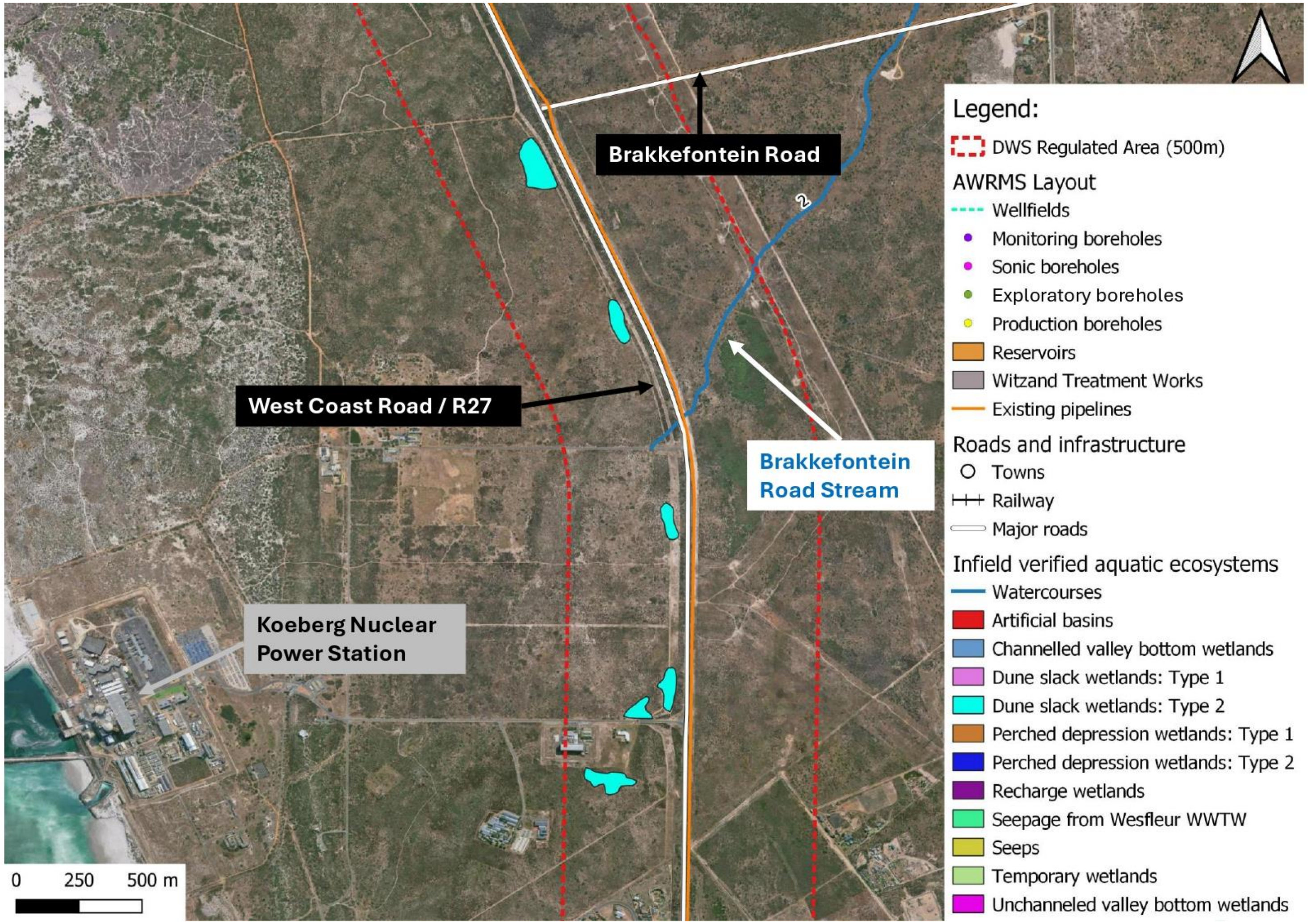

Figure 4.3: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

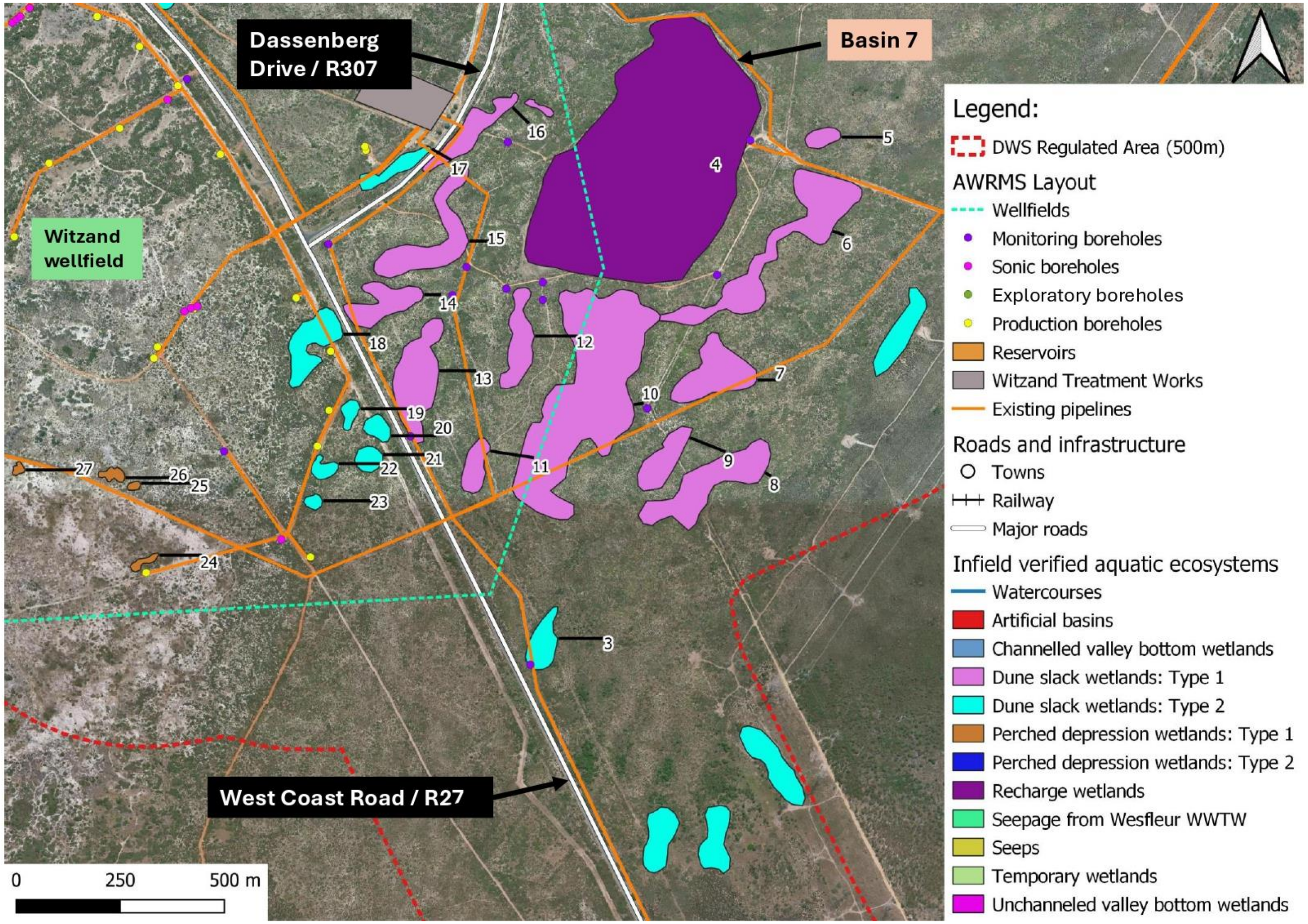

Figure 4.4: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

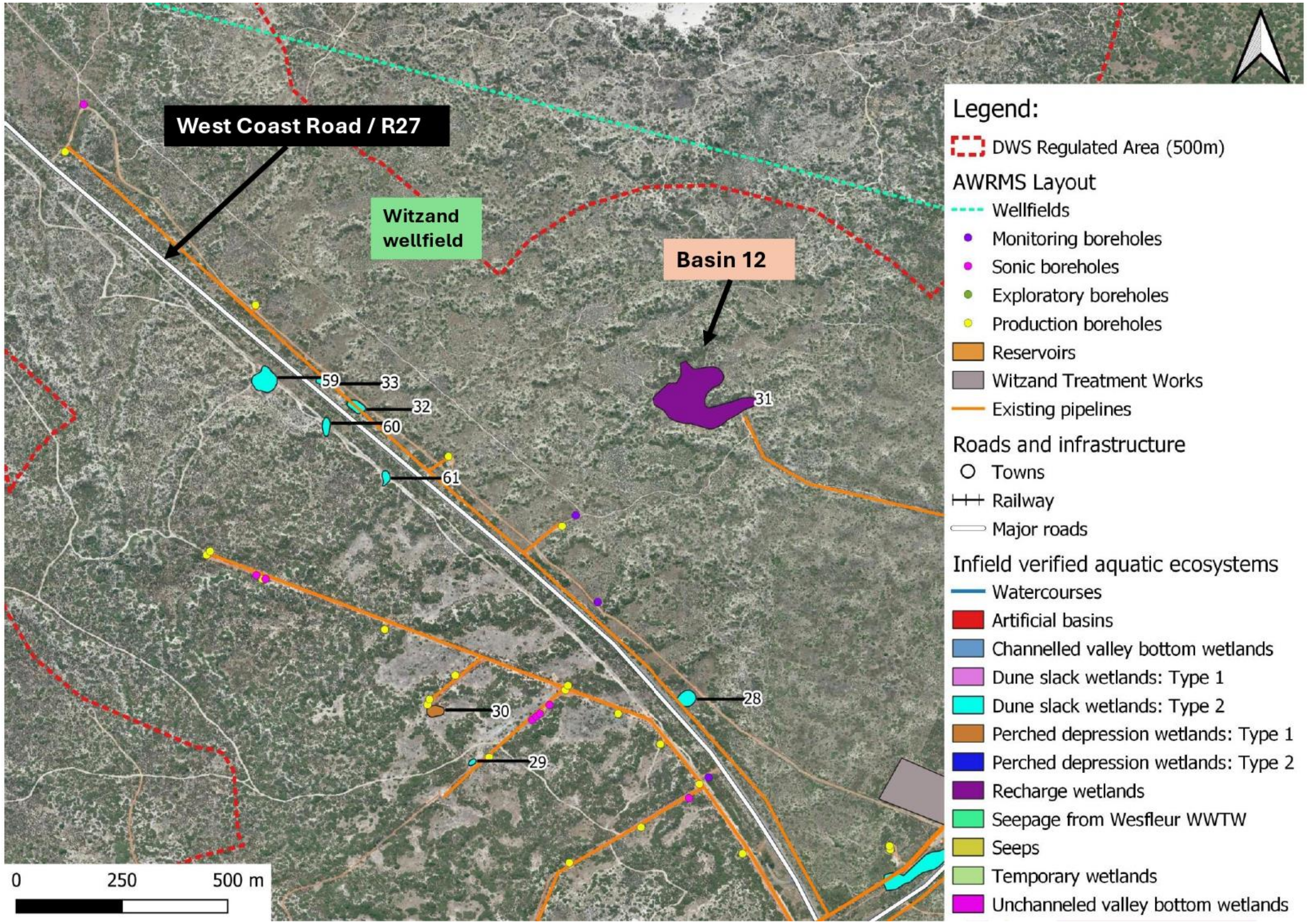

Figure 4.5: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

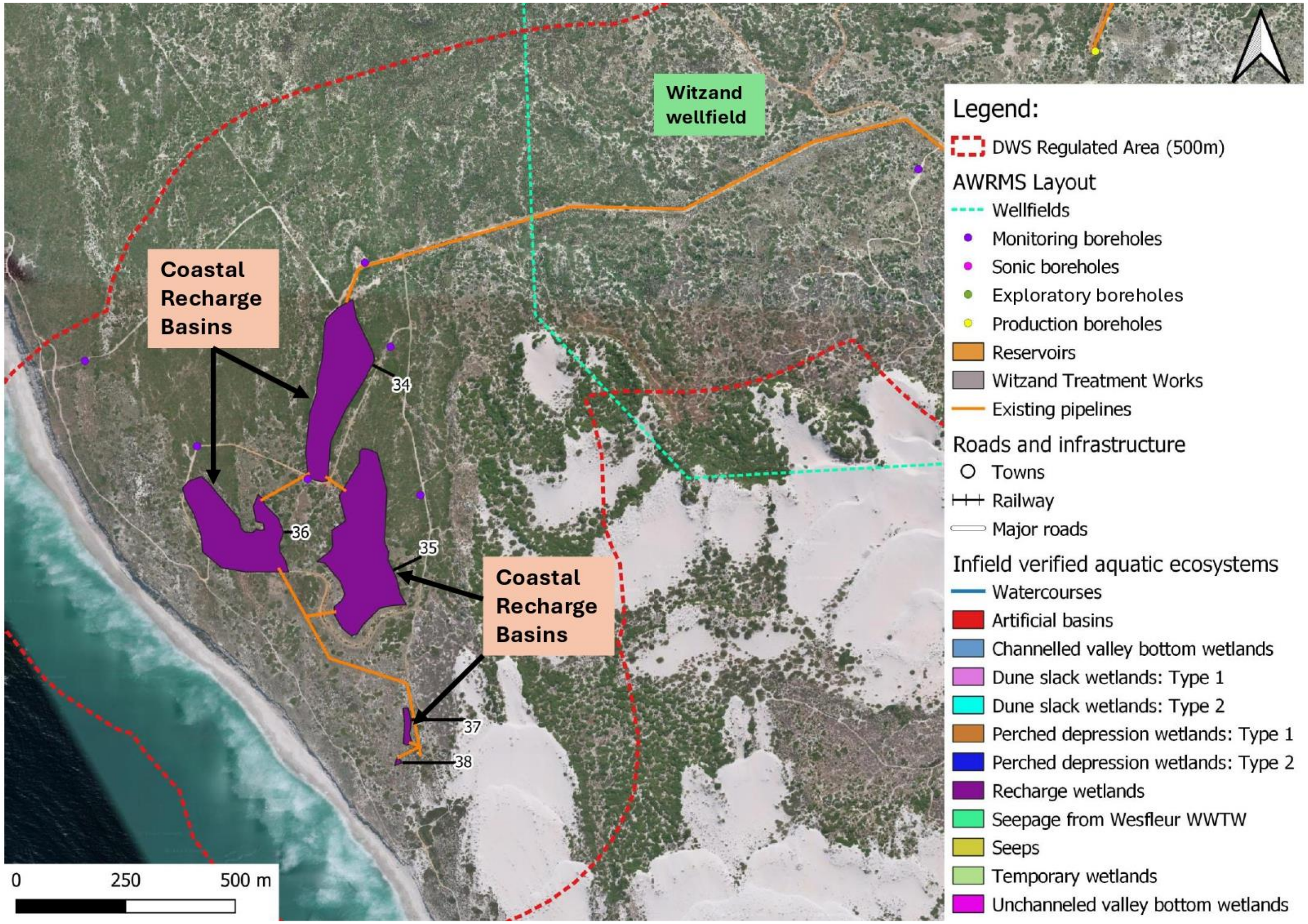

Figure 4.6: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

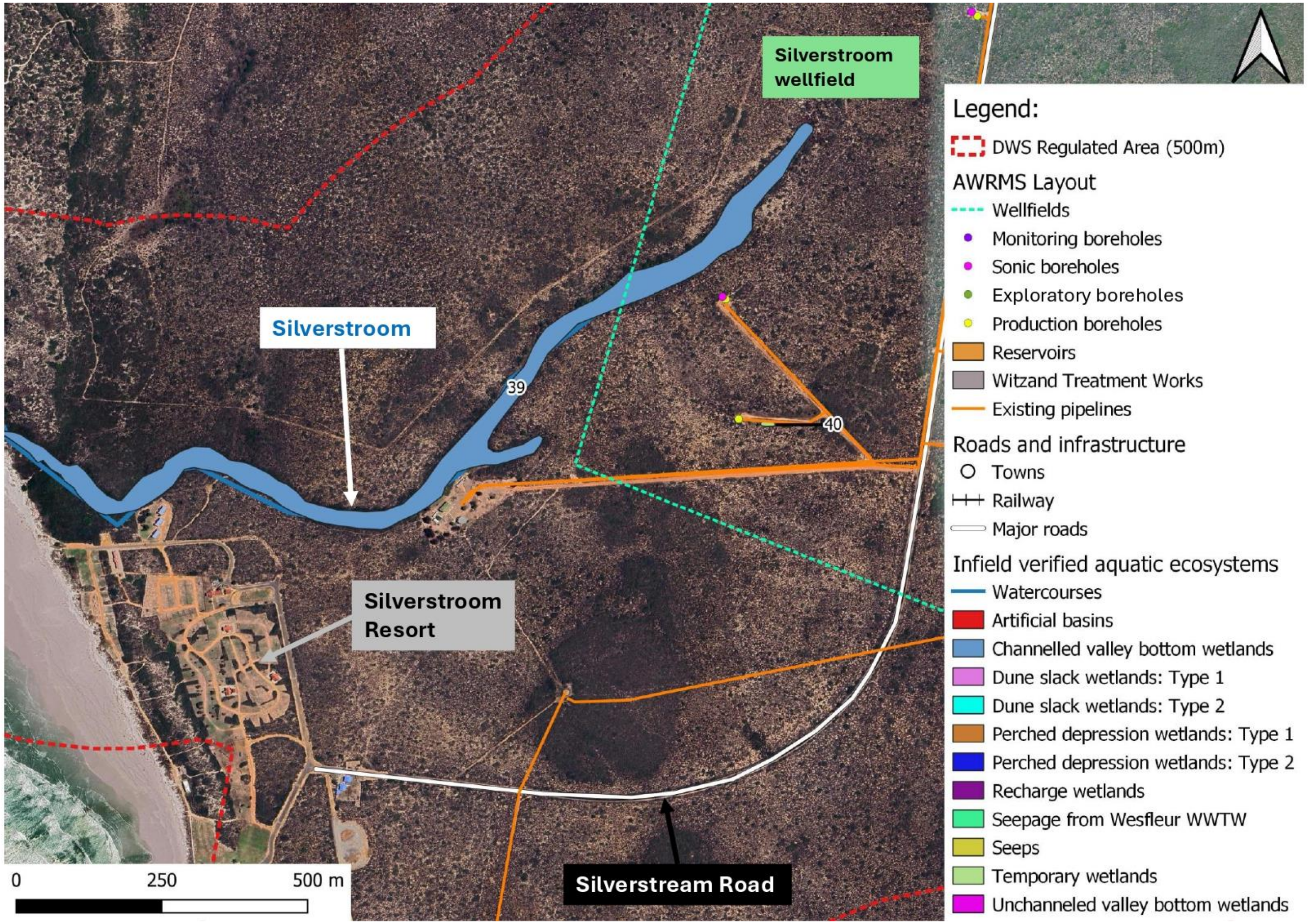

Figure 4.7: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

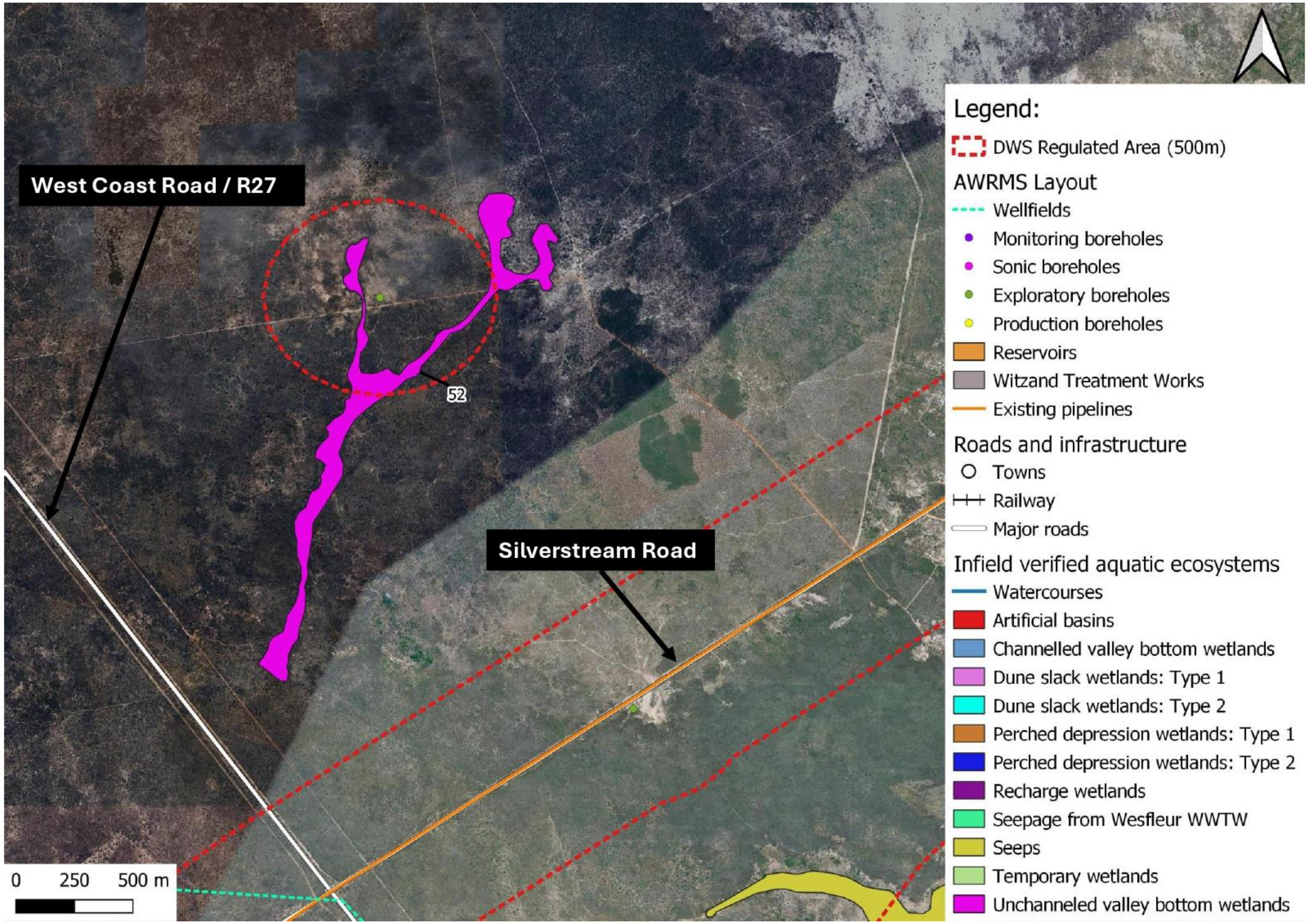

Figure 4.8: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

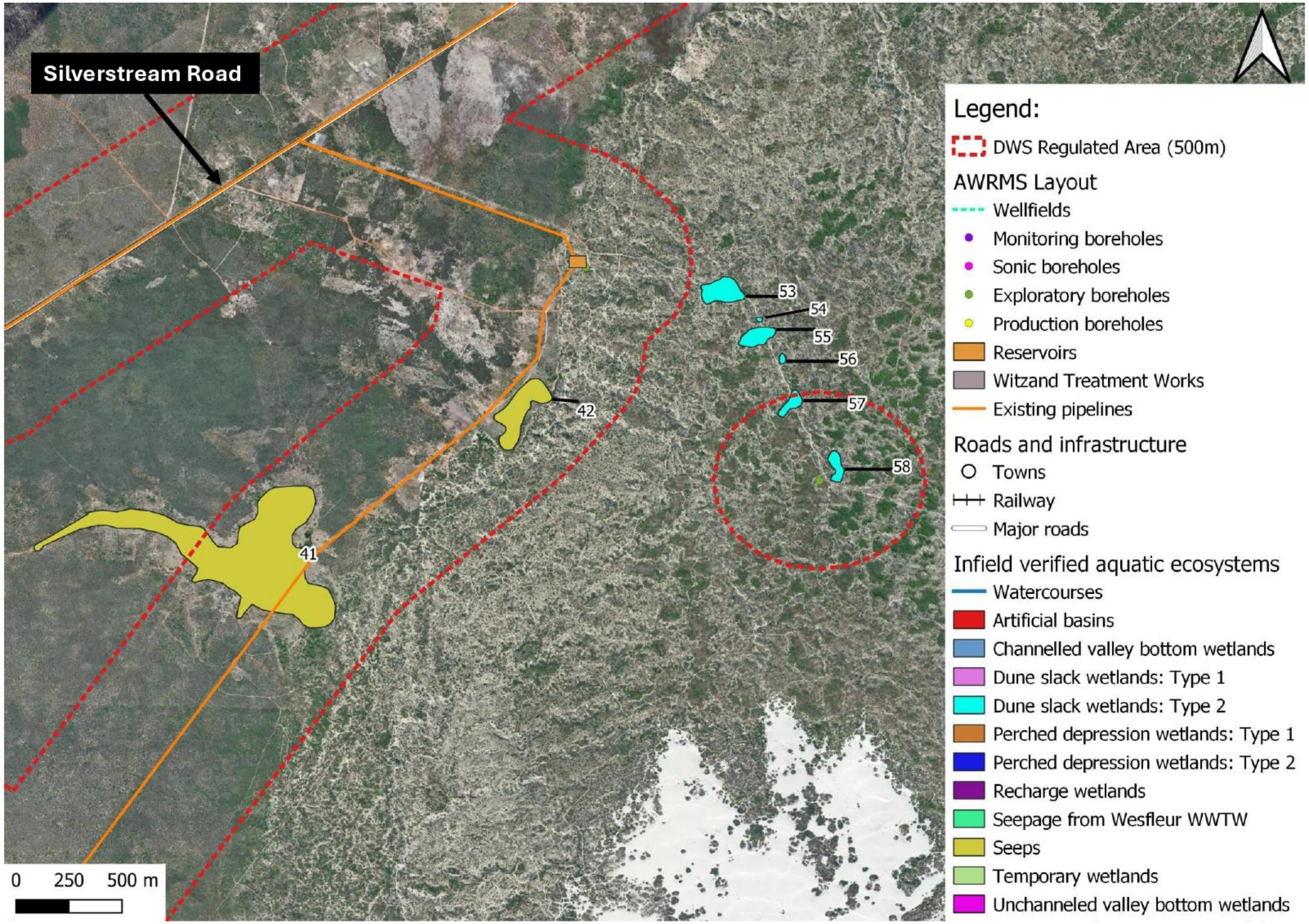

Figure 4.9: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

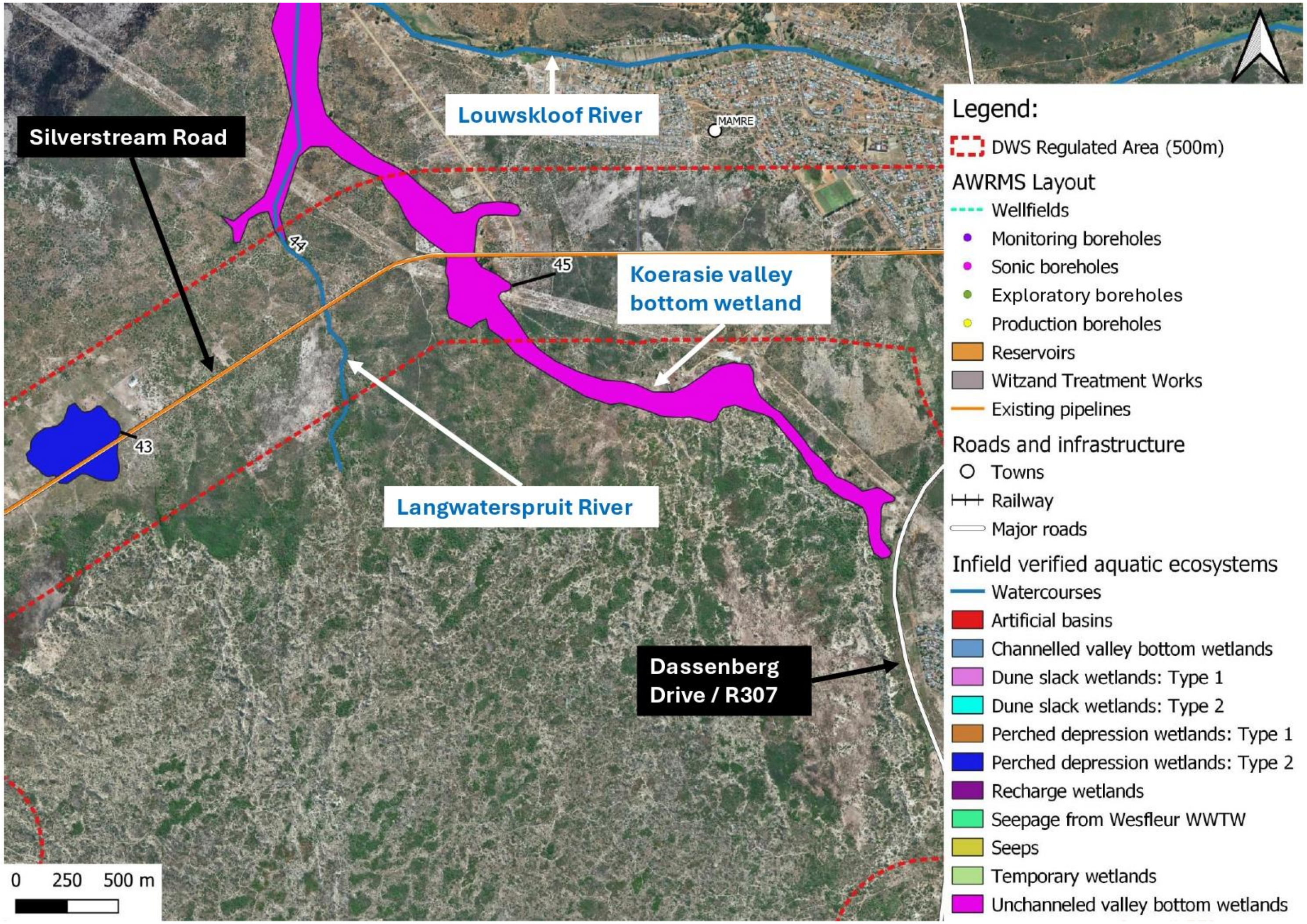

Figure 4.10: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

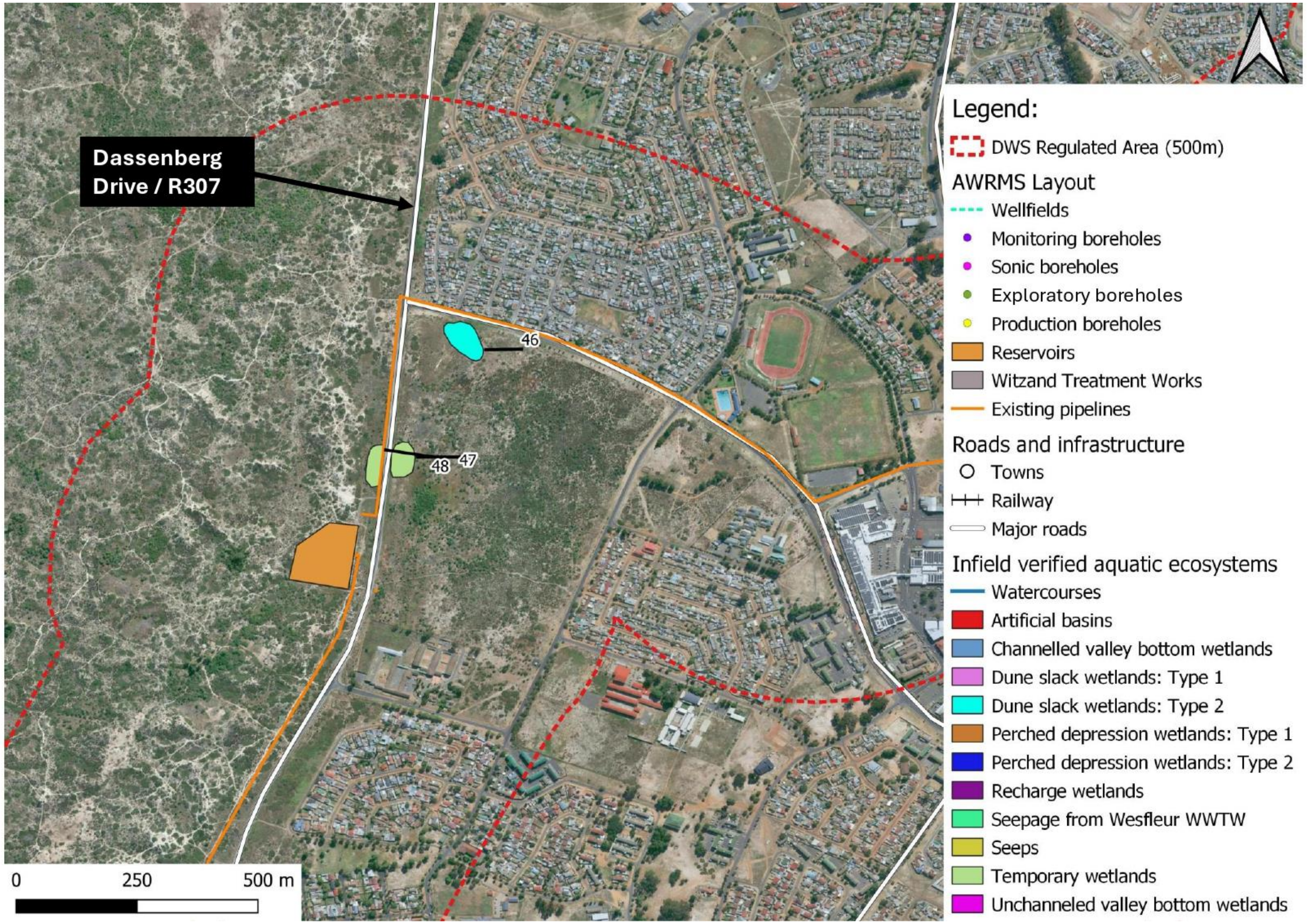

Figure 4.11: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

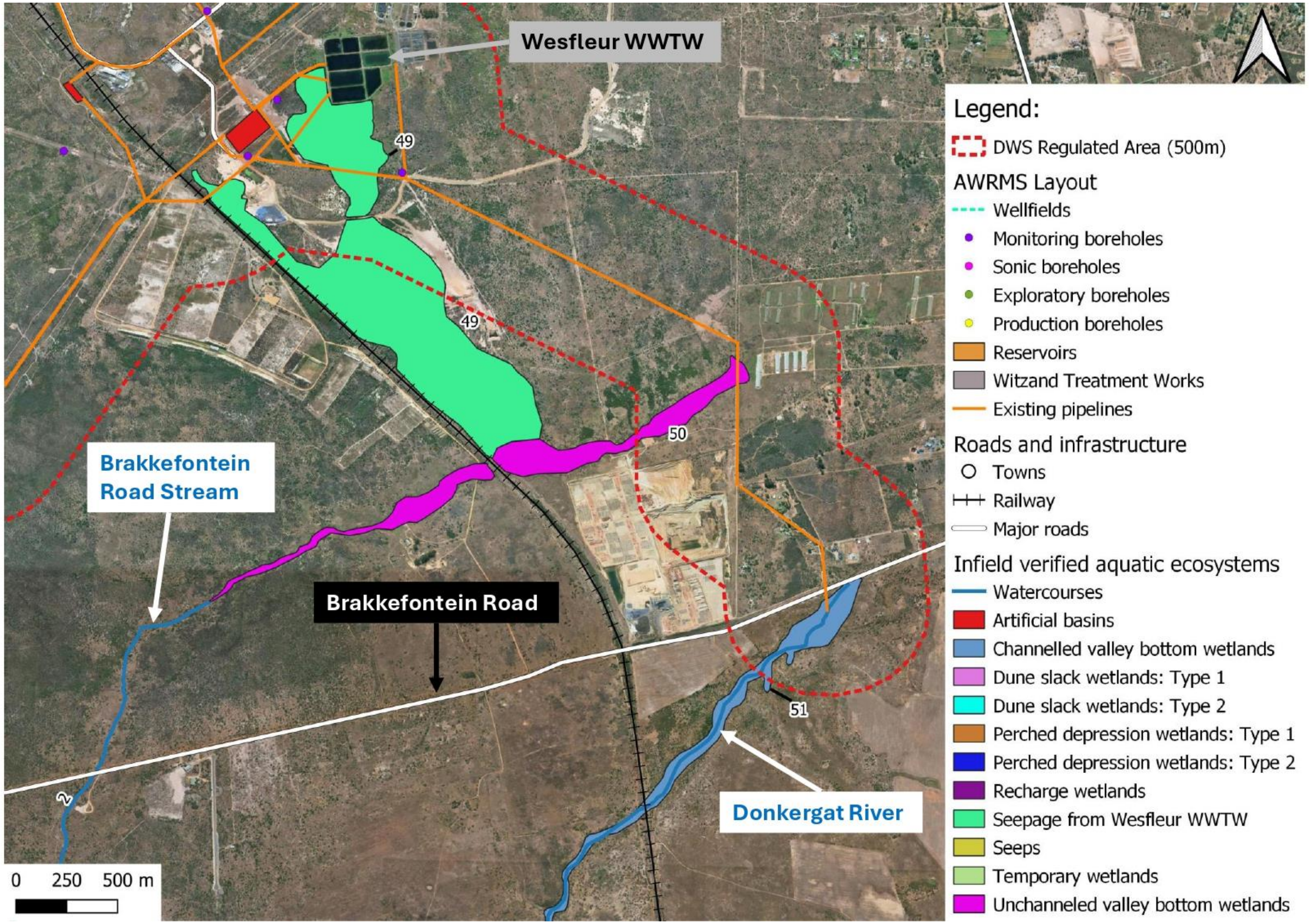

Figure 4.12: Map showing the inland aquatic ecosystems within the DWS-regulated area of the existing AWRMS infrastructure. Potentially impacted infield verified aquatic ecosystems are labelled with numbers, while unimpacted aquatic ecosystems are unlabelled. This map shows only a portion of the larger AWRMS infrastructure as shown in Figure 4.1.

4.2 *Ecological assessment of aquatic ecosystems*

As indicated above, only inland aquatic ecosystems that will potentially be impacted by the proposed maintenance activities have undergone an ecological assessment and will be described within this section.

4.2.1 Present Ecological State (PES)

Protocol for wetlands

The WET-Health assessment methodology was developed for the assessment of the Present Ecological State (PES) of the hydrology, geomorphology, water quality and vegetation of wetlands (MacFarlane et al., 2020). The method is based on the hydrogeomorphic (HGM) approach to wetland classification, providing a PES score for a wetland within each of the four modules – hydrology, geomorphology, water quality and vegetation - and a combined overall score. The score provides a quantitative measure of the extent, magnitude and intensity of deviation from the reference or unimpacted condition. The score places the wetland in a wetland health category, A – F (see Table 4.1). The wetland is divided into HGM units, and each unit assessed separately. Considering the large number of wetlands that needed to be assessed within this study, the WET-Health Level 1B method was utilised.

Table 4.1 Present Ecological State categories used to define the overall health or integrity of a wetland (from MacFarlane *et al.*, 2020).

CATEGORY	PES SCORES (%)	DESCRIPTION
A	90 – 100	Unmodified, natural.
B	80 – 89	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.
C	60 – 79	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats and biota may have taken place.
D	40 – 59	Largely modified. A large change in ecosystem processes and loss of natural habitats and biota has occurred.
E	20 – 39	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.
F	0 – 19	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.

Protocol for rivers

Habitat Integrity refers to the degree of naturalness of an inland aquatic ecosystem. It involves an assessment of key criteria, relating to the present condition of a system, compared to the probable natural condition.

The Index for Habitat Integrity (IHI) for rivers described in DWAF (1999a) was used to assess the ecological condition of the natural rivers within the study area. This assessment results in the assignment of a specific river reach to one of six Present Ecological Status (PES) Habitat Integrity Categories ranging from Category A (unmodified system) to Category F (critically modified) (Table 4.2).

Habitat Integrity assessments involve an assessment of a number of pre-weighted criteria, with each criterion being scored between 1 and 25 and the final Habitat Integrity score being calculated as a percentage. The criteria are: water abstraction; flow modification; bed modification; channel modification; water quality; inundation; exotic macrophytes; exotic fauna; solid waste disposal; indigenous vegetation removal; encroachment of exotic vegetation; bank erosion; channel modification (Table 4.3).

Table 4.2: Descriptions of habitat condition for different baseline categories and percentage scores, relative to natural (Kleynhans *et al.* 2009).

Baseline Category	Baseline Score (%)	Description of the habitat
A	90-100	**Unmodified**, natural.
B	80-89	**Largely natural with few modifications**. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.
C	60-79	**Moderately modified**. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	40-59	**Largely modified**. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	20-39	**Seriously modified**. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0-19	**Critically / Extremely modified**. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 4.3: Criteria used in the assessment of Present Ecological Status of rivers (Kleynhans *et al.* 2009).

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
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.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Flow modification – floods and low flows	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. 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.
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.
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	Invasion by exotic fauna will influence indigenous biodiversity, with possible knock-on effects for habitat quality and availability.
Solid waste disposal	This refers to litter and any other solid waste, i.e. a direct anthropogenic impact which may alter habitat structurally, obstruct flow, or have a direct impact on biota. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the vegetated buffer will reduce its ability to protect the river from sediment and polluted runoff from the surrounding catchment. Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Riparian area habitat diversity is reduced, and timing and quality of food source (leaves, wood, etc) for aquatic biota altered.
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.

Wetland and River PES Results

The inland aquatic ecosystems (rivers and wetlands) that were assessed were of varying ecological condition and were impacted by various factors - a summary is provided in Table 4.4. The detailed assessment outcomes are provided in Table 4.5 and Table 4.6.

Table 4.4: Summary of the main impacts affecting the ecological condition of the various inland aquatic ecosystems potentially affected by the proposed maintenance activities on the existing AWRMS infrastructure.

Aquatic feature	Main impacts affecting their PES
Koerasie unchannelled valley bottom wetland	Subsistence farming (primarily through livestock pastures); alien vegetation (e.g. *Acacia spp*); dam within the wetland; road infrastructure crossing wetland with inadequate culverts
Sout River channelled valley bottom wetland	Discharge of treated effluent from the Melkbos WWTW into the wetland; alien vegetation (e.g. *Acacia spp*); sedimentation from dryland agriculture; upstream discharge of treated effluent into Donkergat River – which joins the Sout River
Silwerstroom channelled valley bottom wetland	Abstraction for potable use; damming of the system by weir structures across the wetland; minor infestation of alien plants
Dune slack wetlands: Type 1	Increased saturation due to elevation of the water table as a result of the nearby recharge basin; proliferation of saturation-loving plants i.e. *Typha capensis*; water quality impairment of the local groundwater table; dirt road crossings; some alien vegetation
Dune slack wetlands: Type 2	Minor water quality impairment of the local groundwater table; some alien vegetation; road crossings
Perched depression wetlands: Type 1	Runoff (including sediments and hydrocarbons) from nearby roads (dirt and/or tar)
Perched depression wetlands: Type 2	Subsistence farming (primarily through livestock pastures); extensive overgrazing; roads; farmstead dwellings
Recharge wetlands	Increased saturation of treated effluent from domestic, stormwater and/or industrial origins; water quality impairment due to treated effluent inputs
Seepage from Wesfleur WWTW and sand mining activities	n/a as one cannot determine PES on artificial systems. These systems are, however, impacted by increased alien vegetation, poor water quality, earthworks and subsequent sedimentation due to erosion
Seeps	Alien vegetation; overgrazing and drainage furrows
Temporary wetlands	Alien vegetation; previous earthworks; runoff from dirt and/or tar roads (such as sediments and hydrocarbons)
Unchanneled valley bottom wetland (near chicken farm)	Seepage of treated effluent from Wesfleur WWTW; increased sedimentation from mining activities; earthworks; runoff of nutrient-enriched water from chicken farm; alien vegetation
Donkergat River channelled valley bottom wetland	Receipt of treated effluent discharge from Wesfleur WWTW; alien vegetation; some sedimentation from agricultural catchment runoff
Brakkefontein Road Stream	High sedimentation from upstream sand mining activities; alien vegetation; overland runoff from Wesfleur WWTW seepage
Langwaterspruit River	Dumping of litter and concrete; alien vegetation; grazing pastures

Aquatic feature	Main impacts affecting their PES
Unchannelled valley bottom wetland within the Ganzekraal Conservation Area	Trampling and grazing by cattle/horses; alien invasion; dumping of rubble/rush; increase sedimentation due to overgrazing of the surrounding area; receipt of cattle/horses manure

Table 4.5: Detailed summary of PES assessments of all wetlands (only) potentially impacted by the proposed maintenance activities on the existing AWRMS infrastructure. The results of the PES assessments on potentially impacted rivers are presented in Table 4.6.

Aquatic Feature Number	Classification Type and Name	Size (ha)	PES category				
			Hydrology	Geomorphology	Water quality	Vegetation	Overall
1	Sout River channelled valley bottom wetland	38.85	E	D	D	D	D/E
3	Dune slack wetland: Type 2	0.88	C	B	C	C	B/C
4	Recharge wetland	27.43	D	C	D	C	D
5	Dune slack wetland: Type 1	0.37	C	B	D	C	C
6	Dune slack wetland: Type 1	4.32	C	B	D	C	C
7	Dune slack wetland: Type 1	2.12	C	B	D	C	C
8	Dune slack wetland: Type 1	2.90	C	B	D	C	C
9	Dune slack wetland: Type 1	1.18	C	B	D	C	C
10	Dune slack wetland: Type 1	10.84	C	B	D	C	C
11	Dune slack wetland: Type 1	0.71	C	B	D	C	C
12	Dune slack wetland: Type 1	1.34	C	B	D	C	C
13	Dune slack wetland: Type 1	2.53	C	B	D	C	C
14	Dune slack wetland: Type 1	1.33	C	B	D	C	C
15	Dune slack wetland: Type 1	2.33	C	B	D	C	C
16	Dune slack wetland: Type 1	1.28	C	B	D	C	C
17	Dune slack wetland: Type 2	0.66	B	B	C	B	B
18	Dune slack wetland: Type 2	1.51	B	B	C	C	B
19	Dune slack wetland: Type 2	0.25	A	A	C	B	B
20	Dune slack wetland: Type 2	0.35	B	B	C	C	B
21	Dune slack wetland: Type 2	0.39	A	A	C	B	B
22	Dune slack wetland: Type 2	0.28	A	A	C	B	B
23	Dune slack wetland: Type 2	0.14	A	A	C	B	B
24	Perched depression wetland: Type 1	0.14	B	B	B	B	B
25	Perched depression wetland: Type 1	0.06	B	B	B	B	B
26	Perched depression wetland: Type 1	0.18	B	B	B	B	B

Aquatic Feature Number	Classification Type and Name	Size (ha)	PES category				
			Hydrology	Geomorphology	Water quality	Vegetation	Overall
27	Perched depression wetland: Type 1	0.08	B	B	B	B	B
28	Dune slack wetland: Type 2	0.15	B	B	C	C	B
29	Dune slack wetland: Type 2	0.02	B	B	C	C	B
30	Perched depression wetland: Type 1	0.11	B	B	B	B	B
31	Recharge wetland	2.27	D	C	D	C	D
32	Dune slack wetland: Type 2	0.11	B	B	C	C	B
33	Dune slack wetland: Type 2	0.06	B	B	C	C	B
34	Recharge wetland	3.80	D	C	E	C	D
35	Recharge wetland	5.11	D	C	E	C	D
36	Recharge wetland	3.40	D	C	E	C	D
37	Recharge wetland	0.14	D	C	E	C	D
38	Recharge wetland	0.02	D	C	E	C	D
39	Silwerstroom channelled valley bottom wetland	7.32	C	C	A	C	C
40	Temporary wetland	0.02	C	C	A	D	C
41	Seep	34.53	B	B	A	C	B
42	Seep	4.45	C	C	B	C	C
43	Perched depression wetland: Type 2	14.95	D	C	C	D	D
45	Koerasie unchanneled valley bottom wetland	80.34	C	B	C	D	C/D
46	Dune slack wetland: Type 2	0.51	C	B	C	D	C
47	Temporary wetland	0.36	D	D	C	E	D
48	Temporary wetland	0.31	D	D	C	E	D
49	Seepage from Wesfleur WWTW and sand mining activities	97.22	*not applicable given that it is an entirely artificial system				
50	Unchanneled valley bottom wetland (near chicken farm)	25.75	D	C	D	D	D
51	Donkergat channelled valley bottom wetland	49.07	D	D	E	D	D
52	Unchanneled valley bottom wetland in Ganzekraal Conservation Area	26.20	C	C	B	C	C

Aquatic Feature Number	Classification Type and Name	Size (ha)	PES category				
			Hydrology	Geomorphology	Water quality	Vegetation	Overall
53	Dune slack wetland: Type 2	2.21	B	B	B	D	C
54	Dune slack wetland: Type 2	0.07	B	B	B	D	C
55	Dune slack wetland: Type 2	1.35	B	B	B	D	C
56	Dune slack wetland: Type 2	0.14	B	B	B	D	C
57	Dune slack wetland: Type 2	0.76	B	B	B	D	C
58	Dune slack wetland: Type 2	0.82	B	B	B	D	C
59	Dune slack wetland: Type 2	0.31	B	B	C	C	B
60	Dune slack wetland: Type 2	0.08	B	B	C	C	B
61	Dune slack wetland: Type 2	0.06	B	B	C	C	B

Table 4.6: Results of the Index of Habitat Integrity assessment for the three different rivers (only) that may potentially be impacted by the proposed maintenance activities on the existing AWRMS infrastructure. Each criterion is scored between 0 and 25 with 0 indicating no modification and 25 indicating a critical modification. The results of the PES assessments on potentially impacted wetlands are presented in Table 4.5.

General Information	*River catchment*	**G21B (Sout)**		**G21A (Louwskloof)**	
	River name	***Brakkefontein Road Stream (Aquatic Feature 2)***		***Langwaterspruit Stream (Aquatic Feature 44)***	
	Geomorphological zone	Non-perennial lower foothill watercourse		Non-perennial lower foothill watercourse	
		Score	Confidence	Score	Confidence
Habitat Integrity / Present Ecological Status Assessment	Water abstraction	0	M	0	M
	Inundation	0	M	2	M
	Water Quality	16	M	11	M
	Flow modifications: Floods	15	M	5	M
	Flow modifications: Low flows	8	M	5	M
	Presence of exotic macrophytes	2	M	0	M
	Channel Modification	5	M	5	M
	Bed modification	20	M	8	M
	Exotic encroachment	12	M	17	M
	Presence of exotic fauna	0	L	0	L
	Presence of solid waste	3	M	16	M
	Removal of indigenous vegetation	15	M	15	M
	Erosion	5	M	10	M
			Class		Class
	Instream score (%)	70.5	C	79.8	C
	Riparian score (%)	66.8	C	66.8	C
	Overall score (%)	**68.6**	C	**73.3**	C
	Habitat Integrity	**C**		**C**	

4.2.2 Ecological Importance and Sensitivity

Protocol for wetlands

The importance of the wetlands was assessed by considering the range of goods and services identified in the WET-Ecoservices tool (Kotze *et al.*, 2009). These generic services include:

- Flood attenuation
- Streamflow regulation
- Sediment trapping
- Phosphate trapping
- Nitrate removal
- Toxicant removal
- Erosion control
- Carbon storage
- Maintenance of biodiversity
- Water supply for human use
- Natural resources
- Cultivated foods
- Cultural significance
- Tourism and recreation
- Education and research

The outcomes of the WET-Ecoservices assessment were then used to inform an assessment of the overall importance and sensitivity of the wetlands using the Wetland Ecological Importance and Sensitivity (EIS) assessment tool of Rountree *et al.* (2013). The tool includes an assessment of three suites of importance criteria, namely:

- Traditional ecological importance and sensitivity (biodiversity support, landscape scale importance, and the sensitivity of the wetland to change);
- Hydrological and functional importance (water quality, flood attenuation and sediment trapping ecosystem services that the wetland may provide), and
- Human benefits (subsistence and cultural use of the wetland).

The maximum score for each suite of importance criteria was taken to be the overall EIS category for the wetlands, as described in Table 4.7.

Table 4.7 Ecological Importance and Sensitivity (EIS) Categories for wetlands (Rountree *et al.*, 2013).

Ecological Importance and Sensitivity Categories	Range of EIS scores
Very high: Wetlands that are considered ecologically important and sensitive on a **national or even international** level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and ≤4
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and ≤3
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and ≤2
Low/marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and ≤1

Protocol for rivers

The Ecological Importance and Sensitivity (EIS) methodology derived by DWAF (1999) was used to determine the EIS of the rivers within the study area. According to this methodology, ecological **importance** of inland aquatic ecosystems is defined as “an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales” and “**sensitivity**” as “the extent to which the biota is able to accommodate change in the major physic-chemical features of the system”.

Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity of rivers. It is strongly biased towards the potential importance and sensitivity of the particular stream delineation, as it would be expected under unimpaired conditions. This means that the present ecological status (PES) or condition is generally not considered in determining the ecological importance and sensitivity *per se.* Each river reach is allocated to one of four EIS categories ranging from “very high” to “low/marginal”.

The following components are rated in an EIS assessment:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity should be taken into account for both the instream and riparian components of the river;
- Habitat diversity;
- Biodiversity in its general form;
- The importance of the particular river or stretch of river in providing connectivity between different sections of the river;

- The presence of conservation or relatively natural areas along the river section;
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes;

The above biotic and abiotic determinants are scored, using the criteria detailed in Section 11 (Appendix B), and the median score is calculated to derive the EIS category. These categories are defined in Table 4.8 below.

Table 4.8: Ecological importance and sensitivity categories (taken from DWAF 1999).

Ecological Importance and Sensitivity Categories	General Description
Very high (>3 and ≤4)	Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
High (>2 and ≤3)	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
Moderate (>1 and ≤2)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/marginal (>0 and ≤1)	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

Wetland and River EIS Results

Given the extensive number of wetlands within the study area, wetlands were grouped based on similar condition and HGM type in order to assess the ecosystem services that they provide as well as their ecological importance and sensitivity. The three river systems falling within the study area were assessed separately in terms of the above.

Most wetlands were assessed to be of ***moderate to high ecological importance and sensitivity*** given many are located in protected areas and thus are generally in good condition (Table 4.9). They are therefore important for the provision of good habitat for a large diversity of unique aquatic biota. While these wetland HGM types are fairly well protected within this catchment, these wetland types have experienced significant degradation and cumulative loss in surrounding catchments, thus emphasising their ecological importance. Many of these wetlands have a connection to groundwater sources and are therefore also sensitive to changes in hydrological regimes in the face of over-abstraction. Many of these wetlands also provide important water quality amelioration functionality within the AWRMS and have thus been assessed to be of ***moderate to high hydrological/functional importance*** (Table 4.9). For example, although the Donkergat River receives treated effluent, its surrounding valley bottom wetland provides critical water quality amelioration functionality to such an extent that it supports the threatened *Cape Galaxias* fish, as found in previous studies (CCT 2023). Lastly, the wetlands located outside protected areas are utilised more for their natural resources (such as grazing lands for cattle, water for cattle etc.) than those located within protected areas. These are therefore rated accordingly to be of ***low or moderate importance from a human benefit perspective***.

For the river systems, the Brakkefontein Road and Langwaterspruit Streams were assessed to be of ***low ecological importance and sensitivity*** (Table 4.10). This is because they provide limited diversity of habitat within the landscape and thus likely do not support unique, rare or endangered aquatic biota.

Table 4.9: Summary of the Ecological Importance and Sensitivity assessment results of the affected inland aquatic ecosystems (wetlands only).

Wetland type	Ecological importance and sensitivity (EIS)	Hydrological/functional importance	Direct human benefits
Dune Slack Wetland Type 1	2.5 (HIGH)	1.81 (MODERATE)	1.06 (LOW-MODERATE)
Dune Slack Wetland Type 2	2.5 (HIGH)	1.51 (MODERATE)	1.02 (LOW-MODERATE)
Koerasie unchannelled valley bottom wetland	1.70 (MODERATE)	1.73 (MODERATE)	1.37 (MODERATE)
Perched Depression Wetland: Type 1	2.50 (HIGH)	1.42 (MODERATE)	1.04 (LOW-MODERATE)
Perched Depression Wetland: Type 2	1.60 (MODERATE)	1.42 (MODERATE)	1.28 (MODERATE)
Seeps	2.70 (HIGH)	2.16 (HIGH)	1.68 (MODERATE)

Wetland type	Ecological importance and sensitivity (EIS)	Hydrological/functional importance	Direct human benefits
Silwerstroom channelled valley bottom wetland	2.70 (HIGH)	2.00 (HIGH)	1.70 (MODERATE)
Sout River channelled valley bottom wetland	1.83 (MODERATE)	2.32 (MODERATE)	0.95 (LOW)
Temporary wetlands	1.00 (LOW)	1.00 (LOW)	0.73 (LOW)
Unchanneled valley bottom wetland (near chicken farm)	1.50 (MODERATE)	1.67 (MODERATE)	0.86 (LOW)
Seepage area below Wesfleur WWTW	1.00 (LOW)	2.25 (HIGH)	0.50 (LOW)
Recharge wetlands	1.90 (MODERATE)	2.13 (HIGH)	0.89 (LOW)
Donkergat River channelled valley bottom wetland	1.90 (MODERATE)	2.08 (HIGH)	1.00 (LOW)
Ganzekraal unchannelled valley bottom wetland	2.60 (HIGH)	2.36 (HIGH)	1.45 (MODERATE)

Table 4.10: Summary of the Ecological Importance and Sensitivity assessment results of the affected inland aquatic ecosystems (rivers only).

River	Ecological importance and sensitivity (EIS)
Brakkefontein Road Stream	LOW
Langwaterspruit Stream	LOW

4.2.3 Summary of PES and EIS of all potentially affected ecosystems within the project extent

Table 4.11 provides a summary of the results of the ecological assessments (PES and EIS) conducted on all inland aquatic ecosystems that may be affected by the proposed maintenance activities.

Table 4.11: Summary of the ecological assessments (PES and EIS) for the inland aquatic ecosystems (rivers and wetlands) that may potentially be impacted by the proposed maintenance activities.

Aquatic Feature Number	Classification and Name	Overall PES	EIS
1	Sout River channelled valley bottom wetland	D	Moderate
2	Brakkefontein Road Stream	C	Low
3	Dune slack wetlands: Type 2	B/C	High
4	Recharge wetlands	D	Moderate
5	Dune slack wetlands: Type 1	C	High
6	Dune slack wetlands: Type 1	C	High
7	Dune slack wetlands: Type 1	C	High
8	Dune slack wetlands: Type 1	C	High
9	Dune slack wetlands: Type 1	C	High
10	Dune slack wetlands: Type 1	C	High
11	Dune slack wetlands: Type 1	C	High
12	Dune slack wetlands: Type 1	C	High
13	Dune slack wetlands: Type 1	C	High
14	Dune slack wetlands: Type 1	C	High
15	Dune slack wetlands: Type 1	C	High
16	Dune slack wetlands: Type 1	C	High
17	Dune slack wetlands: Type 2	B	High
18	Dune slack wetlands: Type 2	B	High
19	Dune slack wetlands: Type 2	B	High
20	Dune slack wetlands: Type 2	B	High
21	Dune slack wetlands: Type 2	B	High
22	Dune slack wetlands: Type 2	B	High
23	Dune slack wetlands: Type 2	B	High
24	Perched depression wetlands: Type 1	B	High
25	Perched depression wetlands: Type 1	B	High
26	Perched depression wetlands: Type 1	B	High
27	Perched depression wetlands: Type 1	B	High
28	Dune slack wetlands: Type 2	B	High
29	Dune slack wetlands: Type 2	B	High
30	Perched depression wetlands: Type 1	B	High
31	Recharge wetlands	D	Moderate
32	Dune slack wetlands: Type 2	B	Moderate
33	Dune slack wetlands: Type 2	B	Moderate
34	Recharge wetlands	D	Moderate
35	Recharge wetlands	D	Moderate
36	Recharge wetlands	D	Moderate
37	Recharge wetlands	D	Moderate
38	Recharge wetlands	D	Moderate
39	Silwerstroom channelled valley bottom wetland	C	High
40	Temporary wetlands	C	Low

Aquatic Feature Number	Classification and Name	Overall PES	EIS
41	Seeps	B	High
42	Seeps	C	High
43	Perched depression wetlands: Type 2	D	Moderate
44	Langwaterspruit River	C	Low
45	Koerasie unchanneled valley bottom wetlands	C/D	Moderate
46	Dune slack wetlands: Type 2	C	High
47	Temporary wetlands	D	Low
48	Temporary wetlands	D	Low
49	Seepage from Wesfleur WWTW and sand mining activities	n/a	Low
50	Unchanneled valley bottom wetlands	D	Moderate
51	Donkergat River channelled valley bottom wetland	D	Moderate
52	Unchanneled valley bottom wetland in Ganzekraal Conservation Area	C	High
53	Dune slack wetland: Type 2	C	High
54	Dune slack wetland: Type 2	C	High
55	Dune slack wetland: Type 2	C	High
56	Dune slack wetland: Type 2	C	High
57	Dune slack wetland: Type 2	C	High
58	Dune slack wetland: Type 2	C	High
59	Dune slack wetland: Type 2	B	High
60	Dune slack wetland: Type 2	B	High
61	Dune slack wetland: Type 2	B	High

4.3 Buffer determination

The guidelines provided by MacFarlane and Bredin (2017) were used to recommend buffer zones[3] for the protection of the inland aquatic ecosystems identified and assessed within the study area. The guidelines consider the ecological condition and sensitivity of an inland aquatic ecosystem in relation to the risks associated with a specific land-use activity as well as climatic and topographical features of the landscape such as rainfall, soils and slope.

For the purposes of this assessment, the sector "Service Infrastructure[4]" was selected as the land-use activity that poses a potential risk to aquatic ecosystems. The buffer tool allows the determination of buffer widths both with and without mitigation measures. Considering that mitigation will be implemented as recommended in this report (see Section 5), the recommended buffer for all inland aquatic ecosystems (rivers and wetlands) ranges between 27 and 39m (on either side of the water

[3] Buffer zones are setback areas typically designed to act as a barrier between human activities and water resources thereby protecting their functional and/or biodiversity value from adverse negative impacts (MacFarlane and Bredin 2017).

[4] Sub-sector "Pipelines for the transportation of waste water" is described in MacFarlane and Bredin (2017) as "Pipelines for the transport of waste water (e.g. sewage) to treatment facilities".

resource) for the operational phase of the AWRMS project. To simplify the buffer range, the maximum buffer width (i.e. 40m) must be applied across all inland aquatic ecosystems.

Note: the buffer determination of 40m only applies as a mitigation measure, where aquatic ecosystems will be avoided by the proposed maintenance activities. Where work occurs within a wetland or river, then other mitigation measures apply as outlined in Section 5.

5 PROPOSED MAINTENANCE ACTIVITIES AND ASSESSMENT OF IMPACTS

5.1 *Impact assessment methodology*

This section outlines the proposed method for assessing the significance of the potential environmental impacts of the proposed maintenance activities as provided by Zutari (Pty) Ltd. For each predicted impact, criteria are ascribed, and these include the intensity (size or degree scale), which also includes the type of impact, being either a positive or negative impact; the duration (temporal scale); and the extent (spatial scale), as well as the probability (likelihood). The methodology is quantitative, whereby professional judgment is used to identify a rating for each criterion based on a seven-point scale (refer to Table 5.1); and the significance is auto-generated using a spreadsheet through the application of the calculations in Figure 5.1. Specialists can comment where they disagree with the auto-calculated impact significance rating.

Calculations

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** *(*size or degree scale), which also includes the **type** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is applied to the consequence.

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative.

Figure 5.1: Calculation of significance

Table 5.1: Assessment criteria for the evaluation of impacts

Criteria	Numerical Rating	Category	Description
Duration	**1**	**Immediate**	Impact will self-remedy immediately
	2	**Brief**	Impact will not last longer than 1 year
	3	**Short term**	Impact will last between 1 and 5 years
	4	**Medium term**	Impact will last between 5 and 10 years

Criteria	Numerical Rating	Category	Description
	5	**Long term**	Impact will last between 10 and 15 years
	6	**On-going**	Impact will last between 15 and 20 years
	7	**Permanent**	Impact may be permanent, or in excess of 20 years
Extent	**1**	**Very limited**	Limited to specific isolated parts of the site
	2	**Limited**	Limited to the site and its immediate surroundings
	3	**Local**	Extending across the site and to nearby settlements
	4	**Municipal area**	Impacts felt at a municipal level
	5	**Regional**	Impacts felt at a regional level
	6	**National**	Impacts felt at a national level
	7	**International**	Impacts felt at an international level
Intensity	**1**	**Negligible**	Natural and/ or social functions and/ or processes are negligibly altered
	2	**Very low**	Natural and/ or social functions and/ or processes are slightly altered
	3	**Low**	Natural and/ or social functions and/ or processes are somewhat altered
	4	**Moderate**	Natural and/ or social functions and/ or processes are moderately altered
	5	**High**	Natural and/ or social functions and/ or processes are notably altered
	6	**Very high**	Natural and/ or social functions and/ or processes are majorly altered
	7	**Extremely high**	Natural and/ or social functions and/ or processes are severely altered
Probability	**1**	**Highly unlikely / None**	Expected never to happen
	2	**Rare / improbable**	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
	3	**Unlikely**	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
	4	**Probable**	Has occurred here or elsewhere and could therefore occur
	5	**Likely**	The impact may occur
	6	**Almost certain /**	It is most likely that the impact will occur

Criteria	Numerical Rating	Category	Description
		Highly probable	
	7	**Certain / Definite**	There are sound scientific reasons to expect that the impact will definitely occur

When assessing impacts, broader considerations are also taken into account. These include the level of confidence in the assessment rating; the reversibility of the impact; and the irreplaceability of the resource as set out in Table 5.2, Table 5.3 and Table 5.4, respectively.

Table 5.2: Definition of confidence ratings

Category	Description
Low	Judgement is based on intuition
Medium	Determination is based on common sense and general knowledge
High	Substantive supportive data exists to verify the assessment

Table 5.3: Definition of reversibility ratings

Category	Description
Low	The affected environment will not be able to recover from the impact - permanently modified
Medium	The affected environment will only recover from the impact with significant intervention
High	The affected environment will be able to recover from the impact

Table 5.4: Definition of irreplaceability ratings

Category	Description
Low	The resource is not damaged irreparably or is not scarce
Medium	The resource is damaged irreparably but is represented elsewhere
High	The resource is irreparably damaged and is not represented elsewhere

5.2 Details of the proposed maintenance activities and the assessment of impacts of these activities

Several generic maintenance activities have been proposed as part of the AWRMS project – all of which may potentially impact aquatic ecosystems and thus specific mitigation measures have been proposed. The main eight activities are summarised and categorised in the table below (Table 5.5) – with explanations/details on each activity provided within the assessment of impacts further below.

Table 5.5: Categorisation of all maintenance activities in order to provide targeted mitigation measures.

Broad Category	Description of specific maintenance activities
Activity Type 1: Maintenance of roads and drainage structures along the road network	1.1 Repair of damaged water crossing infrastructure
	1.2 Replacement of damaged road after large storm events
	1.3 Replacement and maintenance of erosion control measures
	1.4 Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses
Activity Type 2: Management of invasive alien plants and clearance of indigenous vegetation near aquatic ecosystems	2.1 Clearing of alien invasive vegetation from watercourses, weirs and basins
	2.2 Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or drilling activities
Activity Type 3: Maintenance of above and below-ground pipeline/powerline repairs near aquatic ecosystems	3.1 Replacement of damaged pipeline infrastructure after large storm events
	3.2 Repair of pipeline and cable infrastructure
Activity Type 4: Maintenance of existing boreholes	4.1 Maintenance of existing boreholes (production and monitoring

The following section describes the specific maintenance activities proposed for the existing Atlantis Water Resource Management Scheme (AWRMS) infrastructure in terms of the impacts associated with these activities, and the mitigation measures that are recommended to reduce the negative consequences for each group of affected inland aquatic ecosystems (rivers and wetlands) (Table 5.6). These measures are all considered essential, and should be incorporated into the overall Maintenance Management Plan (including the Method Statements for each activity) for this project, as compiled by Zutari (Pty) Ltd. The measures outlined in this report serve specifically as input from a freshwater ecological perspective only.

Table 5.6: Summary of the aquatic feature types that will be impacted by specific maintenance activities. A shaded cell means that a specific activity will impact the aquatic type in that specific row, whereas a blank cell means that a specific activity will not impact the aquatic type in that specific row.

<table>
<tr><th rowspan="2">Inland aquatic ecosystem classification/name</th><th colspan="4"><u>Activity Type 1:</u> Maintenance of roads and drainage structures along the road network</th><th colspan="2"><u>Activity Type 2:</u> Management of invasive alien plants and clearance of indigenous vegetation near aquatic ecosystems</th><th colspan="2"><u>Activity Type 3:</u> Maintenance of above and below-ground pipeline/powerline repairs near aquatic ecosystems</th><th><u>Activity Type 4:</u> maintenance of existing boreholes</th></tr>
<tr><th>1.1 Repair of damaged water crossing infrastructure</th><th>1.2 Replacement of damaged road after large storm events</th><th>1.3 Replacement and maintenance of erosion control measures</th><th>1.4 Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses</th><th>2.1 Clearing of alien invasive vegetation from watercourses, weirs and basins</th><th>2.2 Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or redrilling activities</th><th>3.1 Replacement of damaged pipeline infrastructure after large storm events</th><th>3.2 Repair of pipeline and cable infrastruct-ure</th><th>4.1 Maintenance of existing boreholes (production and monitoring)</th></tr>
<tr><td>Dune slack wetlands: Type 1</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td></tr>
<tr><td>Dune slack wetlands: Type 2</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td></tr>
<tr><td>Koerasie unchanneled valley bottom wetland</td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td></td><td bgcolor="#ED7D31"></td><td></td></tr>
<tr><td>Perched depression wetlands: Type 1</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td></tr>
<tr><td>Perched depression wetlands: Type 2</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td></tr>
<tr><td>Recharge wetlands</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td></tr>
<tr><td>Seeps</td><td></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td></td><td bgcolor="#ED7D31"></td><td></td><td></td><td bgcolor="#ED7D31"></td><td></td></tr>
<tr><td>Seepage from Wesfleur WWTW and sand mining activities</td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td><td bgcolor="#ED7D31"></td></tr>
</table>

Inland aquatic ecosystem classification/name	**Activity Type 1: Maintenance of roads and drainage structures along the road network**				**Activity Type 2: Management of invasive alien plants and clearance of indigenous vegetation near aquatic ecosystems**		**Activity Type 3: Maintenance of above and below-ground pipeline/powerline repairs near aquatic ecosystems**		**Activity Type 4: maintenance of existing boreholes**
	1.1 Repair of damaged water crossing infrastructure	1.2 Replacement of damaged road after large storm events	1.3 Replacement and maintenance of erosion control measures	1.4 Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses	2.1 Clearing of alien invasive vegetation from watercourses, weirs and basins	2.2 Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or redrilling activities	3.1 Replacement of damaged pipeline infrastructure after large storm events	3.2 Repair of pipeline and cable infrastruct-ure	4.1 Maintenance of existing boreholes (production and monitoring)
Silwerstroom channelled valley bottom wetland									
Sout River channelled valley bottom wetland									
Temporary wetlands									
Unchanneled valley bottom wetland (near chicken farm)									
Brakkefontein Road Stream									
Langwaterspruit Stream									
Donkergat River channelled valley bottom wetland									
Ganzekraal unchanneled valley bottom wetland									

5.2.1 Activity Type 1: maintenance of roads and drainage structures along the road network

Description of proposed activities

1.1: Repair of damaged water crossing infrastructure

Replacement of broken culverts, redirecting of culverts which are located against the natural flow of a river, dredging within the watercourse to obtain access to infrastructure, removal of flood debris and silt and the infilling of material for stabilisation and support of new infrastructure.

Over time some of the gravel road approaches alongside the stream crossings could erode and cause the need for replacement or installation of erosion control measures. This would entail the infilling of material within close proximity of watercourses or within wetlands.

1.2: Replacement of damaged road after large storm events

In most instances after large storm events there is some degree of damage, including erosion of banks, gravel roads and bridge approaches. Some flood debris could also cause damage to the infrastructure itself which would need to be fixed or replaced (like for like) if damaged extensively. This could entail dredging, excavating and infilling in a stream.

1.3: Replacement and maintenance of erosion control measures

Where erosion control measures are already installed, maintenance would have to be done to ensure these remain in good working order or that areas that become prone to erosion are secured to protect infrastructure and prevent downstream impacts to the aquatic ecosystems. This would entail the potential excavation and infilling of material within watercourses or wetlands and activities such as gabion basket installations.

1.4: Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses

Over time, material such as silt, dead vegetation and litter will accumulate along, under, downstream of, behind and within infrastructure, and in rivers and wetlands. These need to be cleared regularly to ensure proper functioning of the infrastructure and ecosystems and prevent flooding and associated damage within these areas. The clearing would entail the dredging or excavation of debris, silt and other flooded material from the crossings.

Potential impacts

- Destabilisation of slopes, banks and beds of wetlands and rivers, leading to increased mobility of sediments into sensitive areas and possibly gully, head-cut channel (incision) and/or bank erosion.
- Increased sedimentation in sensitive areas, such as wetlands, riparian areas and instream channels, thus reducing habitat quality due to smothering of these habitats.
- Damage to riparian, instream and/or wetland vegetation when accessing working area and conducting the maintenance activity.
- Construction-related water quality impacts such as the leakage of fuels, oils, etc. from construction machinery – this could lead to pollution of the wetlands or rivers.
- Introduction of concrete/cement into rivers and wetlands. This can alter the pH of the water, and cause smothering of habitat, fauna and flora.
- Introduction of sand for construction which may contain alien plant seeds – which would pose a threat to the biodiversity in the area.
- Obstruction or diversion of surface flow during repair work. This could lead to a loss of connectivity within a river or wetland or erosion in an area receiving diverted flow.
- Disturbance of aquatic biota resulting in a change in community structure.
- Construction footprints and the storage of construction materials may lead to the introduction of invasive alien plant seeds/seedlings, compaction of soils and shading of indigenous plants.

Measures to mitigate the severity of these impacts

Various guiding principles should be followed when managing sediments for the AWRMS project. These have been outlined in Section 12 (Appendix C) and should be the basis for implementing the below mitigation measures.

- Where existing dirt roads need to be regraded (especially within aquatic ecosystems), care should be taken not to grade the road deeper than its natural base level.
- Gravel should not be pushed into natural areas during road maintenance.
- Road verges must be monitored for alien species, especially grasses.
- Road edges to be monitored for concentrated flow paths and erosion during maintenance.
- Remove damaged infrastructure that has washed downstream.
- Repair work must be done during the dry season (November to April), where possible, when most rivers and wetlands are dry.
- Wherever possible, concrete or cement must not be mixed on site, but rather delivered pre-mixed. If mixing of concrete is needed on site, the mixing area should be located at least 40m away from the edge of any river, riparian area or wetland.
- Soils/sand brought onto site should be inspected for seedlings throughout the maintenance project. Seedlings must be removed regularly.
- All construction footprints (e.g. construction camps, storage of materials used for repairs, etc.) must be minimised and preferably be located in previously disturbed areas – with sensitive natural areas demarcated along the edge of the buffer (i.e. 40m around rivers and wetlands) as no-go areas. The buffer recommendation only applies as a mitigation measure where

aquatic ecosystems will be avoided by the proposed activities. Where work occurs within a river or wetland, then mitigation measures proposed within this report apply.

- Machinery prone to oil or fuel leakage must be located at least 40m away from the edge of the rivers, riparian areas or wetlands, and the area adequately bunded in order to contain leakages.
- All machinery shall have drip trays to contain oil and fuel leaks – these must be cleaned regularly.
- Following the completion of the maintenance activity and where construction footprints were established, these areas need to be rehabilitated to the satisfaction of the ECO. This may include ripping compacted soils, removal of contaminated soils (if relevant), revegetation and removal of any invasive alien plant seedlings that may have established throughout the period when the maintenance activity took place.
- Care must be taken not to damage or destroy any indigenous riparian, instream or wetland vegetation.
- Maintenance must be monitored before and after repairs have been done by a suitably qualified Environmental Control Officer (ECO). It is not necessary that the ECO is external to or independent of the entity undertaking the maintenance.
- Areas where vegetation must be cleared for repair work to occur, or where vegetation has been damaged or destroyed as a result of repair work, must be rehabilitated and re-planted, to the satisfaction of the ECO (see above).
- Any repair work (in the form of earthworks) on any of the culverts (for the gabion baskets, concrete aprons or other erosion control measures) should be limited to the road reserve. Once complete, the soils need to be stabilized and replanted with indigenous plants (in consultation with a freshwater or rehabilitation specialist) to prevent the movement of sediments into inland aquatic ecosystems downstream.
- Rocks used within the gabion structures should be of a local geology to minimize any potential water quality impairment.
- No new access tracks or driving into the veld are permitted during construction, or for maintenance, except where approved by the ECO in consultation with the appropriate authorities and specialists.
- Road crossings over inland aquatic ecosystems should be demarcated with headwalls, to ensure that vehicles do not drive over wet areas, causing erosion and habitat degradation.
- The edges of roads (tracks) to be used for construction purposes are to be clearly delimited with fence poles before construction activities commence.
- All roads are to have passing areas clearly demarcated for the duration of the construction activities.
- Maintenance activities requiring major earthworks should not commence prior to significant rainfall unless, in emergency scenarios, where critical infrastructure for the operation of the AWRMS is needed.
- Once repair work has been completed, any slopes, banks and beds of wetlands and rivers should be stabilised and revegetated according to the mitigation measures set out under Section 5.2.2.
- When dealing with a channelised or canalised section of a river, or a stormwater drain, sediment can be removed down to the original invert level of the channel.

- Sediment removal can only be done during the dry summer months.
- Sediment in an unlined natural river or channel should only be removed by hand.
- Sediment in a lined river or channel can be removed mechanically, however, only if indigenous riparian vegetation will not be damaged in any way.
- Sediment removed from a river channel or canal should be stored in designated areas at least 40m away from any aquatic ecosystems, and used for other purposes relating to the maintenance project such as road construction, filling of eroded areas, etc. where possible.
- Sediment should never be removed from a wetland, unless supervised by a freshwater ecologist.
- During and after the process of sediment clearing, all litter or solid waste must be removed from within a 25m radius of the work site.
- The footprint associated with the clearing of culverts should be limited to the road reserve itself and not extend beyond this area. Where this is unavoidable (for whatever reason), the expanded disturbance footprint should be rehabilitated to the satisfaction of the ECO following the disturbance activity to ensure that no negative impacts are experienced further downstream.
- Clearing of silt from infiltration and recharge wetlands/basins should be conducted in the dry season (November to April), when these areas are less utilised. Care should be taken not to coincide with periods when biota (e.g. birds) make use of these systems for breeding purposes. Contaminated silt material should be disposed of at a designated and approved waste facility, with proof of disposal retained. Furthermore, silt clearing from these areas should be done with utmost care to prevent unnecessary damage to existing flora and fauna, and be done in a sensible and strategic manner. This should be well planned ahead of time to avoid/minimise disturbance to sensitive areas with input from a freshwater ecologist.

The significance rating (with and without the implementation of mitigation measures outlined above) following the assessment of impacts is summarised per aquatic ecosystem type in Table 5.8.

5.2.2 Activity Type 2: management of invasive alien plants and clearance of indigenous vegetation

<u>Description of proposed activities</u>

2.1: Clearing of alien invasive vegetation from watercourses, weirs and basins

Large alien invasives will be cleared using chainsaws. Smaller plants will be removed by hand using hand tools to remove the roots from the beds and banks of watercourses. Excavators may be needed to clear alien invasives in areas where access is limited, such as within saturated basins and abstraction ponds above weirs. All plant material will be removed and disposed of at a licenced Waste Disposal Facility (WDF), with proof thereof retained.

Eradication of undesired vegetation should be done by either manual or chemical means (not mechanical) and may include the felling and removal of undesirable/alien trees, shrubs, and grass.

2.2: Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or redrilling activities

More than 300 square metres of indigenous vegetation could be cleared during redrilling or maintenance activities (e.g., borehole cleaning) needed at any of the borehole sites for the establishment of drill rigs and/or other equipment.

Potential impacts

- Damage to bed and banks of rivers and wetlands during vegetation removal. This can lead to erosion and sedimentation downstream.
- Erosion of soil due to removal of stabilising plant cover. This can lead to the deposition of sediment downstream.
- Change in temperature regime due to removal of shade.
- Obstructions to flow caused by removed biomass being placed in the river or wetland and resulting in a change in hydrological regime and/or erosion.
- Disturbance of aquatic biota
- Water quality impacts relating to borehole cleaning could lead to pollution of the wetlands or rivers.

Measures to mitigate the severity of these impacts

Various guiding principles should be followed when managing vegetation for the AWRMS project. These have been outlined in Section 12 (Appendix C) and should be the basis for implementing the mitigation measures below.

Vegetation clearing

- Removal of problematic wetland, riparian or instream vegetation must be done by hand, in order to minimise damage to the banks and bed of the river channels and wetland habitats.
- Only herbicides that are appropriate for use close to inland aquatic ecosystems can be used (e.g. Focus Ultra). This must be done with great care and adherence to the recommended application protocols. Herbicides containing glyphosates may not be used in close proximity to wetlands or rivers (e.g. RoundUp). Furthermore, chemical application should be avoided on windy days and before heavy rains. The storage and handling procedures specified by the manufacturer of the chemical must be followed.
- Clearing of vegetation must be done during mid- to late summer/autumn (December – April), when most river channels and wetlands are dry.
- Cleared vegetation (biomass) must be removed from the cleared areas, and preferably chipped for use as mulch, or burned.
- Indigenous vegetation in rivers and wetlands that have a PES of B and above should not be removed without the approval of a freshwater ecologist.
- All alien plant species should be removed in a radius of 25m (within the road reserve) of all culverts, drains and rivers.

- A maximum width of 5m of vegetation around the culvert can be removed in instances where access to the culvert is required for maintenance. In areas where sensitive terrestrial vegetation occurs, guidance should be requested from the botanist in terms of whether search and rescue efforts will be required.
- Wherever possible and where vegetation growth is not a direct problem for surface water flow, cleared areas should be replanted with appropriate indigenous species. This is recommended where cleared areas exceed approximately 25m^2, or where cleared areas are at risk of erosion.
- Clearing activities must be overseen by a suitably qualified ECO, who must visit the clearing sites regularly during clearing, and once all biomass has been removed.
- Vegetation clearing efforts must take cognizance of when biota (e.g. birds) make use of these systems for breeding purposes and should preferably be done outside these periods.
- Cleared areas must regularly be checked for invasive alien plants (IAPs) and these must be removed.

<u>Re-planting</u>

- Mulch must be used in all areas where re-planting is to take place. The following shall apply:
    - All mulch shall be free of alien species.
    - Any vegetative material shall be reduced by either mechanical means (chipper) or by hand-axing to sticks no longer than 100 mm.
    - Compost from a local source can also be utilised as mulch during replanting and rehabilitation of the inland aquatic ecosystem. The compost shall be well decayed, friable and free from weed seeds.
    - Wood chips (including bark), which are half composted and have not been treated with preservatives can also be utilised as mulch during replanting of the site.
    - The chips shall be no longer than 50 mm in length or breadth.
- Sods of plants such as sedges, rushes and grasses are the best means of planting. These will need to be sourced early from local nurseries, as these are sometimes difficult to obtain.
- Plants should be placed in clumps rather than evenly spaced, as this allows some protection of smaller plants by the larger individuals, and appears more natural. This also facilitates more effective irrigation.
- Unless proper nursery conditions are created on site, plants must not be stored for longer than 10 days on site prior to planting.
- Planting shall be done by a skilled team.
- The planted areas shall be monitored for erosion during the first winter, and areas that are subject to erosion shall be stabilised.
- No fertilisers shall be used, as these could have a negative impact on the relatively nutrient-poor soils of the area and thus on the associated vegetation, and also on the water quality within rivers/wetlands.
- The planted areas shall be irrigated for the first year after planting (i.e. the duration of the establishment maintenance period), when appropriate, and longer if conditions are dry. Watering to a depth of at least 100 mm should be repeated at least twice a week, before 10 am or after 6 pm.

- No equipment, vehicles or unauthorised personnel shall be allowed onto areas that have been planted. Only persons or equipment required for the preparation of areas shall be allowed to work in these areas.

Erosion control

- Additional erosion control measures can be put in place, where there is a risk of soil erosion occurring after clearing (or other maintenance activities). The ideal longitudinal slope to prevent erosion in a river channel is 1:7 (roughly 14%), while laterally the banks should in general not be steeper than 1:3 (roughly 33%) (Russell, 2009).
- Stabilisation materials include:
    - Ecologs (dry woody material or sand contained in a hessian and chicken wire roll – (see Figure 5.2);
    - Biodegradable netting/matting;
    - Geotextile matting of thick filaments designed to be secured over a vulnerable slope to prevent surface erosion (see Figure 5.2);
    - Rock packing
    - Mulch stabilisation, or
    - Compost stabilisation.

Figure 5.2 (Left) Ecologs used to stabilise the banks of a stream; (Below) Geotextile stabilisation of a slope.

Recommended plant species

Table 5.7 provides a preliminary list of plant species that could be planted in areas that have been impacted by clearing IAPs or impacted through the implementation of the maintenance activities and thus require rehabilitation (i.e. revegetation is not required in areas that have specifically been cleared to allow for free flow of water). In areas that are dominated by terrestrial plant communities, indigenous plant species, as outlined within the botanical report (Emms 2024), should be replanted.

Table 5.7 List of recommended plant species for re-planting of cleared areas, or areas requiring rehabilitation after maintenance activities near inland aquatic ecosystems. This list has been verified by the project botanist.

Species	Common name
Riparian species (river corridor margins, out of water)	
Willdenowia incurvata	Sonqua Sunreed
Phylica cephalantha	Top Hardleaf
Salvia lanceolata	Lanceleaf sage
Diosma hirsuta	Common bitterbuchu
Eriocephalus racemosus	Kapkap kapok
Muraltia spinosa	Skilpadbessie
Passerina corymbosa	Common gonna
Searsia glauca	Blue kuni-bush
Searsia laevigata	Dune curranthrus
Ruschia tecta	Stiff tentfig
Ficinia bulbosa	Bulbous sedge
Ruschia misera	Tentfig
Lampranthus stipulaceus	Smiley brightfig
Within channel / pond and margins	
Ficinia marginata	Common annual clubrush
Juncus krausii	Brak rush
Isolepis prolifera	Budding Clubrush
Bolboschoenus maritimus	Sea Clubrush
Wetlands (seeps)	
Senecio halimifolius	Tabacco ragwort
Cliffortia strobilifera	Caperose
Carpha glomerata	Vlei sedge
Isolepis prolifera	Budding Clubrush
Wetlands (Dune slacks, depressions, temporary wetlands and recharge basins)	
Ficinia nodosa	Stembract clubrush
Imperata cylindrica	Cogon grass
Scirpoides holoschoenus	Round-headed Clubrush
Wetland (Silwerstroom)	
Senecio halimfolius	Tabacco ragwort
Imperata cylindrica	Cogon grass
Ficinia nodosa	Knobby Clubrush
Plecostachys serpyllifolia	Petite-licorice
Wetlands (Koerasie and Sout River valley bottom wetlands)	
Bolboschoenus maritimus	Sea Clubrush
Juncus krausii	Brak rush

Ficinia nodosa	Knobby Clubrush
Wetlands (unchanneled valley bottom wetland near chicken farm)	
Bolboschoenus maritimus	Sea Clubrush
Juncus krausii	Brak rush
Isolepis prolifera	Budding Clubrush
Carpha glomerata	Vlei sedge
Wetlands (unchanneled valley bottom wetland near chicken farm)	
Ficinia nodosa	Knobby Clubrush
Senecio halimfolius	Tabacco ragwort

The significance rating (with and without the implementation of mitigation measures outlined above) following the assessment of impacts is summarised per aquatic ecosystem type in Table 5.8.

5.2.3 Activity Type 3: maintenance of above and below-ground pipelines/powerlines

Description of proposed sub-activities

3.1: Replacement of damaged pipeline infrastructure after large storm events

In most instances, after large storm events, there is some degree of damage, including erosion of banks, gravel roads and bridge approaches. Some flood debris could also cause damage to the infrastructure itself which would need to be fixed or replaced (like for like) if damaged extensively. This could entail dredging, excavation and infilling in a stream.

3.2: Repair of pipeline and cable infrastructure

Over time some damage could occur to the installed pipeline, electrical and communication infrastructure, which would result in machinery needing to access the pipe or cables over / underneath a wetland or river and would entail dredging, excavating and potentially infilling inside a wetland or river . More than 300 square metres of indigenous vegetation could be cleared for maintenance of below ground linear infrastructure (e.g. pipelines, powerlines, telemetry etc.) where the linear infrastructure would need to be excavated and repaired.

Potential impacts

- Destabilisation of slopes, banks and beds of wetlands and rivers, leading to increased mobility of sediments into sensitive areas and possibly gully, head-cut channel (incision) and/or bank erosion.
- Increased sedimentation in sensitive areas, such as wetlands, riparian areas and instream channels, thus reducing habitat quality due to smothering of these habitats.
- Damage to riparian, instream and/or wetland vegetation when accessing working area and conducting the maintenance activity (e.g. brush-cutting of vegetation along the transmission corridors for maintenance or hauling cables through sensitive habitats).

- Trampling and general disturbance of natural habitat and biota as cabling is hauled by foot through sensitive habitats or vehicular activity required to transport cabling and other construction-related material. This may result in a change in community structure.
- Construction-related water quality impacts such as the leakage of fuels, oils, etc. from construction machinery – this could lead to pollution of the wetlands or rivers.
- Introduction of concrete/cement into rivers and wetlands. This can alter the pH of the water, and cause smothering of habitat, fauna and flora.
- Introduction of sand for construction which may contain alien plant seeds – this would pose a threat to the biodiversity in the area.
- Obstruction or diversion of surface flow during repair work. This could lead to a loss of connectivity within a river/wetland or erosion in an area receiving diverted flow.
- Poor water quality entering the receiving environment along pipelines that cannot be shut off during maintenance. This will cause pollution of rivers and wetlands.
- Construction footprints and the storage of construction materials may lead to the introduction of invasive alien plant seeds/seedlings, compaction of soils and shading of indigenous plants.

Measures to mitigate the severity of these impacts

General construction footprint-related mitigation (where there is a need to establish on site)

- All construction footprints (e.g. construction camps, storage of materials used for repairs, etc.) must be minimised and preferably be located in previously disturbed areas – with sensitive natural areas demarcated along the edge of the buffer (i.e. 40m around rivers and wetlands) as no-go areas.
- Following the completion of the maintenance activity and where construction footprints were established, these areas need to be rehabilitated to the satisfaction of the ECO. This may include ripping compacted soils, removal of contaminated soils (if relevant), revegetation and removal of any invasive alien plant seedlings that may have established throughout the period when the maintenance activity took place.
- During and after the process of establishing a construction camp, all litter or solid waste must be removed from within a 25m radius of the work site. The area should also be inspected for invasive alien plants – details for clearing are provided in Section 5.2.2.
- Wherever possible, concrete or cement must not be mixed on site, but rather delivered pre-mixed. If mixing of concrete is needed on site, the mixing area should be located at least 40m away from the edge of any river, riparian area or wetland.
- Machinery prone to oil or fuel leakage must be located at least 40m away from the edge of the rivers, riparian areas or wetlands, and the area adequately bunded in order to contain leakages.
- All machinery shall have drip trays to contain oil and fuel leaks – these must be cleaned regularly.
- Suitable toilet and wash facilities must be provided to avoid the use of sensitive areas for these activities. These service areas must be maintained, and toilets emptied on at least a weekly basis.
- All solid waste must be removed from site on a weekly basis.

Replacement of above and/or below-ground infrastructure

- The width of the construction footprint must not exceed the total working widths which are the current road width + 4 m work area + 2 m topsoil windrow, with strategically placed bypasses approximately every 200 m – 300 m.
- Trench excavation for maintenance purposes should take place in short sections – 50 m per working front is recommended, or at least the minimum length required for laying of relevant services.
- Opened trenches must be filled as quickly as possible after trenching is initiated. This is to keep the disturbed areas open and unstabilised for the shortest period possible. No trenches must be opened within three days of predicted heavy rainfall.
- The minimum bucket-size for excavators, required to achieve the minimum trench width as per the SANS 1200 DB specifications, must be used at all times, to avoid encroachment of the trench beyond the desired working width, and excavation of a wider trench that faces the risk of bank slumping.
- Trenching through areas likely to collapse, such as through deeper sandy areas, must have the sides battened or shored to prevent collapsing taking place.
- Search and Rescue of plant material as well as seed collection must be undertaken within the disturbed areas starting preferably a year prior to commencement of construction activities to include all seasonal biotic cycles – especially during spring time for seed/geophyte collection. This may be more important in certain portions of the AWRMS where known species of conservation concern have already been identified by a botanist (Emms 2024).
- No areas are to be cleared of vegetation cover unless clearly specified individual time intervals are agreed to, which is intended to allow sufficient time to collect/rescue plant material and to limit potential erosion of cleared (devegetated) surfaces. At least a year's notice, but at minimum 3 months to rescue plants is necessary.
- All alien vegetation within a band of 50 m (i.e. 25 m on each side) from the pipeline route must be cleared prior to trench excavation.
- To mitigate against potential hydrological changes to wetlands, it is important that the pipeline be adequately covered to minimise its negative effects (at a depth of at least 1 m). The ideal depth for the pipe depends on the nature of the wetland. For instance, the pipe should be placed below the impermeable layer lying below perched wetlands, and soils compacted above the pipe to simulate this impermeable layer. For wetlands on deeper soils, especially those fed by groundwater, soils should not be compacted above the pipe, to reduce impacts on sub-surface flows. Generally, the perched nature of a wetland can only be determined once the trench has been excavated – thus it is essential that the depth and covering of the pipe be determined on site by the specialist team, section by section.
- To avoid the trenches or above-ground pipelines becoming drainage channels through wetlands and slopes, the wetland on all sides must be protected by "collars" (either made from compacted excavated material or sandbags with geotextile lining). The collars in the trenches must be installed from underneath the pipes to near surface level and must be filled with sand/cement/concrete so that the whole section of the trench is made relatively impermeable to flows along the length of the trench.

- Dewatering of trenches must be done when necessary, but should not lead to quantities of silt-laden water entering the environment. Reducing the length of time trenches remain open will reduce this likelihood. Shoring of side walls of trenches greater than 1.5m depth will be necessary to prevent the sides from collapsing when waterlogged.
- Discharge of dewatered quantities should be dissipated carefully within a disturbed area of a wetlands or rivers catchment in a manner that does not cause detrimental harm or erosion to the receiving environment (i.e. smothering of habitat from sediment-laden waters). This can be achieved by pumping sediment-laden water into a pond/sump situated 40m away from the river/wetland to allow for the settling of these sediments prior to that water being discharged back into the environment.
- All topsoil must be removed and placed in windrows adjacent to the trench prior to the commencement of construction. Care must be taken to ensure that removed topsoil does not fall into the trench from adjacent windrows, especially where gradients are steep. In some cases, it may be necessary to store topsoil at a nearby stockpile site to avoid this.
- Topsoil is to be protected with dense hessian sheets and must be separated from construction activities by plastic sheeting. The hessian sheets covering the topsoil must be held in place by stakes, large rocks (which may not be sourced from rivers) or similar to hold it in place through strong windy conditions. Note that plastic sheeting must be used to protect the topsoil from contamination from any infrastructure being repaired that may cause pollution of the surrounding environment.
- Topsoil shall be stored for the shortest possible time.
- No topsoil replacement (return) is allowed during the period September to November, regardless of site sensitivity. This is an embargo period to reduce erosion as any seedling regrowth in the returned soil must be given a suitable duration to establish so that they can survive the following dry summer without watering.
- Top material must then be returned to the same habitat from which it was removed following pipe laying, making sure that bed material and top soils are not compacted more than they are naturally.
- Ensure that the profile of the trench once top material is returned has the same cross section profile (within 100 mm) as it was prior to trench excavation. Thus, any excess material would need to be disposed of elsewhere, so that a raised mound is not created along the pipeline. Raising the filled area above natural ground level, in most instances, interferes with the natural flow of water by creating a barrier in the topography. The returned topsoil must be landscaped, planted and seeded so that the area functions in a natural way. Meaningful subsidence should not occur where the returned subsoil is suitably compacted at the 0.5 m level prior to the return of the topsoil (except under specified conditions). Slight subsidence can benefit the return of plants by creating a moister environment, as long as it does not cause channelling down the trench.
- Following the return of top material, it is important that areas affected by the infrastructure route are rehabilitated as far as possible through replanting of indigenous vegetation within the affected areas. This may include a mix of locally indigenous plants that are functional (to stabilise the habitat) as well as replacement of conservation-worthy vegetation. No rehabilitation activities, such as topsoil return and sowing in drylands, are to be done from September to November.

- No interval between return of topsoil and the sowing of seed is to take place. Aqueous smoke solution of suitable concentration must be applied to the sown surface to stimulate germination.
- Sandbags filled with local weed-free sand are to be used to berm off devegetated / bare construction areas such as stored or spoil materials.
- Where existing stormwater pipes carry water under a track or road, the pipe must be replaced if broken, and extended to discharge water beyond the adjacent trench.
- Rock for the filling of gabions for the above-ground sections of pipeline may not be sourced from rivers.
- The final design for above-ground pipes must take into account the need to allow for surface flow of water within wetlands and rivers.
- Gaps in gabions protecting above-ground pipes must be placed to allow for the movement of fauna.
- Maintenance activities requiring major earthworks should not commence prior to significant rainfall unless, in emergency scenarios, where critical infrastructure for the operation of the AWRMS is needed.
- Rolling out of cables should avoid sensitive aquatic ecosystems and take place in disturbed areas that are utilised as part of the maintenance activities.
- For those pipelines that cannot be shut off during maintenance, the continual flow of poor water quality into the receiving environment will need to be managed. More specifically, where continual discharge from these pipelines will occur during maintenance activities (which will likely only occur along pipeline routes in close proximity to Basin 6, Basin 7 or Coastal Recharge Basins), temporary pipelines (with pumps) should be laid within the road reserve (or in disturbed areas) that discharge the water from the damaged pipeline directly into the closest of these basins. These three areas typically contain large bodies of standing water and thus are large enough to offer dilution.

Temporary pipelines

- Temporary pipelines carrying discharge water from dewatering during trenching must be laid down in previously disturbed areas, such as existing roads and tracks.
- During dewatering of trenches during replacement of major pipelines, pipes should be monitored for leaks, to avoid large volumes of water flowing in or across roads, causing erosion.

Stockpiles

- Areas designated for stockpiles must be placed well away from sensitive habitats, and at least 40m away from any wetland or river.
- Sufficient space must always be designated to allow for truck turning, loading and off-loading, so that vehicles will not drive into the natural areas.
- All the sites require pre-utilization control of the alien species present on them and in a buffer 25 m wide around the sites. Control activities must be introduced timeously so that any regrowth of their seed is stimulated for control prior to stockpiling taking place at them. These

preparatory controls are usually required before the preceding winter begins to eliminate the addition of new seed to the stockpile area from the surrounds and to cause the seed already present in the soil to germinate in the disturbed areas with the onset of the wet winter conditions.

- All the sites that are used will need the top materials present on them stored for rehabilitation purposes. These materials will need to be covered using at least 60% shade cloth. Note that hessian cover, if used, needs to be strong and dense and able to function through environmental rigours for extended periods, as the stockpile areas will be utilized for the duration of the construction activities.
- The bermed top materials can form a boundary to the sites. A subsoil berm must be placed along the inner boundary of the topsoil berm, to protect the topsoil.
- Natural wash or flow of surface water leading **onto** the stockpile site must be diverted away from the stockpile site, with input from a freshwater ecologist and / or botanist. Wash or flow **from** the stockpile sites will need to be contained. Sandbags should be used to prevent erosion of stockpiled materials into the surrounding environment.
- The perimeters of the construction stockpile and storage areas will need to be adequately demarcated to avoid ingress into the surrounding veld.

Pipeline/cable infrastructure over river crossings

River crossings are of concern only with regard to the pipeline routes, as powerlines can avoid impacting on rivers. The current pipeline route does not cross over any rivers or wetlands of very high sensitivity, but it crosses over two rivers and numerous wetlands of variable ecological condition, importance and sensitivity which are of moderate to high sensitivity.

The following mitigation measures apply to all river crossings (for infrastructure through wetlands, the mitigation proposed within this section outlining “Replacement of above and/or below-ground infrastructure” should be followed):

- Mitigation of short-term, construction-related damage to the river / vegetation must be guided by clear method statements.
- Work in rivers (i.e. within the active channel) should, as far as possible, take place during the dry season (November to April).
- A larger pipe diameter will allow for a wider span across the river. This could be achieved, even if the smaller diameter pipe must be placed within a wider pipe.
- The exact position of the plinths and of their construction excavations and of the work areas need to be pegged exactly.
- The wetted banks of the rivers (i.e. the part of the bank that is in contact with water) must not be damaged during construction except as approved by the relevant specialist.
- For below-ground crossings, the pipe must be placed such that cover material is returned to the natural level of the channel so that natural flow paths are not altered.
- The disturbed area must be revegetated to ensure re-establishment and stabilisation of slopes.

- No concrete is to be used within the active channel without suitable berms to contain polluted water. This polluted water is to be removed off-site to an approved waste dumping area.
- Concrete and cement must be contained as far as possible away from the active channel.
- Any disturbance to the riparian areas of rivers must be rehabilitated through stabilisation and revegetation of the channel banks with appropriate species.
- The area required for construction must be minimised to avoid the negative effects of trampling, damage to vegetation and soil compaction.
- Bank rehabilitation would require the input of a restoration botanist / freshwater ecologist.
- The pipes need to be painted a colour agreed upon that will blend into the surrounding environment.
- Maintenance activities requiring major earthworks should not commence prior to significant rainfall unless, in emergency scenarios, where critical infrastructure for the operation of the AWRMS is needed.

The significance rating (with and without the implementation of mitigation measures outlined above) following the assessment of impacts is summarised per aquatic ecosystem type in Table 5.8.

5.2.4 Activity Type 4: maintenance of existing boreholes

Description of proposed sub-activities

4.1 Re-drilling, cleaning and maintenance of existing boreholes (i.e. not any new ones)

Maintenance of boreholes (production and monitoring) will be required from time to time and would include activities such as borehole cleaning, redrilling, pump testing and casing maintenance.

Potential impacts

- Water quality-related impacts associated with borehole maintenance activities resulting in uncontrolled effluent, contaminants, spillages and artesian conditions entering aquatic ecosystems.
- Destabilisation of slopes, banks and beds of wetlands and rivers, leading to increased mobility of sediments into sensitive areas and possibly gully, head-cut channel (incision) and/or bank erosion.
- Increased sedimentation in sensitive areas, such as wetlands, riparian areas and instream channels, thus reducing habitat quality due to smothering of these habitats.
- Damage to riparian, instream and/or wetland vegetation when accessing working area and conducting the borehole maintenance activity.
- Trampling and general disturbance of natural habitat and biota of pipes to direct drilling effluent is hauled by foot through sensitive habitats or vehicular activity is required to transport pipes and other construction-related material. This may result in a change in community structure.
- Construction-related water quality impacts such as the leakage of fuels, oils, etc. from borehole maintenance machinery – this could lead to pollution of the wetlands or rivers.

- Introduction of concrete/cement into rivers and wetlands. This can alter the pH of the water, and cause smothering of habitat, fauna and flora.
- Obstruction or diversion of surface flow during repair work. This could lead to a loss of connectivity within a river/wetland or erosion in an area receiving diverted flow.
- Borehole maintenance footprints and the storage of required materials may lead to the introduction of invasive alien plant seeds/seedlings, compaction of soils and shading of indigenous plants.

Measures to mitigate the severity of these impacts

- Construction-related mitigation measures, as outlined within Section 5.2.1, are applicable for any maintenance-related activities of existing boreholes.
- Effluent arising from existing borehole drilling, cleaning or maintenance may not be discharged into any inland aquatic ecosystems.
- Storage of any machinery and materials required for borehole maintenance must remain within disturbed areas outside the 40m buffer around each aquatic ecosystem.
- Within the redrilling footprint itself, all sump material must be returned to the sump pits with top material used for final shaping as part of the rehabilitation process. Where necessary, topsoil and mulch will need to be added and impacted areas revegetated with appropriately specified plants.
- For borehole maintenance of any existing boreholes (monitoring and production), most of which are located within sensitive environments (i.e. within nature reserves), on site contaminants and spillages can be contained to a large extent prior to them entering the surrounding environment by lining the floor of each site within the contained area with heavy duty plastic sheeting. This sheeting should lead runoff into one or more sumps at the lowest end(s) of the drill site. Captured runoff must be pumped into containers for eventual removal off-site, thus reducing the wash of effluents or environmental contaminants on the ground into the surroundings. This would improve the post-drilling clearing up of the drill site. For borehole maintenance of any existing boreholes (monitoring and production) within less sensitive environments (i.e. within in and around the town of Atlantis and the Wesfleur WWTW), every effort should still be undertaken to contain contaminants and spillages via sumps before discharging into an artificial recharge basin (if nearby) or into very disturbed/degraded terrestrial habitats (away from any inland aquatic ecosystems). This should be guided by a suitable specialist.
- The impacts associated with the “blow” of drilling effluent can be somewhat minimized by the use of a rubber ‘sleeve’ surrounding the drill bit such that the extent of the material spread from the borehole is reduced. While the impacts of drilling effluent spilling into sensitive habitats can be reduced by the use of sumps during redrilling and pump testing, together with plastic lined trenches and/or pipes that direct effluent directly to a recharge basin (if nearby) or points approved by the Nature Reserves’ management (away from inland aquatic ecosystems), there are still instances where flows of effluent cannot be effectively contained and thus still pose a risk of contamination to ecologically sensitive habitats. In instances where spillage into watercourses or wetlands does occur, it is recommended that the extent of the impact is measured in terms of water quality, aquatic fauna and flora and geomorphological

(habitat) changes. It is further recommended that remediation measures (e.g. the removal of sediments) under the guidance of a specialist be implemented and that the recovery of the system following the event is monitored.

- Should artesian conditions exist during borehole maintenance, it is imperative that a system be set up to contain artesian flows. Depending on the rate of flow, this could involve setting up a temporary flexible pipe that can carry groundwater to holding tanks and transported offsite for discharge elsewhere.
- Topsoil is to be protected with dense hessian sheets and must be separated from construction/redrilling/borehole maintenance activities by plastic sheeting. The hessian sheets covering the topsoil must be held in place by stakes, large rocks (which may not be sourced from rivers) or similar to hold it in place through strong windy conditions. Note that plastic sheeting must be used to protect the topsoil from contamination from any infrastructure being repaired that may cause pollution of the surrounding environment.
- Topsoil shall be stored for the shortest possible time.
- No topsoil replacement (return) is allowed during the period September to November, regardless of site sensitivity. This is an embargo period to reduce erosion as any seedling regrowth in the returned soil must be given a suitable duration to establish so that they can survive the following dry summer without watering.
- Following the return of top material, it is important that areas affected by the infrastructure route are rehabilitated as far as possible through replanting of indigenous vegetation within the affected areas. This may include a mix of locally indigenous plants that are functional (to stabilise the habitat) as well as replacement of conservation-worthy vegetation. No rehabilitation activities, such as topsoil return and sowing in drylands, are to be done from September to November. More details around appropriate rehabilitation (in terms of soil stabilisation and revegetation) are provided in Section 5.2.2.

Table 5.8: Summary of the significance ratings for the impact assessment on the various aquatic feature types that will be impacted by specific maintenance activities, with and without mitigation. A shaded cell means that a specific activity will impact the aquatic type in that specific row, whereas a blank cell means that a specific activity will not impact the aquatic type in that specific row.

<table>
<tr><th rowspan="2">Inland aquatic ecosystem classification /name</th><th rowspan="2">Mitigation status</th><th colspan="4">Activity Type 1: Maintenance of roads and drainage structures along the road network</th><th colspan="2">Activity Type 2: Management of invasive alien plants and clearance of indigenous vegetation near aquatic ecosystems[5]</th><th colspan="2">Activity Type 3: Maintenance of above and below-ground pipeline/powerline repairs near aquatic ecosystems</th><th>Activity Type 4: Maintenance of existing boreholes</th></tr>
<tr><th>1.1 Repair of damaged water crossing infrastructure</th><th>1.2 Replacement of damaged road after large storm events</th><th>1.3 Replacement and maintenance of erosion control measures</th><th>1.4 Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses</th><th>2.1 Clearing of alien invasive vegetation from watercourses, weirs and basins</th><th>2.2 Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or drilling activities</th><th>3.1 Replacement of damaged pipeline infrastructure after large storm events</th><th>3.2 Repair of pipeline and cable infrastructure</th><th>4.1 Maintenance of existing boreholes (production and monitoring)</th></tr>
<tr><td rowspan="2">Dune slack wetlands: Type 1</td><td>Without mitigation</td><td></td><td colspan="2">Moderate - negative</td><td></td><td colspan="2">Moderate - negative</td><td colspan="2">Moderate - negative</td><td>Moderate - negative</td></tr>
<tr><td>With mitigation</td><td></td><td colspan="2">Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td>Minor – negative</td></tr>
<tr><td rowspan="2">Dune slack wetlands: Type 2</td><td>Without mitigation</td><td></td><td colspan="2">Moderate - negative</td><td></td><td colspan="2">Moderate - negative</td><td colspan="2">Moderate - negative</td><td>Moderate - negative</td></tr>
<tr><td>With mitigation</td><td></td><td colspan="2">Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td>Minor – negative</td></tr>
<tr><td rowspan="2">Koerasie unchanneled valley bottom wetland</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td></td><td>Moderate - negative</td><td></td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td>Negligible - negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
</table>

[5] The clearing of alien invasive vegetation would have a positive impact on the environment, but the potential negative impact could arise if mitigation measures are not strictly applied during alien clearing activities.

<table>
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<tr><td rowspan="2">Perched depression wetlands: Type 1</td><td>Without mitigation</td><td></td><td colspan="2">Moderate - negative</td><td></td><td colspan="2">Moderate - negative</td><td colspan="2">Moderate - negative</td><td>Moderate - negative</td></tr>
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<tr><td rowspan="2">Perched depression wetlands: Type 2</td><td>Without mitigation</td><td></td><td colspan="2">Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td>With mitigation</td><td></td><td colspan="2">Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Recharge wetlands</td><td>Without mitigation</td><td></td><td colspan="3">Moderate – negative</td><td colspan="2">Minor – negative</td><td colspan="2">Moderate – negative</td><td>Minor – negative</td></tr>
<tr><td>With mitigation</td><td></td><td colspan="3">Minor – negative</td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td>Minor – negative</td></tr>
<tr><td rowspan="2">Seeps</td><td>Without mitigation</td><td></td><td colspan="2">Moderate - negative</td><td></td><td>Moderate - negative</td><td></td><td></td><td>Moderate - negative</td><td></td></tr>
<tr><td>With mitigation</td><td></td><td colspan="2">Minor – negative</td><td></td><td>Minor – negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Seepage from Wesfleur WWTW and sand mining activities</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td colspan="2">Minor – negative</td><td colspan="2">Moderate - negative</td><td>Minor – negative</td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td>Minor – negative</td></tr>
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<tr><td rowspan="2">Silwerstroom channelled valley bottom wetland</td><td>Without mitigation</td><td></td><td colspan="3">Moderate - negative</td><td colspan="2">Moderate - negative</td><td colspan="2">Moderate - negative</td><td>Moderate - negative</td></tr>
<tr><td>With mitigation</td><td></td><td colspan="3">Minor – negative</td><td colspan="2">Minor – negative</td><td colspan="2">Minor – negative</td><td>Minor – negative</td></tr>
<tr><td rowspan="2">Sout River channelled valley bottom wetland</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Moderate - negative</td><td></td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Temporary wetlands</td><td>Without mitigation</td><td></td><td></td><td></td><td></td><td>Minor – negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
<tr><td>With mitigation</td><td></td><td></td><td></td><td></td><td>Minor – negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Unchanneled valley bottom wetland (near chicken farm)</td><td>Without mitigation</td><td></td><td colspan="3">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Moderate - negative</td><td></td></tr>
<tr><td>With mitigation</td><td></td><td colspan="3">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Brakkefontein Road Stream</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
</table>

<table>
<tr><th rowspan="2">Inland aquatic ecosystem classification /name</th><th rowspan="2">Mitigation status</th><th colspan="4"><u>Activity Type 1:</u> Maintenance of roads and drainage structures along the road network</th><th colspan="2"><u>Activity Type 2:</u> Management of invasive alien plants and clearance of indigenous vegetation near aquatic ecosystems[5]</th><th colspan="2"><u>Activity Type 3:</u> Maintenance of above and below-ground pipeline/powerline repairs near aquatic ecosystems</th><th><u>Activity Type 4:</u> Maintenance of existing boreholes</th></tr>
<tr><th>1.1 Repair of damaged water crossing infrastructure</th><th>1.2 Replacement of damaged road after large storm events</th><th>1.3 Replacement and maintenance of erosion control measures</th><th>1.4 Clearing of silt or flood debris from infrastructure (e.g., culverts, weir and basins) and watercourses</th><th>2.1 Clearing of alien invasive vegetation from watercourses, weirs and basins</th><th>2.2 Clearing of indigenous vegetation around the borehole sites in case of borehole maintenance or drilling activities</th><th>3.1 Replacement of damaged pipeline infrastructure after large storm events</th><th>3.2 Repair of pipeline and cable infrastructure</th><th>4.1 Maintenance of existing boreholes (production and monitoring)</th></tr>
<tr><td rowspan="2">Langwaterspruit Stream</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td></td><td>Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Donkergat River channelled valley bottom wetland</td><td>Without mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td>With mitigation</td><td colspan="4">Minor – negative</td><td>Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td></tr>
<tr><td rowspan="2">Ganzekraal unchannelled valley bottom wetland</td><td>Without mitigation</td><td colspan="3">Moderate – negative</td><td></td><td colspan="2">Moderate - negative</td><td></td><td>Moderate - negative</td><td>Moderate - negative</td></tr>
<tr><td>With mitigation</td><td colspan="3">Minor – negative</td><td></td><td colspan="2">Minor – negative</td><td></td><td>Minor – negative</td><td>Minor – negative</td></tr>
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6 WATER USE AUTHORISATION

6.1 Water uses

The main regulatory requirements with regards to aquatic features relates to the National Water Act No. 36 of 1998 (NWA). The NWA regulates 11 water uses that require authorisation under Section 21, as follows:

a) Taking water from a water resource;
b) Storing water;
c) Impeding or diverting the flow of water in a watercourse;
d) Engaging in a stream flow reduction activity;
e) Engaging in a controlled activity identified and declared as such in terms of the Act;
f) Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
g) Disposing of waste in a manner which may detrimentally impact on a water resource;
h) Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
i) Altering the bed, banks, course or characteristics of a watercourse;
j) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
k) Using water for recreational purposes.

Maintenance activities in and around rivers or wetlands can lead to changes in flow (Section 21 (c)) or alterations to the bed and banks/characteristics of (Section 21 (i)) the affected inland aquatic ecosystem, and so a water use authorisation must be obtained for these activities.

Such water uses apply within a **regulatory zone**, which extends 500m from the outer boundary of a **wetland**, and either up to the 1:100 year floodline (where this has been calculated) or 100m from the edge of the active channel or the outer boundary of the riparian area around a **watercourse**. Given that both rivers and wetlands were found within the study site, the maximum regulatory zone applies i.e. 500m from the outer boundary of a wetland.

The process to be followed to obtain authorisation for these categories of water use is different for each water use, and relates to the **risk** associated with the water use. The General Authorisation (GA) in terms of Section 39 of the Water Act (1998) provided in Notice 509 of 2016 (GN 40229 of 26th August 2016) provides guidance and the conditions of authorisation regarding impeding and diverting the flow in a watercourse (Section 21 (c)), or altering the bed, banks, course and characteristics of a watercourse (Section 21 (i)). In 2016, an amendment of the Section 21 (c) and (i) GA introduced a risk assessment matrix (RAM) that allows for the determination of the level of risk associated with any given activity. This piece of legislation (including its RAM) was subsequently updated in December 2023 in accordance with GA 4167 of December 2023. **Low risk water uses** are **generally authorised**, requiring registration of the water use only, while activities with a **moderate to high level of risk** to the water resource require a **full water use licence application**.

6.2 *Risk assessment matrix*

The risk assessment matrix approach provided in the GA of December 2023 adopts an approach similar to the EIA regulations, where each impact is assessed in terms of severity, likelihood and consequence. The matrix requires the assessment of each activity associated with the various phases of any development project in terms of the impacts expected to affect abiotic habitat drivers (hydrology, water quality and geomorphology) and the biotic responses (vegetation and fauna) within watercourses and wetlands. Each impact is scored in terms of the intensity of its effect on each of the resource quality characteristics, and calculated as an overall intensity score out of a maximum of 10. Each impact is then scored in terms of its spatial scale and duration in order to calculate a severity score out of 20. The following are then calculated:

- **Consequence**, which is the product of the severity of the impact and the EIS rating of the watercourse (in this case, low) and
- **Likelihood**, which is the % probability of the activity having an impact on the resource quality of the watercourse.

The **significance of the impact is calculated as the product of its consequence and likelihood**. The final score is used to assign a risk rating to the impact (see Table 6.1). The risk assessment matrix makes reference to control measures that are required in order to ensure that the risks to the resource are minimised or even avoided.

Table 6.1: Rating Classes for the Risk Assessment.

Rating	Class	Management Description
1 – 29	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality is small and easily mitigated.
30 - 60	M) Moderate Risk	Risk and impact on watercourses are notable and require mitigation measures on a higher level, which costs more and requires specialist input. License required.
61 - 100	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. License required.

6.3 *Results of risk assessment*

A summary of the risk assessment matrices (RAM) for each of the inland aquatic ecosystems on which several different maintenance activities will occur is provided in Table 6.2 – with full RAMs being available in Appendix D). Separate RAMs have been conducted for each group of aquatic ecosystems as they have been grouped based on type and are subject to similar impacts. Thus, as per the RAMs completed for each group of affected inland aquatic ecosystems (rivers and wetlands) along the existing AWRMS infrastructure routes, and assuming that all recommended mitigation measures are implemented, the **risk to aquatic ecosystems is considered low**, suggesting that the water use activities should be Generally Authorised, rather than requiring a full Water Use Licence (WUL). Nevertheless, the findings of this report should be discussed in consultation with the Department of Water and Sanitation as part of the Water Use Authorisation (WUA) process.

Table 6.2: Summary of the results from the PES, EIS and RAM on affected aquatic ecosystems. More detailed RAM results can be viewed in Section 13 (Appendix D).

Classification Type and Name	PES	EIS	Result based on RAM
Dune slack wetlands: Type 1	C	High	Low
Dune slack wetlands: Type 2	B+C	High	Low
Koerasie unchanneled valley bottom wetland	C/D	Moderate	Low
Perched depression wetlands: Type 1	B	High	Low
Perched depression wetlands: Type 2	D	Moderate	Low
Recharge wetlands	D	Moderate	Low
Seeps	B+C	High	Low
Seepage from Wesfleur WWTW and sand mining activities	n/a	Low	Low
Silwerstroom channelled valley bottom wetland	C	High	Low
Sout River channelled valley bottom wetland	D	Moderate	Low
Temporary wetlands	D	Low	Low
Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	Low
Brakkefontein Road Stream	C	Low	Low
Langwaterspruit Stream	C	Low	Low
Donkergat River channelled valley bottom wetland	D	Moderate	Low
Ganzekraal unchannelled valley bottom wetland	C	High	Low

7 MONITORING

Implementation of this MMP should be monitored by a suitably qualified freshwater ecologist, as required under a WULA or a GA. It is recommended that one monitoring visit is scheduled as soon as each maintenance activity has been completed, and one year on. The ecologist should monitor the following:

- Repair work is done to the original specifications;
- No new erosion or sedimentation has occurred;
- The bed and banks of rivers and wetlands that have been impacted by the removal of vegetation and sediment must be in good condition, and not eroding or bare;
- IAPs have been removed from areas that have been prioritised for clearing (i.e. within a 25m radius of each maintenance activity);
- Vegetation management has not resulted in deterioration in the condition of rivers or wetlands (i.e. that PES has not changed, where the desired state is the maintenance of existing condition);
- Areas within the rivers, wetlands and their ecological buffers that have been impacted by maintenance activities and vegetation clearing have been re-planted, where relevant.

Fixed point photography should be used as a means to document changes in the environmental conditions in areas where maintenance activities will occur, where these are likely to impact on inland aquatic ecosystems. More specifically, the appointed ECO should take photographs at a minimum of three strategic sites before, during and after the maintenance activities where impacts (e.g. erosion) can be expected. Following the completion of the activity, photographs should be repeated quarterly for a period of a year. In the event that any negative residual impacts are observed following the one-year monitoring period associated with a particular maintenance activity or should the recovery of the affected ecosystem be unsatisfactory to the authorities, then rehabilitation measures (as indicated in this report) should be reinstated and monitoring as per the above program should continue until no negative residual impacts on the affected inland aquatic ecosystems are noted.

It is the responsibility of City of Cape Town (Bulk Water Department) to ensure that these monitoring visits take place timeously. It is the responsibility of the ecologist to provide a short report (in the form of a letter) regarding the condition of the aquatic ecosystems along the existing infrastructure routes within the AWRMS. The report must be submitted to the entity undertaking the maintenance activity, and to the case officer at the Department of Water and Sanitation, Bellville.

8 CONCLUSIONS AND RECOMMENDATIONS

- The existing Atlantis Water Resource Management Scheme (AWRMS) infrastructure spans across the G21B, G21A and G21D quaternary catchments in the Berg-Olifants Water Management Area (WMA) and the lower Berg sub-WMA in the City of Cape Town, Western Cape. Within the G21B quaternary catchment in particular, a significant portion of the area within which the AWRMS infrastructure is situated is protected formally or conserved and is thus largely pristine in nature. The remaining portions of the AWRMS infrastructure are situated in and around the town of Atlantis (residential and industrial), rural agricultural areas (subsistence and commercial) as well as tracks of land that are invaded by alien trees such as Acacias, Eucalyptus and Pine species.
- The DFFE EIA screening tool indicates that the AWRMS falls within areas that are classified as both low and very high sensitivity. The reason for the very high sensitivity classification is because of the presence of inland aquatic ecosystems that are mapped as: Aquatic CBA 1, Aquatic CBA 2 (degraded), Aquatic ESA1, FEPA sub-catchment, Rivers B and D, Depression, floodplain and seep wetlands within the Southwest Fynbos Bioregion, Depression and seeps within the West Coast Renosterveld Bioregion and Depression wetlands within the West Strandveld Bioregion.
- A three-day site visit was conducted on 1, 2 and 11 October 2024 (spring) and one additional trip on 21 February 2025 (summer) to verify the desktop mapped ecosystems. Many inland aquatic ecosystems were identified within the DWS-regulated area of 500m, but only a total of 61 rivers and wetlands were identified as potentially affected inland aquatic ecosystems (2 rivers and 59 wetlands). These were grouped according to their type and ecological condition. The wetlands ranged in ecological condition and were assessed to be between a B to a D PES – with low, moderate or high ecological importance and sensitivity. The rivers ranged in ecological condition and were assessed to be between a C and D PES – with low to moderate ecological importance and sensitivity.
- The proposed maintenance activities include maintenance of roads, drainage structures, above- and below-ground pipeline/power line repairs as well as management of silt and vegetation. Not all activities affect each of these groups of aquatic ecosystems and were thus assessed according to what activities would affect these systems.
- Potential impacts to rivers and wetlands can easily be minimised through the implementation of mitigation measures as outlined in this report. The recommended buffer for all inland aquatic ecosystems is 40m (on either side of the water resource) for the operational phase of the AWRMS. The buffer recommendation applies as a mitigation measure, as a no-go area for maintenance activities, except where activities must occur within or close to aquatic ecosystems. Where work occurs within a river or wetland, then other mitigation measures as proposed within this report apply. Furthermore, monitoring guidelines have also been proposed.
- The maintenance activities within or near inland aquatic ecosystems will trigger Section 21 (c) and (i) water uses of the National Water Act and thus require Water Use Authorisation by the Department of Water and Sanitation. Considering that the risk to inland aquatic ecosystems is LOW after the implementation of recommended mitigation measures, it is strongly encouraged that these water uses are generally authorized.

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10 APPENDIX A: SHORT CURRICULUM VITAE

FRESHWATER ECOLOGIST (NAME): PHILIP FRENZEL			
EMPLOYER AND CURRENT JOB TITLE	**QUALIFICATIONS AND DATES**	**ASSOCIATION AND PROFESSIONAL REGISTRATION NO.**	**NO. OF YEARS POSTGRADUATE EXPERIENCE**
Freshwater Consulting cc Junior Consultant Freshwater Consulting	MSc (Conservation Ecology) (2016-2018) BSc (with Hons) (Conservation Ecology) (2012-2015) (*cum laude*) Both degrees from Stellenbosch University	Registered Professional Natural Scientist by SACNASP (Reg No 123620)	6

Background

Philip Frenzel is a freshwater ecologist with 6 years of experience in the field of freshwater ecology – 5 of which are in the environmental consulting sphere. His experience ranges across numerous fields and includes specialist input into biomonitoring, impact assessments, ecological and water quality monitoring, and research. Philip completed his MSc at Stellenbosch University which focused on evaluating the efficacy of nature-based solutions to improve water quality and enhance biodiversity provision. His experience includes the assessment and evaluation of aquatic ecosystems in terms of extent (through delineations) and assessment of ecological health and functional value. Philip also presented his work on local, national and international platforms. He has also attended a number of professional courses – most notably, achieving competency status for the 'Tools for Wetland Assessment' course hosted by Rhodes University in 2021.

RELEVANT FIELDS OF SPECIALIZATION, EXPERIENCE AND COMPARABLE PROJECTS

Specialisation:

- Specialist ecological and water quality assessments for wetlands and rivers
- Freshwater ecological and water quality monitoring
- River and wetland rehabilitation
- Environmental Impact Assessments
- Management and Maintenance Plans
- Research and development
- Water Use Authorisation applications (GA and WUL)

Overview of post graduate experience:

2019 - present	Junior Aquatic Ecosystem Consultant, Freshwater Consulting cc
2019 - 2020	Researcher with the Freshwater Research Centre
2018 – 2019	Intern with the Freshwater Research Centre

Experience & completed projects (key projects only):

Ecological Monitoring:

- Table Mountain Group Aquifer (TMGA): hydro (geo) logical and Ecological Monitoring (February 2023-ongoing) (Client: City of Cape Town: Bulk Water)
- Fish survey of the Century City Waterbody: Biannual Report (2013 to 2023) (2023) (Client: Century City Property Owners Association)
- Table Mountain Group Aquifer (TMGA): hydro (geo) logical and Ecological Monitoring (May 2019 – June 2022) (Client: City of Cape Town: Bulk Water)
- River Health Assessment of the Baths River, Caledon (2022) (Client: Theewaterskloof Municipality contracted by Bigen Africa)
- Operational Phase Input into water quality and aquatic ecosystem management at Green Point Urban Park (2020-2023) (Client: City of Cape Town contracted by Servest)

- Water Use License Compliance Monitoring: River Health Assessments on the Baths, Palmiet and Elands Rivers receiving treated effluent within the Theewaterskloof Municipality (2021-2022) (Client: Theewaterskloof Municipality contracted by Bigen Africa)
- Biomonitoring programme for discharge of treated effluent from the Grabouw Wastewater Treatment Works into the Palmiet River (2021) (Client: Theewaterskloof Municipality contracted by Bigen Africa)
- Table Mountain Group Aquifer (TMGA): hydro (geo) logical and Ecological Monitoring (2018-2021) (Client: City of Cape Town: Bulk Water)

Wetland and River Assessments:

- Ecological infrastructure for water security project (EI4WS): Field-validated condition assessments of inland aquatic ecosystems in the Berg-Breede and greater uMngeni demonstration catchments (2024) (Client: SANBI)
- Reconstruction of the Meerlust Scour Valve Chamber adjacent to the Eerste River near Faure: Freshwater ecological input into the Emergency response protocol (2024) (Client: City of Cape Town contracted by Bigen Africa)
- Proposed Vaalfontein Cemetery: Aquatic ecosystem assessment report (2024) (Client: City of Cape Town contracted by Bigen Africa)
- Proposed expansion of the Kuils River Cemetery: Aquatic ecosystem assessment report (2024) (Client: City of Cape Town contracted by Bigen Africa)
- Proposed expansion of the Rusthof Cemetery: Aquatic ecosystem assessment report (2024) (Client: City of Cape Town contracted by Bigen Africa)
- Proposed Swartklip Cemetery: wetland verification and delineation (2024) (Client: City of Cape Town contracted by Bigen Africa)
- Proposed housing development on portions of Erf 6300, Stikland, Cape Town: Wetland verification and delineation (2024) (Client: ARG Design contracted by GEOSS (Pty) Ltd)
- The proposed Wynberg Public Transport Interchange, Cape Town – Input to the water use authorization process: wetland verification (2024) (Client: SMEC South Africa (Pty) Ltd contracted by JLS Group (Pty) Ltd)
- Aquatic ecosystem assessment for the proposed groundwater abstraction related activities on Bosch Kloof 187, Robertson, Western Cape (2023) (Client: private landowner)
- Proposed potable pipeline to the Cape Flats WWTW, City of Cape Town: Aquatic Biodiversity Compliance Statement (2023) (Client: City of Cape Town contracted by JG Afrika (Pty) Ltd)
- Aquatic ecosystem assessment for the proposed road maintenance project between Vanrhynsdorp and Nieuwoudtville, Western Cape (2023) (Client: Western Cape Government: Department of Infrastructure contracted by JG Afrika (Pty) Ltd)
- Aquatic Biodiversity Site Sensitivity Verification and Compliance Statement for the proposed Photo-Voltaic Facility at the Athlone WWTW (2023) (Client: City of Cape Town: Generation Development & Municipal Efficiency Department contracted by JG Afrika (Pty) Ltd)
- Freshwater assessment for the proposed Photo-Voltaic Facility at the Fisantekraal WWTW (2023) (Client: City of Cape Town: Generation Development & Municipal Efficiency Department contracted by JG Afrika (Pty) Ltd)
- Freshwater assessment for the proposed Photo-Voltaic Facility at the Wesfleur WWTW (2023) (Client: City of Cape Town: Generation Development & Municipal Efficiency Department contracted by JG Afrika (Pty) Ltd)
- Environmental Screening for Electricity Grid Infrastructure in the Cape Corridor, Western Cape: Inland aquatic ecosystems (2023) (Client: Eskom contracted by Afzelia Environmental and Sustainable Development Solutions)
- Field investigation to identify activities that may have an effect on water resources downstream from the dam on the Limietberg Nature Reserve, Western Cape (2023) (Client: CapeNature contracted by Carin Bosman Sustainability Solutions)
- Freshwater assessment of the proposed gym and solarium development on erf 7090 Constantia, Western Cape (2023) (Client: Private landowner contracted by Claire Abrahamse Architecture – Urban Design and Heritage)
- Aquatic Ecosystem Assessment for the proposed road maintenance project between Still Bay and Groot-Jongensfontein (2023) (Client: Western Cape Government: Transport and Public Works contracted by Zutari (Pty) Ltd)
- Environmental Impact Assessment and Water Use Authorisation for the Suikerbekkie Solar Photo-Voltaic Facility and its associated infrastructure: Facility 1 (2021-2022) (Client: ABO Renewables)
- Environmental Impact Assessment and Water Use Authorisation for the Suikerbekkie Solar Photo-Voltaic Facility and its associated infrastructure: Facility 2 (2021-2022) (Client: ABO Renewables)
- Baseline assessment of ecosystems potentially impacted by the Eikenhof-Nuweberg Wellfield Development: Freshwater and terrestrial specialist report (2022) (Client: City of Cape Town contracted by Zutari (Pty) Ltd)
- Freshwater assessment of the proposed construction and operation of evaporation ponds near Marchand, Northern Cape (2022) (Client: The Raisin Company)
- Situation assessment of the condition and water quality impact on the reedbeds within the Potsdam Wastewater Treatment Works on the downstream environment: Phase 1 (2022) (Client: City of Cape Town contracted by Bigen Africa)
- Freshwater assessment of the proposed mixed-use development on Portion 7 of Farm Port Michael 653 in Witsand, Western Cape (2022) (Client: Michael Barry Trust contracted by Enviro EAP Environmental Consultants)

- Freshwater assessment of the proposed construction of Heuningberg Residential Estate on erf 6952 and 6954, Bredasdorp (2022) (Client: Clear Lake Capital (Pty) Ltd contracted by Enviro-EAP Environmental Consultants)
- Impact assessment of the proposed upgrade of the Bredasdorp Wastewater Treatment Works: Freshwater ecosystems (2022) (Client: Cape Agulhas Municipality)
- Assessment of potential impacts to the Breede River and adjacent freshwater ecosystems associated with the development of a resort: Rivierzicht Resort on Le Chasseur 90 (Portion 7) in Robertson (2022) (Client: Rivierzicht Resort)
- Freshwater assessment of activities associated with the proposed Concordia Copper Prospecting Area (CCPA), Northern Cape: Input to the Section 21 (c) and (i) WULA (2022) (Client: SHiP (Ltd) Pty)
- Assessment of potentially affected freshwater ecosystems: Development of a tented camp and function areas on the Pat Busch Mountain Reserve, Robertson (2022) (Client: Private landowner contracted by Roelof Lindeque Environmental Assessment Practitioner)
- Proposed ARA gas pipeline network, Saldanha - freshwater ecosystems: scoping report (2022) (Client: Lewton (Pty) Ltd contracted by Exigent Engineering Consultants)
- Assessment of wetland condition for a residential development in Mont Rochelle Nature Reserve, Franschhoek (2021) (Client: Private landowner)
- Proposed upgrade of the Doornbach informal settlement, erf 36925, Milnerton, Cape Town (2021) (Client: City of Cape Town contracted by EcoSense cc)
- Freshwater assessment and rehabilitation plan for a watercourse on erf 17-23, Kraaifontein (2021) (Client: Change for the Better Foundation)
- Assessment of potential impacts to the Berg River and the adjacent freshwater ecosystems associated with earth moving activities and input to rehabilitation on Bellegam Farm, Wemmershoek (2021) (Client: Neopharm (Pty) Ltd)
- The New Water Project (2018-2021) (Client: City of Cape Town: Bulk Water contracted by Zutari)
- Assessment and evaluation of potential impacts to freshwater ecosystems associated with effluent discharge, Klip River, Swellendam. (2020) (Client: Southern Oil (Pty) Ltd)
- Evaluation of risk to freshwater ecosystems associated with the extension of the Fedex building at the Cape Town International Airport (2019) (Client: Fedex contracted by DHK Architects)
- A Baseline Assessment for Freshwater Biodiversity Conservation in the Riviersonderend catchment, South Africa: River Health Report (2019) (Client: The Nature Conservancy)

Management Plans:

- Management Maintenance Plan for the proposed road maintenance project between Vanrhynsdorp and Nieuwoudtville, Western Cape: Inland Aquatic Ecosystems (2023) (Client: Western Cape Government: Department of Infrastructure contracted by JG Afrika (Pty) Ltd)
- Aquatic Input into Management Maintenance Plan for the proposed road maintenance project between Still Bay and Groot-Jongensfontein, Western Cape (2023) (Client: Western Cape Government: Department of Infrastructure contracted by Zutari (Pty) Ltd)
- Management Maintenance Plan for Boschendal Estate: Inland Aquatic Ecosystems (2022) (Client: Chand Environmental Consultants)

Water Use Authorisation applications:

- Road maintenance project between Vanrhynsdorp and Nieuwoudtville (GA) (2024)
- Photovoltaic projects at Athlone, Fisantekraal and Wesfleur WWTW (GA) (2023)
- Hydropower turbine installation in Tulbagh (GA) (2023)
- Hartenbos Residential Garden Estate (WULA) (2023)
- Residential development in Mont Rochelle Nature Reserve (GA) (2022)

Policy:

- Towards a groundwater policy for the City of Cape Town (2024-2025) (Client: City of Cape Town contracted by Bigen Africa)

Research:

- Investigating the use of floating wetlands to purify agricultural effluent (2021) (Honours student supervision at Stellenbosch University)
- Development of the national Freshwater Biodiversity Information System (FBIS) (2018-2020) (Client: JRS Foundation)
- Simaika J.P., Samways M.J. & Frenzel P.P. 2016. Artificial ponds increase local dragonfly diversity in a global biodiversity hotspot. *Biodiversity and Conservation*. DOI: 10.1007/s10531-016-1168-9

Thesis:

- Master's thesis (2018): Investigating the potential of floating wetlands in small farm dams in the Western Cape, South Africa

• Honours thesis (2015): The extent to which artificial ponds in the Western Cape are of conservation value for dragonflies and damselflies (Odonata)

End August 2024

Freshwater Consulting

Kate Snaddon Pr. Sci. Nat.

Curriculum vitae

Name	Catherine (Kate) Diana Snaddon
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Date of birth	19 July 1969
Nationality	South African
Position in company	Senior consultant

KEY QUALIFICATIONS

B.Sc., Majoring in Zoology (with Distinction), University of Cape Town, 1989

B.Sc. (Hons), Zoology (with Distinction), University of Cape Town, 1990

M.Sc, Zoology (with Distinction), University of Cape Town, 1998

WORK EXPERIENCE & RESPONSIBILITIES

March 2003 – present	Freshwater Ecological Consultant, The Freshwater Consulting Group, Cape Town
March 2012 - present	Researcher, Freshwater Research Centre, Cape Town
Position held within FCG	Member and Senior consultant. The FCG is a registered company (Freshwater Consulting cc) of freshwater ecological consultants, based in Cape Town.
Responsibilities	Responsibilities on projects completed for the FCG range from specialist consultant on small projects, to working as a team of multi-disciplinary consultants on larger projects. The maximum number of sub-consultants, or assistants under my employ as lead consultant, is seven. I have managed some of the larger projects on which fellow FCG consultants have worked.
July 2000 - October 2002	Sustainable Business Solutions team, PricewaterhouseCoopers, London, UK
Position held within company	Senior associate
Responsibilities	My responsibilities at PWC were primarily as co-consultant on large projects focusing on waste management, environmental compliance, life cycle analysis, and environmental due diligence.
March 1995 - March 2000, part-time basis	Freelance ecological consultant, Cape Town.
January 1996 - January 2000	Research officer on Water Research Commission project, Freshwater Research Unit, University of Cape Town
February 1991 - August 1992	Research Assistant, Freshwater Research Unit, University Of Cape Town

KEY EXPERIENCE

Kate has 26 years of experience in the field of freshwater ecology (both as a researcher and consultant) and general environmental consulting. Her specialist skills lie in the areas of:

- Freshwater ecology, specifically wetlands, lakes and rivers
- Wetland mapping and delineation;
- River and wetland management and rehabilitation;
- Conservation planning for the aquatic environment;
- Strategic Environmental Assessments of infrastructure projects that may impact on the aquatic environment;
- Environmental Impact Assessment, specifically the assessment of the impacts of anthropogenic activities on freshwater ecosystems;
- Management and implementation of ecological monitoring and research programmes;
- Freshwater macroinvertebrate collection and identification;
- SASS5 bio-monitoring and water quality monitoring.

Kate has worked extensively in the Western Cape, and, more recently, in the Northern Cape, and elsewhere in Africa including Mozambique and Kenya. She has submitted over 100 specialist freshwater ecological consultancy reports, and has published three Water Research Commission reports, two chapters in international books, a South African National Biodiversity Institute wetland classification manual and 11 scientific papers. For the past four years, Kate has been the wetland specialist for the Western Cape's Working for Wetlands Programme.

Kate is a professional member (ecologist) of the South African Council for Natural Scientific Professionals. She is also an accredited SASS5 practitioner. Kate sits on SANBI's National Wetland Ecosystem Classification Committee, and is a Founding Board Member of the South African Wetland Society. Kate is also a researcher at the Freshwater Research Centre, a research Non-Profit Organisation, which runs and participates in freshwater ecological research projects around the country.

May 2023

11 APPENDIX B: PROTOCOL FOR THE ASSESSMENT OF ECOLOGICAL IMPORTANCE AND SENSITIVITY OF RIVERS

Ecological Importance and Sensitivity of rivers (taken from DWAF 1999b)

This approach estimates and classifies the ecological importance and sensitivity of the streams in a catchment by considering a number of components surmised to be indicative of these characteristics. The following ecological aspects should be considered as the basis for the estimation of ecological importance and sensitivity:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity should be taken into account for both the instream and riparian components of the river.
- Habitat diversity should also be considered. This can include specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc.
- With reference to points 1 and 2, biodiversity in its general form (i.e. Noss 1990) should be taken into account as far as the available information allows.
- The importance of the particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species should be considered.
- The presence of conservation or relatively natural areas along the river section should also serve as an indication of ecological importance and sensitivity.
- The sensitivity (or fragility) of the system and its resilience (i.e., the ability to recover following disturbance) of the system to environmental changes should also be considered. Consideration of both the biotic and abiotic components is included here.

A number of biotic and habitat determinants considered to be important for the determination of ecological importance and sensitivity are scored. The medians of these scores are calculated to derive the ecological importance and sensitivity category (Table A1).

Table A1 Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Categories	General Description
Very high (>3 and ≤4)	Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.

Ecological Importance and Sensitivity Categories	General Description
High (>2 and ≤3)	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
Moderate (>1 and ≤2)	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/marginal (>0 and ≤1)	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

Determinants

Generally, a four point (1 to 4) scoring system is used to assess the various aspects of ecological importance and sensitivity. In some cases, a five point (0 to 4) scoring system is used (Table A1). Determinants are assessed according to biological determinants (Table A2) and aquatic habitat determinants (Table A3).

Due to the uniqueness of the Fynbos Biome, it was decided to treat the Western Cape somewhat different with regard to some determinants in order to increase the applicability of the methodology in this part of the country (Luger 1999a & b). These modifications are indicated in the relevant tables.

Table A2 Biotic determinants (instream and riparian) for assessment of ecological importance and sensitivity.

Determinant*	Guidelines And Description	Scoring Guidelines
Rare and[@] endangered biota	Biota can be rare or endangered on a local, Provincial and National scale. Useful sources for this information include the South African Red Data Books that are suitable for assessment on a National scale. However, species (or taxa in the case of invertebrates) can be rare or endangered on a Provincial or local scale but not on a National scale. Professional judgement needs to be utilised in such cases.	Very High - rating=4; One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books). High - rating=3; One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.

Determinant*	Guidelines And Description	Scoring Guidelines
		Moderate - rating=2; More than one species/taxon judged to be rare or endangered on a local scale. Marginal - rating=1; One species/taxon judged as rare or endangered at a local scale. None - rating=0; No rare or endangered species/taxon at any scale
Unique biota@	Endemic or uniquely isolated species populations (or taxa, i.e. in the case of invertebrates) that are not rare or endangered should be included here. This assessment should also consider local, Provincial and National scales and should be treated separately from rare and endangered species (i.e. the same species should not be considered). The assessment should be based on professional knowledge. Fynbos biome: Within this biome all the biota would be unique. The rivers were therefore assessed within the context of the biome for the Western Cape (Luger 1999a).	Very High - rating=4; One or more population (or taxon) unique on a National scale. For the Western Cape – rated on a biome scale. High - rating=3; One or more population (or taxon) judged to be unique on a Provincial/regional scale. For the Western Cape - rated on a sub-regional scale (i.e. northern, western, southern and karroid). Moderate – rating=2; More than one population (or taxon) judged to be unique on a local scale. Marginal - rating=1; One population (or taxon) judged to be unique at a local scale. None - rating=0; No population (or taxon) judged to be unique at any scale.
Intolerant biota	Intolerant biota includes those species (or taxa in the case of invertebrates) that are known (or derived or suspected) to be intolerant to decreased or increased flow conditions as well as changed physical habitat and altered water quality conditions related to decreased or increased flows. As little experimental information is available on the intolerance of indigenous biota, assessment should be based on professional judgement. Kwa-Zulu Natal: There is no quaternary without flow and everywhere that there is flow an invertebrate community dependent on flow develops. This would mean that every	Very High - rating=4; A very high proportion of the biota is expected to be dependent on permanently flowing water during all phases of their life cycle. High - rating=3; A high proportion of the biota is expected to be dependent on permanently flowing water during all phases of their life cycle. Moderate - rating=2; A small proportion of the biota is expected to be dependent on permanently flowing water during some phases of their life cycle.

Determinant*	Guidelines And Description	Scoring Guidelines
	quaternary should be rated highly with respect to this criterion. The solution to the problem was to use only fish (Chutter 1999).	Marginal - rating=1; A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient. None - rating=0; Rarely if any biota expected with any dependence on flowing water.
Species/taxon richness	Species/taxon richness can be assessed on a comparative basis according to a local, Provincial or National scale. Strictly, this kind of assessment should be based on the grouping of ecologically similar rivers. However, such a system is still under development and assessment will again have to be based on professional judgement.	Very High - rating=4; Rated on a National scale. For the Western Cape - rated on a biome scale. High - rating=3; Rated on a Provincial/regional scale. For the Western Cape - rated on a sub-regional scale (i.e. northern, western, southern and karroid). Moderate - rating=2; Rated on a local scale. Marginal/low - rating=1; Not significant at any scale. (a rating of none is not appropriate in this context)

*: The current guidelines will mostly be applicable to vertebrates and vascular plants for which information is more readily available than for other groups. In cases where expert knowledge allows for the assessment of biota other than vertebrates and vascular plants, such information should be included. The taxonomic groups on which the assessment is based should be indicated. In cases where invertebrates (in particular) and other plants are used as indicators, the relevant scoring system may have to be adapted by the relevant ecological experts.

In the case of rare and endangered and unique biota: the highest of the possible scores should be provided, i.e.:

- If a species is rare and endangered on a national scale, it should be scored as very high for this determinant.
- If a species is rare and endangered on a regional scale but it is very unique on a national scale, it should be scored as very high for this determinant.

Table A3 Habitat (instream and riparian) determinants for assessment of ecological importance and sensitivity.

Determinant*	Guidelines And Description	Scoring Guidelines
Diversity of aquatic habitat types or features	Diversity of habitat types in a river delineation should be assessed according to local, Provincial and National scales (riffles, rapids, runs, pools and backwaters and the associated marginal areas and substrate types, lotic wetlands (source sponges, floodplain habitat types) and the riparian zone). Assessment should again be based on professional judgement.	Very High - rating=4; Rated on a National scale. High - rating=3; Rated on a Provincial/regional scale. Moderate - rating=2; Rated on a local scale Marginal/low – rating=1; Not significant at any scale. (a rating of none is not appropriate in this context)
Refuge value of habitat types	The functionality of the habitat types present should be assessed in terms of their ability to provide refugia to biota during periods of environmental stress on a local, Provincial and National scale. Assessment is based on available information and expert judgement.	Very High – rating=4; Rated on a National scale. High - rating=3; Rated on a Provincial/regional scale. Moderate - rating=2; Rated on a local scale Marginal/low - rating=1; Not significant at any scale. (a rating of none is not appropriate in this context)
Sensitivity of habitat to flow changes	This assessment should essentially take into account the size of the stream as well as the habitat types available. The presumption is that only a limited decrease or increase in the flow (and the related depth and width) of certain rivers (often "smaller" streams) will result in particular physical habitat types (i.e. riffles), becoming unsuitable for biota as compared to "larger" streams. Assessment is based on available information and expert judgement.	Very High - rating=4; Streams of a particular size and with abundant habitat types highly sensitive to flow decreases or increases at all times High - rating=3; Streams of a particular size and with some habitat types being highly sensitive to flow decreases or decreases at all times. Moderate - rating=2; Streams of a particular size and with some habitat types being susceptible to flow

Determinant*	Guidelines And Description	Scoring Guidelines
		decreases or increases during certain seasons. Marginal/low - rating=1; Streams of a particular size and with habitat types rarely sensitive to flow decreases or increases. (a rating of none is not appropriate in this context)
Sensitivity to flow-related water quality changes	This assessment should also consider the size and flow of the stream in terms of its sensitivity to water quality changes. A decrease in the natural flow volume may, for example, result in a diminished assimilative capacity (in the situation where effluent forms part of the total flow volume) or may cause natural water quality variables (i.e. water temperature and oxygen) to reach levels detrimental for biota (also applicable to increases in flow). The assumption regarding the sensitivity of "smaller" streams is also applicable here. In terms of organic pollution load, it has been pointed out that slow flowing deep rivers would be impacted over greater distances than fast flowing shallow rivers where re-aeration rates would be high (Chutter 1999). Assessment is based on available information and expert judgement.	Very High - rating=4; Streams of a particular size (usually "small") and with abundant habitat types highly sensitive to water quality changes related to flow decreases or increases at all times. High - rating=3; Streams of a particular size (usually "small") and with some habitat types being highly sensitive to water quality related changes related to flow decreases or increases at all times. Moderate - rating=2; Streams of a particular size (often "larger") and with some habitat types being sensitive to water quality related flow decreases or increases during certain seasons. Marginal/low - rating=1; Streams of a particular size (often "larger") and with habitat types rarely sensitive to water quality change related to flow decreases or increases. (a rating of none is not appropriate in this context)
Migration route/corridor for instream and riparian biota	The importance of a specific stream delineation in terms of the link it provides for the upstream and downstream biological functioning of other sections of the stream, is indicated here (i.e. connectivity). In essence the biological connectivity provided by a particular	Very high - rating=4; The stream delineation is a critical link in terms of connectivity for the survival of biota upstream and downstream and is very sensitive to modification.

Determinant*	Guidelines And Description	Scoring Guidelines
	stream delineation can influence its ecological importance and result in an adapted (i.e. higher) rating than it would have had if was assessed only on its own. Assessments should be based on the results of ratings for individual stream network delineations, professional judgement and available information. The sensitivity of the migration route/corridor to modifications and disruptions form part of the assessment. Within this context, headwater quaternaries/delineations could have a low importance as a migration route /corridor (at a sub-quaternary or other smaller delineation, migration route/corridor may be more important)	High - rating=3; The stream delineation is an important link in terms of connectivity for the survival of biota upstream and downstream and is sensitive to modification. Moderate - rating=2; The stream delineation is a moderately important link in terms of connectivity for the survival of biota upstream and downstream and is moderately sensitive to modification. Marginal/Low - rating=1; The stream delineation is a marginally/low important link in terms of connectivity for the survival of biota upstream and downstream and has a marginal sensitivity to modification None – rating=0; The stream delineation is not of any importance in terms of connectivity for the survival of biota upstream and downstream.

Determinant*	Guidelines And Description	Scoring Guidelines
National parks, Wilderness areas, Nature reserves Natural Heritage sites Natural areas	The presence of conservation (i.e. National Parks, Wilderness areas and Nature Reserves) and natural areas (i.e. unproclaimed, relatively unmodified/undisturbed areas) within a stream delineation will logically place an additional emphasis on the ecological importance and sensitivity of a stream. The importance of such areas for the conservation of the aquatic ecological diversity on different scales must be judged, i.e. the presence of a quaternary or other delineation in a conservation or natural area does not automatically indicates a high score.	Very high - score=4; The stream delineation is present within an area very important for the conservation of ecological diversity on a National and even international scale. High - score=3; The stream delineation is present within an area important for the conservation of ecological diversity on a National scale. Moderate - score=2; The stream delineation is present within an area important for the conservation of ecological diversity on a provincial /regional scale. Marginal/Low - score=1; The stream delineation is present within an area important for the conservation of ecological diversity on a local scale. Very low - score=0; The stream delineation is not present within an area important for the conservation of ecological diversity on any scale.

*: The scoring system indicated here is mainly applicable to vertebrates. In cases where invertebrates (in particular) and plants are used as indicators, the relevant scoring system may have to be adapted by the relevant ecological experts.

<u>Determining the ecological importance and sensitivity category (EISC)</u>

In determining the ecological importance and sensitivity, no weighting of the relative importance of the various components of ecological importance and sensitivity is proposed at this stage. However, it is required that the relative confidence of each rating also be estimated based on a scale of four classes as indicated in Table B4. The possibility of using confidence ratings as indicators of the relative weights of various determinants is currently receiving attention.

The median score for the biotic and habitat determinants is interpreted as indicated in Table A4.

Table A4 Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants.

Ecological Importance And Sensitivity Category*	Range Of Median
Very high Quaternaries/delineations that are considered unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3 and ≤4
High Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but may have a substantial capacity for use.	>2 and ≤3
Moderate Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.	>1 and ≤2
Low/marginal Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.	>0 and ≤1

*: Quaternaries refer to the mainstem river in a quaternary.

12 APPENDIX C: GUIDING PRINCIPLES ON MANAGING SEDIMENT AND VEGETATION

12.1 Principles on managing sediment

Watercourses naturally transport sediment through the catchment, while wetlands accumulate sediment. A natural sediment regime ensures that transport and deposition are balanced, such that erosion and sediment accumulation do not accelerate to the point that causes rapid change in the system, such as flooding, channel-switching, and flood-outs. Vegetative cover within a catchment helps to ensure that excessive sediment is not mobilised, and deposited in watercourses and wetlands. In agricultural catchments where soil is worked, and can remain un-vegetated (fallow) for periods of time, sediment loads into watercourses can be high, especially during the wet season. Hardening of the catchment through development leads to higher runoff velocities and an increase in erosion.

The following ecological principles should guide sediment management where applicable for existing infrastructure of the AWRMS project:

- The aim of sediment management should not be to stop the natural processes of sediment transport and deposition, but rather to undertake "damage control" where these processes may be placing infrastructure at risk.
- Sediment management should never lead to the alteration of the natural shape and slope of watercourse / wetland banks and beds. In other words, the aim should always be to return a channel to its natural pre-sedimented state, in order to reinstate the natural capacity of the channel to hold and transport water.

12.2 Principles on managing invasive alien plants and bush encroachment

The following ecological principles must be applied to maintenance activities relating to the management of invasive alien plants and bush encroachment:

- Indigenous riparian and instream vegetation is essential for the healthy functioning of watercourses, so care must be taken in its management. The vegetation is important for:
    - The provision of food (leaves, woody material), refuge and nesting sites.
    - Protection of the watercourse (or wetland) from pollutants, sediments, etc. entering the ecosystem from the surrounding landscape, for instance as overland flow or contaminated road runoff. The water must flow through a vegetated "buffer" before it reaches the river or wetland, and the plants themselves in this buffer take up pollutants, hold back sediment, accumulate excess nutrients, and generally clean up the water flowing through it.
    - Shading – the extent of cover over a stream or wetland will determine water temperature, and the amount of sunlight entering the ecosystem. The aquatic fauna are adapted to the natural temperature regime, as determined by the plant cover (amongst other factors).

    - Protection from erosion – the plants growing in the riparian buffer around a river or wetland and within the channel serve to bind the soil with their roots, and stabilise it, protecting the soil from erosion.
- Indigenous tree species growing in and around watercourses and wetlands must be left in place. The only exception to this is where trees are directly blocking the free passage of surface water.

13 APPENDIX D: RISK ASSESSMENT MATRICES FOR AFFECTED AQUATIC ECOSYSTEMS

PROJECT: **Input into an MMP: Aquatic ecosystem assessment for the existing AWRMS infrastructure**

RISK ASSESSMENT MATRIX for Section 21 (c) and (i) Water Use activities (Version 2.1.1)

POTENTIALLY AFFECTED WATERCOURSE/S			FIELD-VERIFIED ASSESSMENT RESULTS				
Watercourse number	**Watercourse name**	**Watercourse type**	**PES**	**EI**	**ES**	**EIS**	**Wetland Importance**
(1)	Brakkefontein Road Stream	River / Natural channel	C			Low	
(2)	Donkergat River channelled valley bottom wetland	Wetland (incl. pans)	D			High	
(3)	Dune slack wetlands: Type 1	Wetland (incl. pans)	C			High	
(4)	Dune slack wetlands: Type 2	Wetland (incl. pans)	B			High	
(5)	Koerasie unchanneled valley bottom wetland	Wetland (incl. pans)	C/D			Moderate	
(6)	Langwaterspruit Stream	River / Natural channel	C			Low	
(7)	Perched depression wetlands: Type 1	Wetland (incl. pans)	B			High	
(8)	Perched depression wetlands: Type 2	Wetland (incl. pans)	D			Moderate	
(9)	Recharge wetlands	Wetland (incl. pans)	D			Moderate	
(10)	Seepage from Wesfleur WWTW and sand mining activities	Wetland (incl. pans)	n/a (artificial)			Low	
(11)	Seeps	Wetland (incl. pans)	B/C			High	
(12)	Silwerstroom channelled valley bottom wetland	Wetland (incl. pans)	C			High	
(13)	Sout River channelled valley bottom wetland	Wetland (incl. pans)	D			Moderate	
(14)	Temporary wetlands	Wetland (incl. pans)	D			Low	
(15)	Unchanneled valley bottom wetland (near chicken farm)	Wetland (incl. pans)	D			Moderate	
(16)	Ganzekraal unchanneled valley bottom wetland	Wetland (incl. pans)	C			High	

DETAILED PROJECT SPECIFICATIONS:
Include detailed project description, including all proposed control measures to prevent/minimise impacts on watercourses

The details of the **existing** infrastructure of the Atlantis Water Resource Management Scheme (AWRMS) as well as the impacts and their proposed mitigation measures of the various proposed maintenance activities are outlined in Section 5 and 7 of the freshwater report.

PROJECT: Input into an MMP: Aquatic ecosystem assessment for the existing AWRMS infrastructure

RISK ASSESSMENT MATRIX for Section 21 (c) and (i) Water Use activities - Version 2.1.1

Name of Assessor: Philip Frenzel | Signature: P.FRENZEL

SACNASP Registration No: 123620

Date of assessment: 20/05/2025

Risk to be scored for all relevant phases of the project (**factoring in specified control measures**). MUST BE COMPLETED BY SACNASP PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE.

Phase	Activity	Impact	Potentially affected watercourses: Name/s	PES	Overall Watercourse Importance	Intensity of Impact on Resource Quality – Abiotic Habitat (Drivers): Hydrology	Abiotic Habitat (Drivers): Water Quality	Abiotic Habitat (Drivers): Geomorph	Biota (Responses): Vegetation	Biota (Responses): Fauna	Overall Intensity (max = 10)	Spatial scale (max = 5)	Duration (max = 5)	Severity (max = 20)	Importance rating (max = 5)	Consequence (max = 100)	Likelihood (Probability) of impact	Significance (max = 100)	Risk Rating	Confidence level
OPERATIONAL	Dredging a trench through a wetland/river to replace pipelines and cables (like for like)	Destabilisation of slopes, banks and beds of wetlands resulting in damage/loss to vegetation and increased sedimentation and a subsequent reduction in habitat quality	Brakkefontein Road Stream	C	Low / Very low	1	2	3	2	2	6	2	2	10	2	20	60%	12	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	1	2	3	2	2	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 1	C	High	1	2	2	3	2	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 2	B	High	1	2	2	3	2	6	2	2	10	4	40	60%	24	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	3	2	2	6	2	2	10	3	30	60%	18	L	Medium
			Langwaterspruit Stream	C	Low / Very low	1	2	3	2	2	6	2	2	10	2	20	60%	12	L	Medium
			Perched depression wetlands: Type 1	B	High	1	2	2	3	2	6	2	2	10	4	40	60%	24	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	1	2	2	3	2	6	2	2	10	3	30	60%	18	L	Medium
			Recharge wetlands	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Seeps	B/C	High	1	2	2	3	2	6	2	2	10	4	40	60%	24	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	1	2	3	3	2	6	2	2	10	4	40	60%	24	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	1	2	3	2	2	6	2	2	10	3	30	60%	18	L	Medium
			Temporary wetlands	D	Low / Very low	1	2	2	1	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	2	2	3	2	2	6	2	2	10	4	40	60%	24	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	3	2	2	6	2	2	10	3	30	60%	18	L	Medium
OPERATIONAL	Dredging a trench through a wetland/river to replace pipelines and cables (like for like)	Obstruction or diversion of surface flow could lead to a loss of connectivity within a watercourse/wetland or erosion in an area receiving diverted flow.	Brakkefontein Road Stream	C	Low / Very low	3	1	3	2	3	6	2	2	10	2	20	60%	12	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	3	2	3	2	3	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 1	C	High	2	1	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Dune slack wetlands: Type 2	B	High	2	1	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	3	2	3	2	3	6	2	2	10	3	30	60%	18	L	Medium
			Langwaterspruit Stream	C	Low / Very low	3	1	3	2	3	6	2	2	10	2	20	60%	12	L	Medium
			Perched depression wetlands: Type 1	B	High	2	1	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	2	1	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Recharge wetlands	D	Moderate	2	1	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	2	1	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Seeps	B/C	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	3	2	3	2	3	6	2	2	10	4	40	60%	24	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	3	2	3	2	3	6	2	2	10	3	30	60%	18	L	Medium
			Temporary wetlands	D	Low / Very low	2	1	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	3	2	3	2	3	6	2	2	10	4	40	60%	24	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	3	2	3	2	3	6	2	2	10	3	30	60%	18	L	Medium
OPERATIONAL	Dredging a trench through a wetland/river to replace pipelines and cables (like for like)	Smothering of habitat from sediment-laden water as a result of the dewatering of trenches	Brakkefontein Road Stream	C	Low / Very low	1	2	3	2	2	6	2	3	11	2	22	60%	13.2	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	1	2	3	2	2	6	2	3	11	4	44	60%	26.4	L	Medium
			Dune slack wetlands: Type 1	C	High	2	3	2	3	3	6	2	3	11	4	44	60%	26.4	L	Medium
			Dune slack wetlands: Type 2	B	High	2	3	2	3	3	6	2	3	11	4	44	60%	26.4	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	3	2	2	6	2	3	11	3	33	60%	19.8	L	Medium
			Langwaterspruit Stream	C	Low / Very low	1	2	3	2	2	6	2	3	11	2	22	60%	13.2	L	Medium
			Perched depression wetlands: Type 1	B	High	2	3	2	3	3	6	2	3	11	4	44	60%	26.4	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	2	3	2	3	3	6	2	3	11	3	33	60%	19.8	L	Medium
			Recharge wetlands	D	Moderate	2	3	2	3	3	6	2	2	10	3	30	60%	18	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	2	4	2	3	9	2	18	60%	10.8	L	Medium
			Seeps	B/C	High	2	3	2	3	3	6	2	3	11	4	44	60%	26.4	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	2	3	3	3	3	6	2	3	11	4	44	60%	26.4	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	1	2	3	2	2	6	2	3	11	3	33	60%	19.8	L	Medium
			Temporary wetlands	D	Low / Very low	1	2	2	2	2	4	2	3	9	2	18	60%	10.8	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	1	2	3	2	2	6	2	3	11	4	44	60%	26.4	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	3	2	2	6	2	3	11	3	33	60%	19.8	L	Medium

Phase	Activity	Impact	Potentially affected watercourses			Intensity of Impact on Resource Quality: Abiotic Habitat (Drivers)			Intensity of Impact on Resource Quality: Biota (Responses)		Overall Intensity (max = 10)	Spatial scale (max = 5)	Duration (max = 5)	Severity (max = 20)	Importance rating (max = 5)	Consequence (max = 100)	Likelihood (Probability) of impact	Significance (max = 100)	Risk Rating	Confidence level
			Name/s	PES	Overall Watercourse Importance	Hydrology	Water Quality	Geomorph	Vegetation	Fauna										
OPERATIONAL	Clearing of encroaching vegetation close to infrastructure	Erosion of soil due to removal of stabilising plant cover and subsequent sedimentation; change in temperature change; trampling of vegetation	Brakkefontein Road Stream	C	Low / Very low	1	2	3	1	1	6	2	2	10	2	20	60%	12	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	1	2	3	2	2	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 1	C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 2	B	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Langwaterspruit Stream	C	Low / Very low	1	2	3	2	2	6	2	2	10	2	20	60%	12	L	Medium
			Perched depression wetlands: Type 1	B	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	1	2	2	3	3	6	2	2	10	3	30	60%	18	L	Medium
			Recharge wetlands	D	Moderate	1	2	2	3	3	6	2	2	10	3	30	60%	18	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Seeps	B/C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Temporary wetlands	D	Low / Very low	1	2	2	1	1	4	2	2	8	2	16	60%	9.6	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	1	2	3	2	2	6	2	2	10	4	40	60%	24	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
OPERATIONAL	Damage to riparian, instream and/or wetland vegetation when accessing working area and conducting the maintenance activity	Loss of ecological integrity and possible biodiversity loss	Brakkefontein Road Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	1	2	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Dune slack wetlands: Type 1	C	High	1	2	3	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 2	B	High	1	2	3	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Langwaterspruit Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Perched depression wetlands: Type 1	B	High	1	2	3	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	1	2	3	3	3	6	2	2	10	3	30	60%	18	L	Medium
			Recharge wetlands	D	Moderate	1	2	3	3	3	6	2	2	10	3	30	60%	18	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Seeps	B/C	High	1	2	3	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	1	2	3	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Temporary wetlands	D	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	1	2	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
OPERATIONAL	Movement and noise from workers, trucks and machinery near inland aquatic ecosystems resulting in local disturbance of fauna and flora	Noise and trampling resulting in fauna moving away from the site and thus a potential loss of biodiversity/change in community structure	Brakkefontein Road Stream	C	Low / Very low	0	0	1	2	2	4	2	1	7	2	14	80%	11.2	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	0	0	1	2	2	4	2	1	7	4	28	80%	22.4	L	Medium
			Dune slack wetlands: Type 1	C	High	0	0	1	3	3	6	2	1	9	4	36	80%	28.8	L	Medium
			Dune slack wetlands: Type 2	B	High	0	0	1	3	3	6	2	1	9	4	36	80%	28.8	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	0	0	1	2	2	4	2	1	7	3	21	80%	16.8	L	Medium
			Langwaterspruit Stream	C	Low / Very low	0	0	1	2	2	4	2	1	7	2	14	80%	11.2	L	Medium
			Perched depression wetlands: Type 1	B	High	0	0	1	3	3	6	2	1	9	4	36	80%	28.8	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	0	0	1	2	2	4	2	1	7	3	21	80%	16.8	L	Medium
			Recharge wetlands	D	Moderate	0	0	1	2	2	4	2	1	7	3	21	80%	16.8	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	0	0	1	2	2	4	2	1	7	2	14	80%	11.2	L	Medium
			Seeps	B/C	High	0	0	1	3	3	6	2	1	9	4	36	80%	28.8	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	0	0	1	3	3	6	2	1	9	4	36	80%	28.8	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	0	0	1	2	2	4	2	1	7	3	21	80%	16.8	L	Medium
			Temporary wetlands	D	Low / Very low	0	0	1	1	1	2	2	1	5	2	10	80%	8	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	0	0	1	2	2	4	2	1	7	4	28	80%	22.4	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	0	0	1	2	2	4	2	1	7	3	21	80%	16.8	L	Medium
OPERATIONAL	Replacement of infrastructure requiring introduced sand/soil during reconstruction activities may contain alien plant seeds	Disturbed areas will be susceptible to invasion of IAP and pose a threat to biodiversity in the area	Brakkefontein Road Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Donkergat River channelled valley bottom wetland	D	High	1	2	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Dune slack wetlands: Type 1	C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Dune slack wetlands: Type 2	B	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Langwaterspruit Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Perched depression wetlands: Type 1	B	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Perched depression wetlands: Type 2	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Recharge wetlands	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L	Medium
			Seeps	B/C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Silwerstroom channelled valley bottom wetland	C	High	1	2	2	3	3	6	2	2	10	4	40	60%	24	L	Medium
			Sout River channelled valley bottom wetland	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium
			Temporary wetlands	D	Low / Very low	1	2	2	1	1	4	2	2	8	2	16	60%	9.6	L	Medium
			Ganzekraal unchanneled valley bottom wetland	C	High	1	2	2	2	2	4	2	2	8	4	32	60%	19.2	L	Medium
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	2	2	2	4	2	2	8	3	24	60%	14.4	L	Medium

Phase	Activity	Impact	Potentially affected watercourses			Intensity of Impact on Resource Quality					Overall Intensity (max = 10)	Spatial scale (max = 5)	Duration (max = 5)	Severity (max = 20)	Importance rating (max = 5)	Consequence (max = 100)	Likelihood (Probability) of impact	Significance (max = 100)	Risk Rating
						Abiotic Habitat (Drivers)			Biota (Responses)										
			Name/s	PES	Overall Watercourse Importance	Hydrology	Water Quality	Geomorph	Vegetation	Fauna									
OPERATIONAL	Road maintenance activities and removal of silts within or near aquatic ecosystems	Destabilisation of slopes, banks and beds of wetlands resulting in damage/loss to vegetation and increased sedimentation and a subsequent reduction in habitat quality	Brakkefontein Road Stream	C	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Donkergat River channelled valley bottom wetland	D	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Dune slack wetlands: Type 1	C	High	3	2	3	3	3	6	2	2	10	4	40	60%	24	L
			Dune slack wetlands: Type 2	B	High	3	2	3	3	3	6	2	2	10	4	40	60%	24	L
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Langwaterspruit Stream	C	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Perched depression wetlands: Type 1	B	High	3	2	3	3	3	6	2	2	10	4	40	60%	24	L
			Perched depression wetlands: Type 2	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Recharge wetlands	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Seeps	B/C	High	3	2	3	3	3	6	2	2	10	4	40	60%	24	L
			Silwerstroom channelled valley bottom wetland	C	High	3	2	3	3	3	6	2	2	10	4	40	60%	24	L
			Sout River channelled valley bottom wetland	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Temporary wetlands	D	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Ganzekraal unchanneled valley bottom wetland	C	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
OPERATIONAL	Generation of waste and wastewater during construction related activities	Loss of the ecological integrity in aquatic ecosystems due to poor water quality (hydrocarbons, liquid byproducts from washing equipment, mixing cement, etc.) and litter/rubble	Brakkefontein Road Stream	C	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Donkergat River channelled valley bottom wetland	D	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Dune slack wetlands: Type 1	C	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Dune slack wetlands: Type 2	B	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Langwaterspruit Stream	C	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Perched depression wetlands: Type 1	B	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Perched depression wetlands: Type 2	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Recharge wetlands	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Seeps	B/C	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Silwerstroom channelled valley bottom wetland	C	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Sout River channelled valley bottom wetland	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Temporary wetlands	D	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Ganzekraal unchanneled valley bottom wetland	C	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
OPERATIONAL	Construction footprints and the storage of construction materials near aquatic ecosystems	Introduction of invasive alien plant seeds/seedlings, compaction of soils and shading of indigenous plants.	Brakkefontein Road Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Donkergat River channelled valley bottom wetland	D	High	1	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Dune slack wetlands: Type 1	C	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Dune slack wetlands: Type 2	B	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Koerasie unchanneled valley bottom wetland	C/D	Moderate	1	2	2	2	1	4	2	2	8	3	24	60%	14.4	L
			Langwaterspruit Stream	C	Low / Very low	1	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Perched depression wetlands: Type 1	B	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Perched depression wetlands: Type 2	D	Moderate	1	2	2	2	1	4	2	2	8	3	24	60%	14.4	L
			Recharge wetlands	D	Moderate	1	2	2	2	1	4	2	2	8	3	24	60%	14.4	L
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	1	2	2	2	1	4	2	2	8	2	16	60%	9.6	L
			Seeps	B/C	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Silwerstroom channelled valley bottom wetland	C	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Sout River channelled valley bottom wetland	D	Moderate	1	2	2	2	1	4	2	2	8	3	24	60%	14.4	L
			Temporary wetlands	D	Low / Very low	1	2	2	2	1	4	2	2	8	2	16	60%	9.6	L
			Ganzekraal unchanneled valley bottom wetland	C	High	1	2	3	3	1	6	2	2	10	4	40	60%	24	L
			Unchanneled valley bottom wetland (near chicken farm)	D	Moderate	1	2	2	2	1	4	2	2	8	3	24	60%	14.4	L
OPERATIONAL	Borehole maintenance of existing boreholes	Loss of the ecological integrity in aquatic ecosystems due to poor water quality	Dune slack wetlands: Type 1	C	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Dune slack wetlands: Type 2	B	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Perched depression wetlands: Type 1	B	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L
			Recharge wetlands	D	Moderate	2	2	2	2	2	4	2	2	8	3	24	60%	14.4	L
			Seepage from Wesfleur WWTW and sand mining activities	n/a (artificial)	Low / Very low	2	2	2	2	2	4	2	2	8	2	16	60%	9.6	L
			Silwerstroom channelled valley bottom wetland	C	High	3	3	3	3	3	6	2	2	10	4	40	60%	24	L
			Ganzekraal unchanneled valley bottom wetland	C	High	2	2	2	2	2	4	2	2	8	4	32	60%	19.2	L