BROOKDALE ASSESSMENT CENTRE ON ERVEN 1086 AND ERVEN 1661 IN PHOENIX, ETHEKWINI MUNICIPALITY, KWAZULU-NATAL

Wetland Rehabilitation & Management Plan

Version 1.0

Revision No. 0

Date: 24th January 2022

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Report No: EP574-02

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REHABILITATION / MANAGEMENT PLAN DETAILS AND DECLARATION OF INDEPENDENCE

This is to certify that the following rehabilitation plan has been prepared independently of any influence or prejudice as may be specified by the relevant environmental authorities (DFFE, DWS, etc.).

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Client:	Woodglaze Trading (PTY) Ltd

Details of Specialist Team

The relevant experience of specialist team members involved in the compilation of this report are briefly summarized below. *Curriculum Vitae's* of the specialist team are available on request.

Name	Details
Douglas Macfarlane *Director, Chief Scientist & Wetland Ecologist* *Pr.Sci.Nat.*	Douglas Macfarlane is a Chief Scientist at Eco-Pulse and the director of the company. His qualifications include a BSc in Wildlife science (completed Summe Cum Laude) and an MSc in Environment & Development. He is a registered Professional Natural Scientist in the field of Ecological Science, having worked both in the corporate sector and consulting environment. He has been working in the field of wetland and ecological assessments for over 15 years since working for Sappi Forests (PTY) Ltd where he commenced working in 2001. He will participate in site visits and provide focused support to the project team.
Adam Teixeira-Leite *Principal Scientist & Wetland Ecologist* *Pr.Sci.Nat.*	Adam is an employee at Eco-Pulse and Principal Scientist with a Masters degree (MSc) in Environmental Science (thesis focused on wetland rehabilitation and ecological monitoring). He is a registered Professional Natural Scientist (*Pr.Sci.Nat*.) with SACNASP in the field of 'Ecological Science' and 'Environmental Science'. Over the past 14 years he has worked extensively on numerous wetland projects requiring the delineation of wetlands and assessment of wetland functional importance and sensitivity, as well as wetland, river and terrestrial habitat rehabilitation planning, in KwaZulu-Natal, the Western Cape and Eastern Cape, the Free State, North West Province, Mpumalanga and in Gauteng as well as Lesotho and Swaziland. Adam has also been involved in a range of projects requiring the assessment of terrestrial and aquatic biodiversity, requiring both desktop analysis and field verification as well as in the development of a Biodiversity Sector Plan for the Ugu District Municipality. He has also been involved in vegetation assessments and extensively in alien invasive plants surveys and nursery audits for eThekwini Municipality. Adam has successfully completed several Water Use License Applications (WULAs) for residential / commercial developments within KZN (eThekwini Municipality, KwaDukuza Municipality) and the Eastern Cape.
Ryan Kok *Scientist & Wetland Ecologist* *Pr.Sci.Nat.*	Ryan is an employee at Eco-Pulse and Scientist with a BSc degree in Environmental Science; BSc Honours and MSc degree in Biological & Ecological Sciences. He is a registered Professional Natural Scientist (Pr.Sci.Nat.) with SACNASP in the 'Ecological Science' field of practice. Ryan has >8 years' experience in GIS and environmental modelling, with extensive field experience in monitoring and analyzing data. Since being part of Eco-Pulse Ryan has utilized his GIS skills in Environmental Management Frameworks, Wetland Inventories and Prioritization Assessments for major Municipalities. Over the past 5 years Ryan has worked extensively on numerous wetland projects requiring the delineation of wetlands and assessment of wetland functional importance and sensitivity, as well as wetland and river rehabilitation planning, in KwaZulu-Natal, the Eastern Cape, Mpumalanga and in Gauteng. Ryan has also successfully completed several Water Use License Applications (WULAs) for various developments within KZN.

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DISCLAIMER

- This wetland rehabilitation & management plan has been compiled for the sole use on the wetlands referred to as 'W01' and 'W02' residing on Erven 1086 and Erven 166, Phoenix, eThekwini Municipality in KwaZulu-Natal, South Africa. Neither its guidelines/recommendations nor background information may be used in any form without prior permission from the owner of the properties.
- This plan must not be amended without prior consultation and approval from the Client (Woodglaze Trading) and a qualified and experienced Wetland Specialist/Ecologist.
- All changes to the plan must be formally motivated and supplemented with additional information as necessary.
- Eco-Pulse Environmental Consulting Services takes no liability for the poor implementation of the various mitigation measures and management and rehabilitation guidelines provided in this Plan.

ASSUMPTIONS AND LIMITATIONS

In compiling this document, the following has been assumed:

- The information provided in this rehabilitation & management plan is based on site visits that have been undertaken by the project team (Wetland Ecologists from Eco-Pulse Consulting) and their subsequent inputs into the Reporting, which includes baseline wetland assessments. It is understood that this information is sufficient for the relevant Court Order.
- The Rehabilitation & Management Plan should be read in conjunction with the following specialist wetland assessment reports:

  *Eco-Pulse Consulting. 2020. Brookdale Housing Project NEMA Section 24G**: Wetland Assessment Report**. Unpublished specialist report prepared for Woodglaze Trading (PTY) Ltd. Report No. EP493-01 (version 1.0). May 2020.*

  *Eco-Pulse Consulting, 2021. **Specialist Wetland Delineation Report**: Brookdale Assessment Centre on Erven 1086 and Erven 1661 in Phoenix. Unpublished report for Woodglaze Trading. Version 1.0. Report No. EP574-01. January 2022.*

- Information contained in this Rehabilitation Plan (report) will be used to inform the rehabilitation of on-site wetlands and buffer on the target property and to guide the relevant rehabilitation actions and activities needed. Implementing Agents will thus use this Rehabilitation Plan and the information contained therein to inform the implementation of a rehabilitation programme for the residual impacts to the wetland(s).
- Rehabilitation activities should not be carried out until the Rehabilitation Plan has been approved and formally signed off by the Client and the assessing officer from DFFE and have been notified of the commencement of the rehabilitation activities.

Other relevant limitations include:

- The information in this Report is based on existing available information and input from the wetland ecologists from Eco-Pulse Consulting. Until this Wetland Rehabilitation Plan has been finalised and signed off by the Client, and approved by the relevant environmental authorities, the content of the document should be considered as preliminary (draft form).
- Rehabilitation activities and management interventions have been developed for site conditions as at the time of the planning site visits. Should site conditions change before the rehabilitation plan is implemented, changes to the plan may be necessary. In this case, project implementers may require the assistance of a wetland ecologist to revise the relevant section(s) of the plan.

KEY REFERENCES AND SOURCES OF INFORMATION

A number of key documents were referred to in compiling this conceptual level wetland rehabilitation plan. The principal ones included:

- WET-RehabPlan: Guidelines for planning wetland rehabilitation in South Africa (Kotze *et al.*, 2009).
- Wetland Restoration: A handbook for New Zealand Freshwater Systems (Clarkson and Peters, 2012).
- WET-Rehab Methods: National guidelines and methods for wetland rehabilitation (Russell, 2009).
- WETRehabEvaluate: Guidelines for the monitoring and evaluation of wetland rehabilitation projects (Cowden and Kotze, 2008).
- Walters, D., Kotze, D., Cowden, C., Browne, M., Grecock, M, Janks, M and Eggers, F., 2019. WET-REHAB Evaluate (V2): an integrated monitoring and evaluation framework to assess wetland rehabilitation in South Africa. September 2019. WRC Report No. 2344/1/19, Water Research Commission, Pretoria.

1. INTRODUCTION

Wetlands and rivers are dynamic ecosystems that are highly sensitive to influences from both natural and anthropogenic factors. In order to maintain the biological diversity and productivity of aquatic ecosystems such as rivers and wetlands, and to permit the wise use of aquatic resources by people whilst ensuring that the requirements of the natural environment are met, an overall agreement is essential between the various managers, landowners, occupiers and other stakeholders. A Wetland & Rehabilitation and Management Plan provides an appropriate mechanism to achieve this.

Wetland rehabilitation is rather broadly defined and generally refers to the process of assisting in (i) the recovery of a degraded aquatic ecosystems (such as a wetland or river/stream) by reinstating the natural ecological driving forces, or alternatively, (ii) halting the decline in health of an ecosystem that is in the process of degrading (Russell, 2009). The management of wetlands refers to activities that can be conducted in order to protect, improve or manipulate wetlands and their ecosystem functions. The ultimate goal of protecting and even improving wetland functionality should involve not only protecting wetlands from direct human pressures, but also maintaining important natural processes that operate indirectly from the outside and that may be altered by human activities in the broader wetland catchment area.

This introductory section of the Wetland Rehabilitation & Management Plan provides the background to the project and defines the purpose of the Plan as well as roles and responsibilities for implementing the Plan for the wetlands on the property. The legal context with regards to wetland rehabilitation & management in South Africa is also described, for interest's sake.

1.1 Purpose

The Wetland Rehabilitation & Management Plan contained in this document has been developed to guide the rehabilitation, management and sustainable use of the wetlands located on Erven 1086 and Erven 1661 in Phoenix, eThekwini Municipality, KZN. This is in line with the recommendations made in the Wetland Report by Eco-Pulse (Report No. EP493-01 & EP574-01) which concludes as follows:

> *"In addressing the 'unauthorised' activities investigated, is has been recommended that all fill material located in onsite wetland and associated 20m buffer be removed. Furthermore, it is recommended that that the entire wetland and buffer zone be rehabilitated. This would translate to an overall net gain in wetland condition and functioning which would more than compensate for any reduced habitat condition as a result of the unauthorised earthen platforming within the wetlands (and buffer) on Erven 1086 and Erven 1661. It is important to note that the quantification of the wetland impact, to inform what level of compensation is required, is likely to be complicated by the fact that assessing the extent and pre-infilling condition of the wetland habitat is extremely challenging and probably not possible to obtain with any reasonable level of confidence."* (Eco-Pulse, 2020; Eco-Pulse, 2022).

Furthermore, onsite wetland rehabilitation for wetlands 'W01' and portion of 'W02' on the target property has been recommended to address the residual impacts to wetlands caused by sedimentation, infilling and dumping of solid waste and building rubble within the wetlands below the existing earthen platforms.

This plan provides an outline of the rehabilitation required for the wetlands on the property with guidelines to support the implementation of the rehabilitation. In addition, recommendations for long-term wetland management (post-rehabilitation) have also been provided. This report aims to address the rehabilitation requirements as outlined in the court order (Agreement between the state and the accused, in terms of Section 105 (A) of Act 51 of 1977, as amended; Case No. 662/2020).

Note that rehabilitation will deal with the historic infilled wetland as well as the recommended wetland 'buffer zone'.

As for 'Wetland Offsets' this not recommended, and rather on site rehabilitation will take place, the reader is referred the Chapter 10: 'Need & Desirability for Wetland Offsets' in wetland specialist report for further clarity (Eco-Pulse, 2020).

1.2 Contents

This document contains the following:

- **Chapter 2: Wetland Rehabilitation Plan**
- **Chapter 3: Wetland Management Plan**
- **Chapter 4: Wetland Monitoring Plan**

1.3 Structure of the Plan

This document contain the **Wetland Rehabilitation & Management Plan** developed specifically for wetlands located on the property in question. The plan should be read and implemented in conjunction with the specialist wetland assessment report compiled by Eco0Pulse Consulting in 2020 (report reference: EP EP493-01) and the specialist wetland delineation report by Eco-Pulse Consulting in 2022 (report reference: EP574-01). This Plan is intended to be both educational and provide a practical tool that can be used to implement the rehabilitation and management of the wetlands on the target property. The Plan is a structured document that:

- Provides details on the target wetland particulars (location, extent, type, land ownership, etc.);
- Defines the purpose and objectives of the plan;
- Outlines the existing problems and impacts to wetlands;
- Defines the key roles and responsibilities of the various stakeholders involved;
- Describes the need for intervention;
- Sets out the steps to be taken to rehabilitate wetland areas on the target property;
- Provides particulars of the type of intervention(s), the materials to be used and dimensions of the interventions proposed (where relevant);

- Provides guidance on the proposed timing of rehabilitation activities;
- Describes key negative environmental impacts that the rehabilitation interventions may have on the environment and recommends means for managing these impacts;
- Outlines requirements for follow-up/maintenance work and ecological monitoring; and
- Provides management recommendations.

1.4 Site Locality

The focal area for wetland rehabilitation and management in accordance with this Plan is located on Erven 1086 and Erven 1661 which is located on the corner of Lenham Dr and JG Champion Dr, in Phoenix, eThekwini Municipality, KZN (see Figure 1, below).

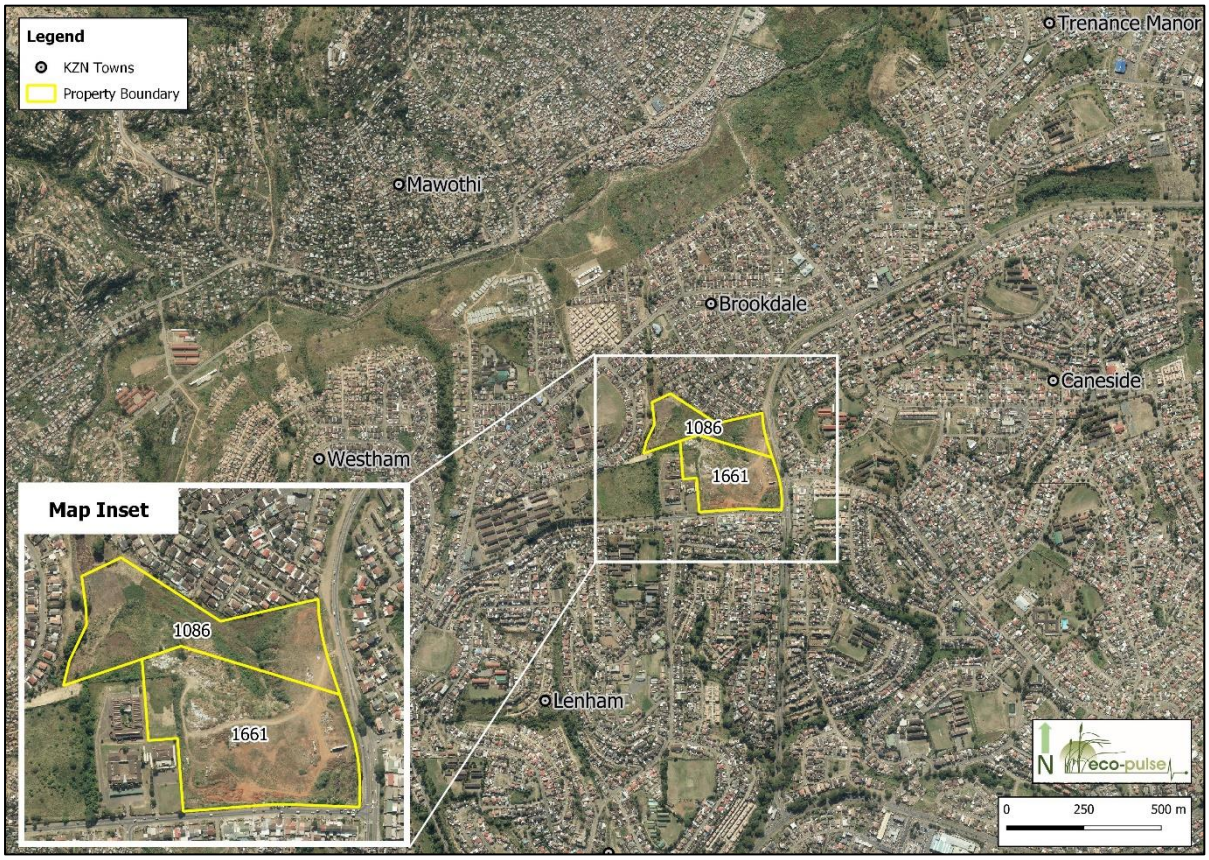

Figure 1 Locality map showing the location and extent of ERF 1086 & ERF 1661 in Phoenix, eThekwini Municipality, KZN.

1.5 Site History (land use)

The land-use of the properties has a rich history which includes historic sugarcane farming dating back to 1953 (if not earlier) to approx. 1985. Thereafter, the site was left vacant, and ownership given to the eThekwini Local Municipality. During this period 3of formal inactivity, both properties experienced a large amount of illegal dumping from local communities from approx. 2007.

In 2012, Woodglaze (Pty) Ltd purchased the vacant properties from the eThekwini Municipality and obtained permission to construct low-cost housing to service the impoverished and disadvantaged

communities in the area. An extensive bulk infill programme appears to have commenced approximately during the latter portion of 2014 (*this was based on a review of historic satellite imagery of the site in Google Earth™*). Infilling had taken place generally across the eastern and southern portions of the site.

1.6 Target Wetlands

The two (2) wetlands affected by the 'illegal/unauthorised' activities that have taken place on Erven 1086 and 1661 were subject to detailed delineation and baseline ecological assessment, with the initial findings contained in the Wetland Assessment Report (Eco-Pulse, 2020, Report No. EP493-01).

Subsequently, the approximate historical wetland boundary was delineated as per the instruction of the Court Order (Agreement between the state and the accused, in terms of Section 105 (A) of Act 51 of 1977, as amended; Case No. 662/2020), with these findings contained in the Wetland Delineation Report (Eco-Pulse, 2022, Report No. EP574-01). A summary of the key findings is contained below in Table 1.

Table 1. Project/site details.

Project/Site Name	Brookdale Assessment Centre /
Properties	Erf 1086 and Erf 1661
Region (Province)	KwaZulu-Natal
Coordinates	29°41'23.32"S | 30°59'55.56"E
Nearest Town	Phoenix
Owner	Mr. Ravi Jagadasan
Watercourses and Buffer (see also the map in Figure 2)	**Wetland 01**: 1.31 ha in extent, seep wetland targeted for rehabilitation & management. PES[1]: D – Largely Modified, EIS[2]: Very Low **Wetland 02**: 0.4 ha in extent, channel valley-bottom wetland targeted rehabilitation & management. PES: E – Seriously Modified, EIS: Very Low **Buffer:** recommended width of 20m and 1.48 ha in extent (Eco-Pulse, 2020)

[1] **PES**: Present Ecological State (a measure of the current condition or 'health' status of a wetland).

[2] **EIS:** Ecological Importance and Sensitivity (a measure of how ecologically important and ecologically sensitive the wetland is, based on an ecological assessment).

Figure 2 Wetland delineation showing the extent of wetlands 01 and 02 on Erf 1086 and Erf 1661, the recommended 20m buffer zone (dashed 'green' line) and with the location and extent of 'unauthorised' earthen platforms, sediment deposits, building rubble, general waste, etc. also indicated (shaded 'grey').

1.7 Wetland management, rehabilitation and the 'mitigation hierarchy'

The protection of wetlands and river systems begins with the avoidance of adverse impacts and where such avoidance is not feasible; to apply appropriate mitigation in the form of reactive practical actions that minimizes or reduces in situ impacts and aims to prevent the occurrence of large-scale damaging events as well as repeated, chronic, persistent, subtle events which can in the long-term be far more damaging (e.g. as a result of sedimentation and pollution). 'Impact Mitigation' is a broad term that covers all components involved in selecting and implementing measures to conserve biodiversity and prevent significant adverse impacts as a result of potentially harmful activities to natural ecosystems. The mitigation of negative impacts on aquatic resources is a legal requirement for authorisation purposes and must take on different forms depending on the significance of impacts and the particulars of the target area being affected. This generally follows some form of 'mitigation hierarchy' (see diagram in Figure 3,) which aims firstly at avoiding disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided, to minimise, rehabilitate, and then finally offset any remaining significant residual impacts.

In the case of particularly sensitive ecosystems, where ecological impacts can be severe, the guiding principle should generally be "*anticipate and prevent*" rather than "*assess and repair*". The onus shall therefore rest upon the developer and landowner to '**rehabilitate**' any disturbed/degraded

watercourses (wetlands) on the property in order to ensure 'no net loss' of water resource integrity and functioning through appropriate rehabilitation actions and interventions. Rehabilitation will aid the recovery of the disturbed wetland/riparian habitat and can be seen as critical in preventing further impacts to these sensitive ecosystems.

Refers to considering options in project location, sitting, scale, layout, technology and phasing **to avoid impacts** on biodiversity, associated ecosystem services, and people. This is the best option but is not always possible. Where environmental and social factors give rise to unacceptable negative impacts mining should not take place. In such cases it is unlikely to be possible or appropriate to rely on the latter steps in the mitigation.

Refers to considering alternatives in the project location, siting, scale, layout, technology and phasing that would **minimise impacts** on biodiversity and ecosystem services. In cases where there are environmental and social constraints every effort should be made to minimise impacts.

Refers to **rehabilitation** of areas where impacts are unavoidable, and measures are provided to return impacted areas to near-natural state or an agreed land use. Although rehabilitation may fall short of replicating the diversity and complexity of a natural system.

Refers to measures over and above rehabilitation to compensate for the residual negative effects on biodiversity, after every effort has been made to minimise and then rehabilitate impacts. **Biodiversity offsets** can provide a mechanism to compensate for significant residual impacts on biodiversity.

Figure 3 Diagram illustrating the 'mitigation hierarchy' (after DEA *et al.,* 2013).

1.8 Rehabilitation and the Law: *a legislative background to wetland rehabilitation in the South African context*

Wetlands are defined in the National Water Act as '*land which is transitional between terrestrial and aquatic systems*'. In view of the fact that they are transitional, they are subject to a wide range of legislation that reflects their location as well as their importance in the landscape and to society (see Figure 4). Given the value of wetlands and other aquatic ecosystems (such as rivers and estuaries) and the fact that humans depend on aquatic resources, it is against the law to deliberately damage wetlands and rivers. The law also places, directly and indirectly, the responsibility on landowners and other responsible parties, such as managers, to repair or rehabilitate damaged or lost wetlands and riparian areas (Armstrong, 2009). Of relevance to the development project are a number of laws that compel the rehabilitation of wetlands/rivers. These are summarised below in Table 2. Of particular importance is the requirement of 'duty of care' with regards to environmental remediation: stipulated in Section 28 of NEMA (National Environmental Management Act, Act 107 of 1998):

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

reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment."

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

'A person who lawfully impedes or diverts the flow of water in a wetland, or who alters the beds, banks or characteristics of a wetland must take necessary measures to stabilise the diversion structure and surrounding area through:

- *rehabilitation of the riparian habitat using only indigenous shrubs and grasses;*
- *rehabilitation of disturbed and degraded riparian areas;*
- *restoring and upgrading the riparian habitat integrity to sustain a biodiverse riparian ecosystem;*
- *removal of alien vegetation, and*
- *conducting an annual habitat assessment.'*

Table 2. Key legislation that compels the rehabilitation of aquatic ecosystems in South Africa (after Armstrong, 2008).

Legislation/Act	Key Principles/Requirements
National Environmental Management Act 107 of 1998 (NEMA)	• The loss or disturbance of ecosystem and loss of biological diversity must be avoided. • The pollution and degradation of the environment must be avoided. • The disturbance of landscapes and sites that constitute the Nations' cultural heritage must be avoided. • The use and exploitation of non-renewable and renewable natural resources must be avoided. • The development and exploitation of renewable resources and ecosystem of which they are part, must not exceed the level beyond which the integrity is jeopardised. • Sensitive, vulnerable, highly dynamic or stressed ecosystems such as wetlands require specific attention. A duty of care rests in all persons to avoid environmental degradation and pollution.
National Environmental Management: Biodiversity Act 10 of 2004 (NEM:BA)	• The South African National Biodiversity Institute (SANBI) may co-ordinate and finance programmes for the rehabilitation of ecosystems. • The Minister may publish national lists of ecosystems that are threatened and in need of protection, as may a provincial MEC.
National Water Act 36 of 1998 (NWA)	• The Minister must determine the class of water-resource and resource-quality objectives, and must give effect to the determination of the reserve. • A duty of care rests on the owner of the land, a person in control of the land or a person who occupies or uses the land, to take all reasonable measures to prevent pollution of a water resource. • A person who is responsible for an incident; or who owns a substance involved in an incident or who was in control of a substance involved in an incident, must take all reasonable measures to contain and minimise the effects of an incident and any other such measures that a Catchment Management Agency (CMA) may require. • Water-resource management is delegated to Catchment Management Agencies. • A Catchment Management Agency must advise interested persons on: the protection, use for development, conservation, management and control of water resources the development of a catchment management strategy the co-ordinated activities related to water uses the co-ordination of any relevant development plan, and the promotion of community participation in the control of water resources. • The Minister may establish bodies to implement international agreements in respect of the management of water resources with neighbouring countries. • The Minister may establish and operate government waterworks and fund such works. • A holder of a servitude must maintain the servitude area, and repair and maintain infrastructure relating to the servitude and access roads.

Legislation/Act	Key Principles/Requirements
	• A person who lawfully impedes or diverts the flow of water in a wetland, or who alters the beds, banks or characteristics of a wetland must take necessary measures to stabilise the diversion structure and surrounding area through: - rehabilitation of the riparian habitat using only indigenous shrubs and grasses; - rehabilitation of disturbed and degraded riparian areas; - restoring and upgrading the riparian habitat integrity to sustain a biodiverse riparian ecosystem; - removal of alien vegetation, and - conducting an annual habitat assessment.
Conservation of Agricultural Resources Act 43 of 1983 (CARA)	• This Act does not apply to land in urban areas, except with respect to the provisions relating to alien invader plants.
National Forests Act 84 of 1998 (NFA)	• Natural forests may not be destroyed save for "exceptional circumstances". • In terms of the National Forest Act, all forests are protected and no trees (dead or alive) may be cut, damaged or removed without a license from DAFF (or a delegated authority). • Forests must be managed to conserve biological diversity, ecosystems and habitats. • Maintaining natural forests in a good state and the rehabilitation of degraded forests must be promoted. • Any decisions on land use or development that will affect natural forests must be taken with the utmost care (the precautionary principle) and with due consideration for: - Keeping the dynamic forest processes intact; - Preventing disturbance to forest ecosystems, fauna and flora; - The most sensitive parts of forests have to be avoided; - Keeping forest margins and surrounding mosaics of habitats in place as far as possible (inter alia through sufficient buffer zones, corridors and protected areas); - Natural corridors linking forests and other habitats must be retained as far as possible; and - Not allowing disturbance caused by poor land management to be used as a motivating factor for land use change that transforms natural forest

Context of the information contained in this Plan in terms of the National Water Act requirements:

The NWA or National Water Act (No. 36 of 1998) imposes 'duty of care' on all landowners, to ensure that water resources are not polluted. Chapter 4 of the NWA is of particular relevance to wetlands and addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use water. Water use is defined very broadly in the Act and effectively requires that any activities with a potential impact on wetlands (within a distance of 500m upstream or downstream of a wetland) be authorized. Relevant to wetland/river rehabilitation, certain water-use activities require registration and/or licensing by the Department of Water & Sanitation (DWS) where activities trigger Section 21 of the National Water Act. According to the Act, water use must be licensed unless its use is excluded. Application for a water use license, permit or authorisation must therefore be made for the following listed activities under Section 21 of the NWA applicable to wetland/river rehabilitation:

- Section 21 (c) water use: Impeding or diverting the flow of water in a watercourse; and
- Section 21 (i) water use: Altering the bed, banks, course or characteristics of a watercourse.

1.9 Roles and Responsibilities for Wetland Rehabilitation, Management and Monitoring

The ultimate responsibility for the implementation of this wetland rehabilitation & management plan lies with the landowner: Woodglaze Trading. They will be tasked with overseeing the rehabilitation and/or appointing an appropriate implementer to undertake the required rehabilitation and management tasks should they not have the required expertise needed to complete the recommended tasks.

The rehabilitation implementer will also be required to undertake post-rehabilitation monitoring (as defined in this Plan) in order to ensure that rehabilitation has been completed to the satisfaction of the competent Authority. Eco-Pulse Consulting will provide input into the rehabilitation during implementation of the rehabilitation plan. All relevant parties involved in the wetland rehabilitation must be familiar with the relevant Rehabilitation Plan and Method Statements and implement rehabilitation in accordance with the guidelines and requirements contained therein. The roles and responsibilities of Key Stakeholders has been summarised as per Table 3, below.

Table 3. Roles and key responsibilities for Key Stakeholders involved in the implementation of the Wetland Rehabilitation and Management Plan.

Role Players	Roles and responsibilities
Landowner	i. Shall be ultimately responsible for the implementation of the wetland rehabilitation and management measures as set out in the relevant plan; ii. Shall be responsible for ensuring that appropriate monitoring of all rehabilitation is undertaken, and remedial actions taken where necessary; and iii. Shall be responsible for the actions of all sub-contractors as well as disseminating information pertaining to management and rehabilitation of the site.
Rehabilitation implementer	iv. Shall be responsible (where contracted by the landowner) to implement the wetland rehabilitation measures as set out in this document, to the satisfaction of the competent authority.
Wetland Ecologist	v. Shall be responsible for providing practical input into the onsite rehabilitation and revising rehabilitation methods/measures, where deemed necessary and relevant to the project. vi. Shall be responsible for monitoring the rehabilitation project and providing reporting deliverables on the rehabilitation outcomes.

1.10 Funding

This Plan has not attempted to address financial requirements associated with the implementation of this plan. The lead agent (Woodglaze Trading) is however responsible for securing adequate funding to implement the Wetland Rehabilitation & Management Plan and a financial budget including costing of all rehabilitation activities detailed in the method statement (Section 2, below) and equipment costs should be compiled prior to any rehabilitation activities occurring in collaboration with any contracted parties (rehabilitation implementer, landscapers, etc.).

1.11 Term of the plan

As per the directives contained in the court order (Agreement between the state and the accused, in terms of Section 105 (A) of Act 51 of 1977, as amended; Case No. 662/2020) the implementation of this Plan shall be undertaken over a maximum 2-year period, until such time as rehabilitation has been deemed successful through appropriate 'post-rehabilitation monitoring'. Wetland management will be on-going for the property (essentially in perpetuity as long as the current catchment land use prevails).

2. WETLAND REHABILITATION PLAN

2.1 Introduction

Chapter 2 of the document presents the wetland rehabilitation plan for the target properties and wetlands.

2.2 Key concepts & principles of wetland rehabilitation

Wetland rehabilitation and the development of relevant plans to guide the rehabilitation of these sensitive aquatic ecosystems and habitat should be underpinned by a number of general guiding principles. The following key principles relating to wetland/river rehabilitation (after Russell, 2009) were used to guide and inform the development of the wetland rehabilitation plan:

1. **Rehabilitation is a process, not an endpoint.** Rehabilitation is not the static endpoint of a 'recipe-like process' but rather it is a process in its own right, whereby the wetland/river system is given an opportunity for a new beginning. The goal of rehabilitation should not be to return and maintain a wetland in a static state, but rather to achieve a persistent resilient system that is largely self-sustaining and able to respond to change with little human intervention.

2. **Rehabilitation should work with natural processes.** Rehabilitation requires that one attempts to imitate natural processes and reinstate natural ecological driving forces in such a way that rehabilitation aids the recovery (or maintenance) of dynamic systems so that, although they are unlikely to be identical to their natural counterparts, they will be comparable in critical ways so as to function similarly. Rehabilitation essentially involves the reinstatement of these driving ecological forces to a level close to the original system, but seldom fully attaining it.

3. **Rehabilitation interventions are likely to have different starting and ending points**. Rehabilitation interventions may have different ecological starting points (ranging from totally degraded to slightly degraded) and different goal endpoints (ranging from a state that is close to the pristine to one which is still far from pristine, but nonetheless an improvement on the state of the system without any rehabilitation intervention). This ultimately depends on what is achievable, given the site conditions, and those ecosystem attributes and services that are considered most important. Any rehabilitation project should therefore be based on an understanding of both the ecological starting point and on a defined goal endpoint and should accept that it is not possible to predict exactly how the wetland is likely to respond to the rehabilitation interventions.

4. **Rehabilitation is a complex process and often it is more appropriate to focus on reinstating functional values than on reinstating natural processes.** Wetlands and rivers are complex and dynamic systems and some attributes of these systems may have changed irreversibly such that it is impractical to reverse all modifications contributing to degradation and/or loss of wetlands Given these factors there may be an emphasis in rehabilitation – not so much on restoring natural processes – but accepting the irreversible nature of irreversible change and focusing on reinstating functional values instead.

5. **Wetlands are an integral part of catchments and broader landscapes.** Rehabilitation must be integrated with the surrounding landscape if it is to fully address the causes of degradation and not just focus on the symptoms.

6. **Establishing favourable hydrological conditions is generally the key to wetland/river rehabilitation.** Aquatic vegetation, biota and ecological functions of wetlands will tend to follow the reinstatement of favourable hydrological conditions, with little additional external input required in many instances.

2.3 Aim and Objectives

The overall Aim and Objectives of the Wetland Rehabilitation Plan were developed and defined through a process of considering both the present state and functioning of the wetlands and the future requirements for the area, both in terms of legislative requirements and functional requirements within the catchment (i.e. demand for ecosystem services at the local level in particular). In accordance with these requirements, the following Aim for the project has been formulated which defines the overarching intent of the rehabilitation plan:

AIM:

To address illegal activities undertaken at Erf 1086 and Erf 1661 that have resulted in residual impacts to the two wetlands on the properties ('Wetland 01' & 'Wetland 02'), through appropriate rehabilitation and interventions that serve to reinstate and where possible, improve the condition and functioning of the target wetlands.

In considering opportunities to reinstate and improve the condition and functioning of wetland 01 and wetland 02 as well as the recommended 20m wide wetland buffer zone on the properties, rehabilitation of the wetlands in accordance with the proposed project 'Aim' (above) would require that rehabilitation objectives (broad statements) be developed to guide further planning. Two (2) key rehabilitation objectives have been defined for the project and these, together with the specific actions required to meet these objectives, are defined below in Table 4.

Table 4. Summary of key rehabilitation objectives for the wetland (and buffer) rehabilitation and required actions to meet these objectives.

REHABILITATION OBJECTIVES	REQUIRED ACTIONS TO MEET OBJECTIVES
1. **To removal of all infill material, sedimentation within the wetland areas and 20m buffer zone**	**1A**. Removal of fill material from the delineated wetlands and a 20m wide buffer zone. **1B**. Removal of shallow fill material such as solid waste and building rubble and sediment washed into the vegetated portions of the wetland can be easily removed by hand. **1C.** Heavy machinery is to be used to remove the deeper fill, whilst ensuring that no further impact/disturbance is experienced within the more intact portions of the wetlands.

REHABILITATION OBJECTIVES	REQUIRED ACTIONS TO MEET OBJECTIVES
2. To remove alien vegetation from the wetland (and buffer) and re-instate natural wetland vegetation where necessary	**2A**. Remove/control weeds and Invasive Alien Plants (IAPs) affecting the wetlands and the 20m buffer zone, in accordance with the legislative requirements of the latest NEM:BA Alien Species Requirements. **2B.** Reinstate wetland vegetation within the affected fill areas where vegetation was previously lacking through: ➢ Suitable preparation of the topsoil; ➢ Rapidly instating an initial vegetation cover using suitable pioneer grass species to stabilise soils and prevent erosion; ➢ Allowing for natural recruitment of wetland vegetation to follow the reinstatement of the wetland template, soils and hydrology, through successional processes; and ➢ Supplementing natural recolonisation and succession by planting suitable indigenous wetland plants suitable to the conditions at the site and for the specific purpose of improving the wetlands' ability for trapping sediment and nutrients from upstream activities/land uses.

The objectives and actions contained in Table 4 were referred to continuously to inform and guide rehabilitation and management planning and the development of the specific methods and interventions of wetland and buffer zone rehabilitation.

2.4 Timing of rehabilitation

As per the directives contained in the court order (Agreement between the state and the accused, in terms of Section 105 (A) of Act 51 of 1977, as amended; Case No. 662/2020) the implementation of this Plan shall be undertaken over a maximum 2-year period, until such time as rehabilitation has been deemed successful through appropriate 'post-rehabilitation monitoring'.

PLEASE NOTE THAT NO REHABILITATION WITHIN A WATERCOURSE (WETLAND) MAY COMMENCE PRIOR TO A WATER USE LICENSE BEING OBTAINED FOR THE REHABILITATION PLANNED, UNLESS STATED OTHERWISE FROM DWS AND/OR DEPARTMENT OF FORESTY, FISHERIES AND THE ENVIRONMENT (DFFE). THIS WOULD OTHERWISE CONSTITUTE AN UNLAWFUL ACTIVITY/WATER USE ACCORDING TO THE NATIONAL WATER ACT AND THE LANDOWNER COULD BE LIABLE TO FINANCIAL PENALTIES AND/OR CRIMINAL PROSECUTION IF FOUND GUILTY OF UNLAWFUL ACTIVITY.

In terms of the timing of the implementation of re-vegetation, it is best that any supplementary planting of the wetland take place as early in the growing season as possible when the chances of frequent rainfall are high, and temperatures are high to warm (i.e. between November and March). Planting outside of this period may necessitate regular irrigation until establishment is successful. Soil moisture is not the only factor which will slow the rate of plant growth. Low night temperatures and shorter day-lengths – both of which are characteristic of autumn and winter – can also retard plant growth rates to a significant degree. An undesirable consequence of this fact is that if spring (August – October) rains start early and occur as high-intensity events, the ground cover may not have developed sufficiently to reduce soil erosion risks. Careful planning is required to maximise the success of re-vegetation and avoid peak flow events where relevant.

2.5 Outline of the rehabilitation process

This section of the plan outlines the rehabilitation process and relevant guidelines, methods and tasks required for the effective rehabilitation of the wetlands (and including the recommended 20m wetland 'buffer zone') identified on the target properties, including key steps to be followed in order of priority. The key tasks are defined, and the plan provides the details of the individual methods and conceptualizes the interventions to be implemented as part of the rehabilitation of wetlands. Furthermore, the mitigation of both short-term rehabilitation-related impacts as well as the continuous management of potential long-term risks and impacts is included.

The steps in Figure 4 must be followed in specific order during the implementation of the wetland rehabilitation for the project in terms of the key tasks and methods outlined in this rehabilitation plan:

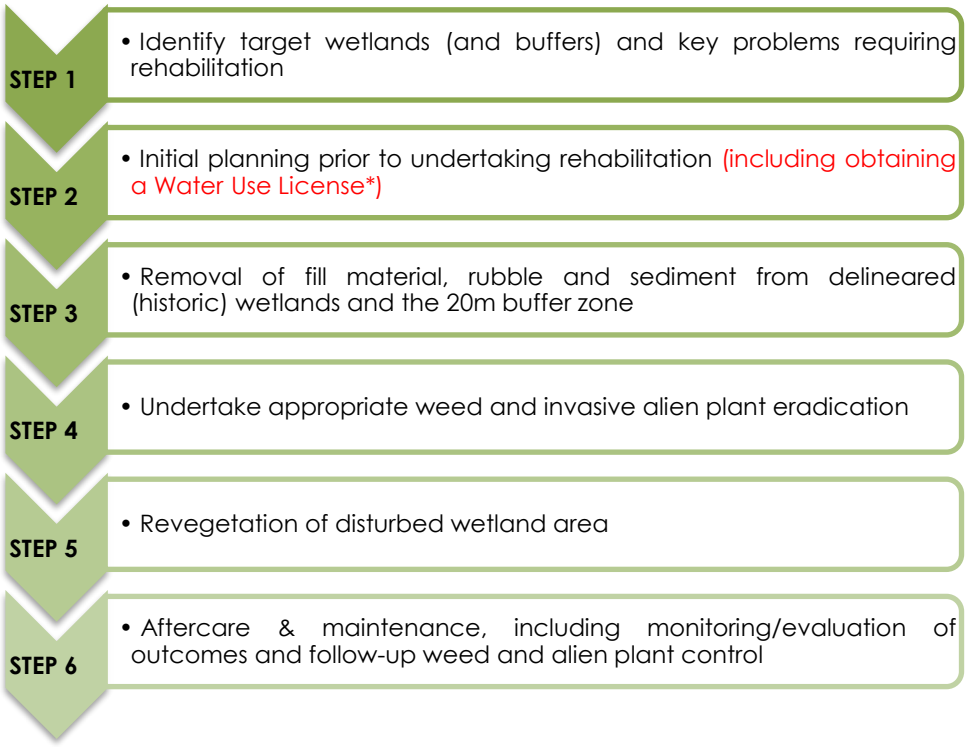

Figure 4 Diagram of the rehabilitation process to be followed in a 'step-wise' fashion when implementing the wetland rehabilitation plan.

2.6 Rehabilitation tasks, methods and interventions

The relevant steps and tasks (as per the rehabilitation process outlined in Figure 4) are detailed in this section of the Plan. This includes Steps 1 through 6, including detailed tasks and intervention details for each step of the rehabilitation process from planning through to completion and post-rehabilitation maintenance and monitoring.

STEP 1: Identify target wetland and key problems requiring rehabilitation

The target area for rehabilitation is a relatively small (0.64 ha) portion of a natural seep wetland (W01), with only a portion (0.04ha) of a second wetland (channelled valley-bottom, W02), as shown mapped in Figure 5, below. The combined target area for the wetland buffer rehabilitation is 1.45ha.

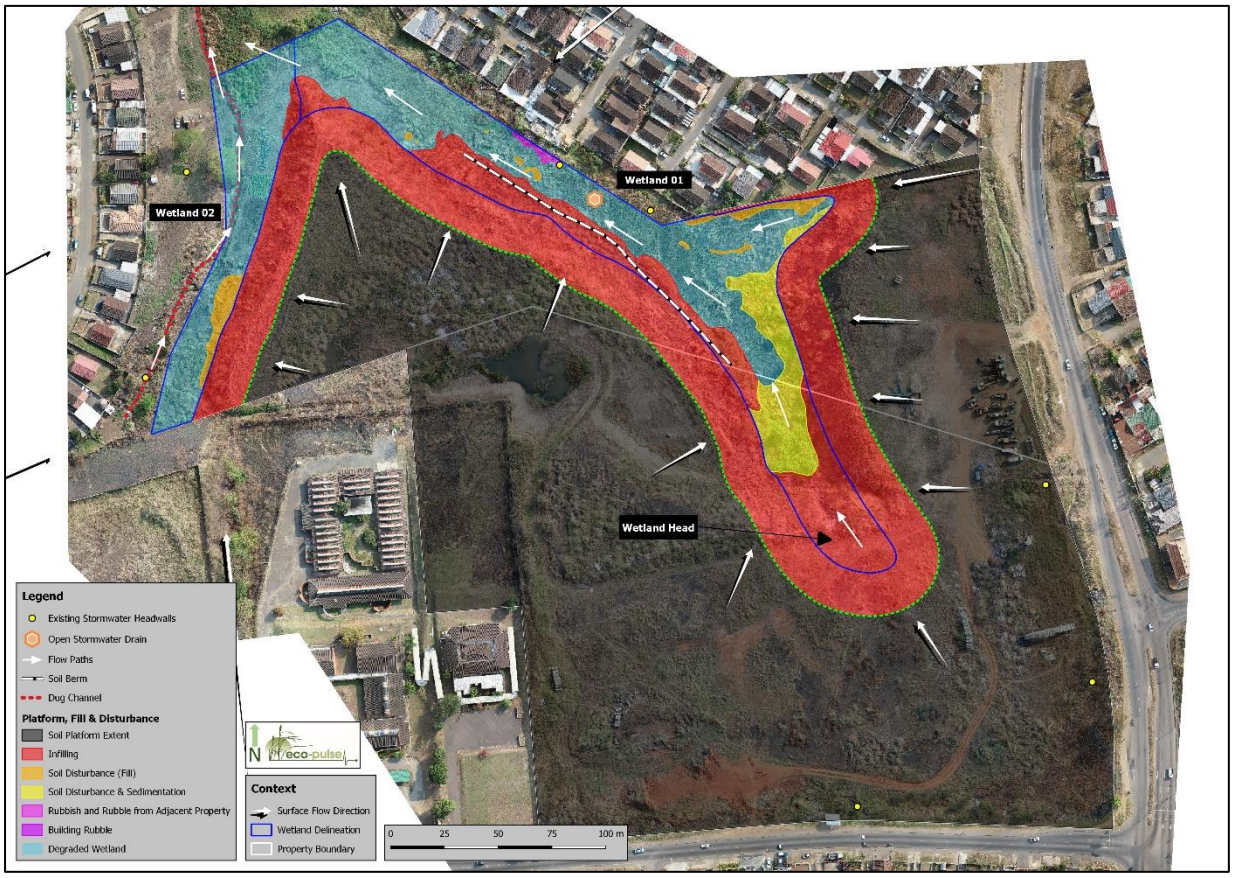

Figure 5 Map showing delineated wetland and buffer targeted for rehabilitation.

Note the plan addresses the following:

1. Infilling of wetlands on the property as a result of the recent earthen platform creation; and
2. Dumping of solid waste and building rubble in wetlands.

The plan <u>DOES NOT</u> address the following:

3. Encroachment of private residences, gardens, fences/walls and cultivated plots into wetlands;
4. Storm water drains (municipal);
5. Pollution from sewage and other sources in the catchment;
6. The dug channel within 'wetland 02' as this could interfere with floodline and endanger property; and
7. Historic impacts of agriculture.

The wetlands are currently in a 'Largely (W01) and Seriously Modified (W02) State' as a result of existing onsite 'unlawful' activities and catchment impacts, which include:

- The wetlands (and buffer) have been infilled, with "foreign" material (e.g. building rubble, solid waste, soil), resulting in direct loss of the wetland habitat;
- The wetland hydrological and geomorphological processes (saturation, flow, erosion and sediment regime) have been altered;
- Associated disturbance has facilitated increased levels of colonization by alien plants; and
- Ecosystem processes have been lost as a result of the direct modification to the wetland and catchment.

Wetland problems affecting the wetlands together with the causes of degradation and recommended rehabilitation interventions to address the problems and causes of degradation have been summarised below in Table 5.

Table 5. Wetland problems requiring rehabilitation along with the potential causes of wetland degradation and recommended rehabilitation interventions in each case.

Wetland Problem	Indicator(s) and causal factors	Recommended rehabilitation options and objectives
Infill/disturbance of wetland soils	Signs of mixing of soils and extensive fill material caused by the construction of platforms within wetland areas.	• Large infill cannot be easily removed or remedied. • Shallow fill material solid waste and building rubble can be easily removed by hand. • No vehicles or heavy machinery is to be used to ensure no further impact/disturbance is experienced within the wetlands.
Increased flow, erosion and sedimentation	Sediment deposits within wetland which are linked to erosion of platform edges and storm water runoff.	• Sediment deposits can be removed by hand. • Implement sediment controls (e.g. silt fences/berms) to reduce sediment inputs to the wetland.
Invasive Alien Plants and weeds	Signs of exotic plants species and weeds that colonise disturbed areas and compete with/replace native wetland plant species as a result of recent platform creation and general soil/vegetation disturbance.	• Clear and control alien plants/weeds. • Revegetate cleared areas with suitable indigenous wetland plants.

STEP 2: Initial rehabilitation planning

Proper planning for rehabilitation is considered critical for ensuring that rehabilitation is successful. Table 6 below highlights key aspects that need to be considered as part of the initial rehabilitation planning process to be undertaken by the rehabilitation implementer. This process will need to be undertaken specifically prior to any wetland rehabilitation activities taking place onsite to avoid unnecessary delays and complications.

Table 6. Aspects to consider during pre-rehabilitation planning.

Planning Aspect	Description
Budget	• A budget including costing of all rehabilitation and re-vegetation activities detailed in this report and equipment costs will need to be compiled prior to commencement of rehabilitation.
Appointment of wetland specialist	• It is recommended that a suitably qualified wetland ecologist with experience in wetland rehabilitation be appointed to provide practical input and oversight into the rehabilitation during implementation of the aquatic rehabilitation plan. ***Eco-Pulse Consulting will be fulfilling this role.***
Timing of rehabilitation	• Implementation as soon as practically possible, bearing in mind planting season limitations as well as ***water use licensing requirements prior to rehabilitation commencing.***
Temporary equipment storage/laydown areas	• Location of any temporary equipment storage/laydown areas to be planned outside of the delineated wetlands and associated buffer zone.
Methods of re-vegetation	• Methods of re-vegetation to be finalised and sources of plant material to be identified (see planting methods and sources as per STEP 5).

General guidelines and restrictions

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

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

ii. The site is characterised by **ERODIBLE SOILS THAT ARE SENSITIVE TO DISTURBANCE**. Site clearing and movement of workers/equipment within the site must therefore be aware of the steep and unstable slopes of the platforms and restrict movement & activities where necessary.

iii. The use of chemicals/herbicides in alien plant control must be **STRICTLY RESTRICTED TO A CERTIFIED HERBICIDE CONTROL APPLICATOR ONLY.** The application of herbicides will need to consider the presence of freshwater ecosystems (wetlands) on site and downstream (wetlands, rivers/streams).

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

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

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

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

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

ix. **BASIC EQUIPMENT REQUIREMENTS:** alien plant control teams must wear the necessary personal protective clothing (PPE) and use appropriate equipment to do the work. This should include the following where relevant:

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

Obtaining relevant licenses prior to undertaking rehabilitation*

Wetland rehabilitation in line with this rehabilitation plan **MAY NOT COMMENCE PRIOR TO PERMISSION IN THE FORM OF A WATER USE LICENSE BEING GRANTED FOR THE REHABILITATION PLANNED UNLESS STATED OTHERWISE BY THE DWS AND/OR DFFE. THIS WOULD OTHERWISE CONSTITUTE AN UNLAWFUL ACTIVITY/WATER USE ACCORDING TO THE NATIONAL WATER ACT (ACT NO. 36 OF 1998) AND THE LANDOWNER COULD BE LIABLE TO FINANCIAL PENALTIES AND/OR CRIMINAL PROSECUTION IF FOUND GUILTY OF UNLAWFUL ACTIVITY.**

STEP 3: Removal of fill material, rubble and sediment from the wetland

Infill material removal from the wetland and buffer zone

The primary recommendation is that the existing fill material (estimated to be >1m deep) must be removed from the wetland areas and associated 20m buffer zone. This will include all waste and soil material in the targeted areas:

- Sediment, erosion and stormwater management infrastructure needs to be in place before the removal of any material from the targeted areas. This is to ensure no further disturbance is experienced for the onsite wetlands.
- The boundary of the existing wetland needs to be clearly demarcated showing the 'No-go zone' are with clearly defined markers / snow fence.
- Civil designs, quantities and planning will be required prior to fill material removal, refer to document titled 'Civil Engineering Report for Erf 1086 & 1661' by Nelson Allopi & Associates (2022).
- The removal of waste material must be done in a systematic fashion, through layered removal by 1m horizontal increments at a time.
- The haul road for the vehicles needs to be designed in order to ensure that the wetland area is no breached at any stage during removal of the fill and waste material.
- No vehicles are permitted to enter the wetland area during any stages.
- All fill material needs to be removed until the natural ground level has been reached.
- The excavated fill will need to be placed in the identified temporary stockpiling area or zone (outside of the wetland) earmarked by the waste management specialist (Anne Bindoff - Waste Disposal: Management and Plans, 2021) and civil engineer (Nelson Allopi & Associates - Civil Engineering Report for Erf 1086 & 1661, 2022).

- A small, compacted earth berm around the temporary storage area should be constructed to prevent sediment runoff from this area towards the wetlands.
- Once all the fill material has been removed and properly disposed of, written confirmation to this effect must be obtained from the ECO and sent to the relevant Authorities (DFFE). 'Before' and 'after' photographs of the affected area, as taken by the ECO, will need to accompany this written confirmation.
- If the area beneath the fill has become compacted, measures would need to be implemented to rectify this impact.

Shallow material and sediment removal from the wetland

The primary recommendation is that where there is very shallow fill material (less than 50cm depth) in wetland areas, this can be carefully removed from the wetland area. This will also include any solid waste and building rubble dumped into the wetland and sediment deposits:

- The rubble and infill material should be carefully removed from the infilled area, using manual labour, and disposed of at an appropriate licensed landfill site, identified by Anne Bindoff (Waste Disposal: Management and Plans, 2021).
- A safe disposal certificate should be obtained from the relevant landfill site when the rubble and other infill material is dropped off and certified copies of this certificate should be sent to the relevant Authorities for their records.
- No heavy earth-moving vehicles or machinery should be used for this task, unless absolutely essential (e.g. for the removal of any large pieces of concrete and/or boulders that may still remain around the edges of the previously cleared area). Before any earth-moving vehicles or machinery are used, the need for such equipment should be confirmed by the ECO and the work carried out under the close supervision of the ECO. It is critically important that no further topsoil is removed from the wetland during any such operations.
- Workers from the local area should preferably be used for the manual labour.
- Any trucks and other vehicles that are used to transport the remaining rubble and other infill material from the affected area to a landfill site should only use the one existing access road on site and these vehicles should not drive off the existing road footprint (e.g. into the cleared area or into any vegetated areas surrounding the cleared area).
- Once all the rubble and other infill material has been removed and properly disposed of, written confirmation to this effect should be obtained from the ECO and sent to the relevant Authorities. 'Before' and 'after' photographs of the affected area, as taken by the ECO, should accompany this written confirmation.
- If the area beneath the fill had become compacted, measures would need to be implemented to rectify this impact (Ollis, 2013).

Reshaping of the wetland and buffer zone

- It is important that the wetland template/shape is correct and ensuring there is sufficient topsoil (at least 30-50cm) of good enough quality (nutrient/mineral status) in the excavated areas (i.e., wetland and buffer zone) to allow plants to seed and take root.
- Reshaping and revegetating the buffer to manage erosion and sediment risks as per the grassland rehabilitation plan (GroundTruth, 2022).

STEP 4: (Invasive) Alien plant eradication and control

Invasive alien plants (IAPs) are plant species that have been introduced, either intentionally or unintentionally, to South Africa. They can reproduce rapidly in their new environments and out-compete indigenous plants for both nutrients and water. Plant species are considered invasive when they occur outside of their natural distribution range, and pose a threat to ecosystems, other species, the economy or human health and therefore must be eradicated.

Alien plants, particularly those considered invasive in terms of the National Environmental Management: Biodiversity Act (NEMBA) will need to be removed/eradicated from the wetland and its 20m buffer zone. During this phase of the rehabilitation, it will also be necessary to address any dry-land erosion within terrestrial areas outside of wetland.

IAP eradication and control will comprise generally of the following three phases:

i. **Initial control phase:** This involves the initial, intensive clearing and drastic reduction of existing alien plant infestations at the site.
ii. **Follow-up control phase:** The follow-up phase involves the control of seedlings, root suckers and coppice growth after the initial control phase to control re-growth of alien seed.
iii. **Maintenance control phase:** This final phase involves a programmed control of alien plants to sustain or maintain low alien plant numbers by suppressing regeneration. Depending on the success of the initial phases this maintenance phase may be carried out at intervals ranging from quarterly annual clean ups to once-a-year clean-ups.

Alien plants will need to be removed/controlled as per the requirements of the NEM:BA guidelines for alien species management and control. There are various means of controlling invasive alien plants in South Africa. The primary methods are discussed below in Box 1. The suitability of control methods depends on a number of factors, including practical constraints, economic constraints and applicability of methods for particular species of alien plants. It is generally advised that a form of integrated control be implemented; however, the final selection of the appropriate methods of control should be based on the following criteria:

- **Species to be controlled:** herbicides are registered for specific species. Selection should be based on "*A Guide to the use of Herbicides*" issued by the Directorate: Agricultural Production Inputs and labels and information brochures provides by herbicide suppliers.
- **Size/age of target plants:**

- For **seedlings:** hand-pulling or hoeing and foliar applications of herbicides for dense stands.
- For **saplings:** hand-pulling or hoeing, foliar applications of herbicides for dense stands, basal stem treatments and cut stump treatments recommended.
- For **mature trees**: ring barking, frilling, basal stem treatments and cut stump treatments recommended.

- **Density of stands:** Overall applications of herbicide can be made to dense stands of seedlings or saplings. Where dense stands of large trees are present, treatment of standing trees may be appropriate to obviate the problem of disposing felled trees.
- **Accessibility of terrain:** In inaccessible areas, methods that rely on the minimum amount of transportation of equipment and chemicals should be given preference.
- **Environmental considerations:** Riparian/wetland areas require a careful approach to treatment/control. Only herbicides approved for use in wetland/riparian areas are to be considered. Washing of equipment or disposal of any chemical substances is prohibited in or near areas where there is a potential risk of contamination of wetlands/riparian areas.
- **Desirable vegetation:** Control methods that will cause the least damage to desirable indigenous vegetation must be considered. Selective herbicides or mixes that will not damage other desirable vegetation should be applied where relevant.
- **Disposal of dead vegetation:** Where possible, utilizable wood should be removed after tree felling. This is also the case for trees that could cause the blockage of water courses. Brushwood should be spread rather than stacked to limit soil damage in instances where burning is planned.
- **Cost of application:** the cost of application and re-treatment should be taken into consideration when selecting methods/herbicides, etc.

Table 7. The most commonly occurring species observed and control recommendations.

Species Name	CARA/NEMBA Category	Photo	Control Recommendations	
			Size	Treatment
Solanum mauritianum (Bugweed)	1 / 1b		Seedling <1m	Hand pull - *NB: keep roots off the ground*
			Seedling 0.5 to 1m and Coppice	Foliar spray
			Mature	Cut stump - *NB: for trial, not registered* Cut stump/frill
Lantana camara (Lantana)	1 / 1b		All	Foliar spray Cut stump / Frill

Species Name	CARA/NEMBA Category	Photo	Control Recommendations	
			Size	Treatment
Chromolaena odorata (Triffid weed)	1 / 1b (KZN)		Seedlings	Hand pull
			Seedlings and regrowth	Foliar spray
			Mature/Adult	Cut stump / Frill
Cardiospermum grandiflorum (Balloon-vine)	1 / 1b		All	Cut down to 2 m and spray (treat or remove, dry out and burn all cut green plant material)
Ageratum conyzoides (Invading ageratum)	1 / 1b		All	Hand pull Foliar spray
Ricinus communis (Castor-oil plant)	2 / 1b		All	Cut stump / Frill
Canna indica (Indian shot)	1 / 1b		All	Hand pull
Tithonia diversifolia (Mexican Sunflower)	1 / 1b		All	Cut stump / Frill
Tecoma stans (Yellow Bells)	1 / 1b		All	Cut stump / Frill

Species Name	CARA/NEMBA Category	Photo	Control Recommendations	
			Size	Treatment
Ipomoea purpurea (Common Morning Glory	1 (KZN) / 1b		All	Cut down to 2 m and spray (treat or remove, dry out and burn all cut green plant material)

Box 1. Alien Plant Control Methods

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

1 Mechanical control

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

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

2 Chemical control

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

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

Some additional recommendations regarding herbicide use include:

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

3 Biological control

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

4 Mycoherbicides

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

5 Integrated control

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

The following integrated control options are available:

- **Basal bark and stem application**: apply recommended herbicide mixed in diesel carrier to the base of the stem of trees (<25cm stem height) and saplings. This method is appropriate for plants with thin bark or stems up to 25cm in diameter. Do not cut the bark. Apply herbicide mix with paintbrushes or using a coarse droplet spray from a narrow angle solid cone nozzle at low pressure. For multi-stemmed plants, each stem must be treated separately.
- **Ring barking**: Invasive trees growing away from any structures or roads can be ring-barked, poisoned and left standing rather than felled. They will slowly collapse over time and can establish habitat for birds, etc. Strip all bark and cambium from a height of 75cm to 100cm down to just below soil level. Cut a ring at the top and pull strips. All bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets should be used for debarking.
- **Frilling:** Using an axe or bush knife, make angled cuts downward into the cambium layer through the bark in a ring. Ensure to effect the cuts around the entire stem and apply herbicide into the cuts.
- **Cut stump treatment**: This is a highly effective and appropriate control method for larger woody vegetation that has already been cut off close to the ground. The appropriate herbicide should be applied to the stump using a paintbrush within 30 min of being cut. Apply recommended herbicide mixture to the cut surface with hand sprayers, a paintbrush or knapsack sprayer at low pressure. Apply only to the cambium or outer layer of large stumps and the entire cut surface of small stumps. Ensure the

stumps are cut as low to the ground as practically possible (about 10 – 15 cm or as stipulated on specific herbicide label). Herbicides are applied in diesel or water as recommended for the herbicide. Applications in diesel should be to the whole stump and exposed roots and in water to the cut area as recommended on the label.

- **Scrape and paint**: This method is suitable for large vines and scrambling plants i.e. creepers. Starting from the base of the stem, scrape 20-100cm of the stem to expose the sapwood just below the bark. Within 20 seconds apply the herbicide to the scraped section. Do not scrape around the stem. Stems over 1cm in diameter can be scraped in 2 sides. Leave the vines to die in place to prevent damaging any indigenous plants they may be growing over.
- **Foliar spray:** This is not an advocated method of application by unqualified applicators due to the danger of spraying indigenous species. Should be restricted to droplet application made directly on the leaves on plants that are no higher than knee height. Use a solid cone nozzle that ensures an even coverage on all leaves and stems to the point of runoff. Do not spray just before rain (a rainfall-free period of 6 hours is recommended) or before dew falls. Avoid spraying in windy weather as the spray may come into contact with non-target plants. Spraying dormant or drought stressed plants is not effective as they do not absorb enough of the herbicide.
- **Burning**: Spindly invasive alien plant species, such as Triffid Weed (*Chromolaena odorata*), growing on sandy soils, where there is between 30-40% grass still present, can be eradicated using annual controlled burns. Moderate to low infestations in wetland areas can be treated by controlled burning at the beginning of autumn, followed by mechanical removal or herbicide application in mid spring. ***Note that burning would generally not be acceptable in a developed area due to fire hazard/risk and nuisance.***
- *Note that no heavy machinery should be used to remove invasive alien plants, no matter how high the infestation, without prior authorization from relevant government departments when operating in wetlands and riverine areas.*

6 Disposal of alien plant material

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

STEP 5: Re-vegetation of wetlands and buffer zones

Vegetation plays an important role in natural wetland and riparian ecosystems. Wetland/aquatic vegetation has compositional and structural characteristics that provide specialized habitats for a range of wetland dependent organisms and is well known for providing a range of wetland ecosystem goods and services (Macfarlane et al., 2020). Aquatic plants assist in binding the soil together and slow down the flow of water, reducing the risk of erosion and promoting sediment deposition. They are also a major source of organic material in wetland/river soils and can affect the quality of surface and subsurface water by providing soil organic matter required by microbes to assimilate nutrients and toxicants and plants contribute through direct uptake of nutrients and toxicants (Russell, 2009). Owing to the vital role of aquatic vegetation in wetland and riverine ecosystem health and functioning, the re-establishment of natural or semi-natural vegetation is widely recognized as an important component of any wetland/river rehabilitation programme. The establishment of plants can be a rehabilitation intervention in its own right or can be used to complement other interventions (Russell, 2009).

Generally, the broad aim of re-vegetation should be to introduce desirable plants in order to develop a wetland plant community that will eventually become naturally self-sustaining over time (Brock & Casanova, 2000). In situations where active re-vegetation is desirable or even necessary, it is important to ensure that the rehabilitation objective(s) of the wetland rehabilitation plan take into account plant species requirements. The focus here will be either on the desired 'functional aspects' of species (such as water filtering capacity or fast growth rate) or on the 'compositional aspects' of the wetland/river ecosystem that is associated with the planted species (includes species diversity, origin of plants, etc.). The specific rehabilitation objectives should therefore ultimately dictate whether functional or compositional aspects are given priority, and how compromises should be sought. For this particular

project, due to the relatively low species diversity and presence of only locally common wetland plants within the wetland areas, a minimalistic approach to re-vegetation is proposed that will involve: ***establishing an initial protective native vegetation cover, allowing for natural recolonisation of wetland areas supplemented by cost-effective methods of planting where necessary to ensure the rapid re-establishment of a robust wetland vegetation community with vegetation cover suitable to the wetness conditions and with extensive root and rhizome networks to maximise soil binding and sediment trapping***. This is supported by authors such as Ollis (2013)[3].

The re-vegetation strategy is summarised in Table 8 and conceptualised in the diagram in Figure 6.

Table 8. Re-vegetation strategy and substantiation for selected planting methods and species for wetland habitat.

Rehabilitation Area	Potential Re-vegetation Method	Possible Species	Substantiation for Selection of Planting Methods and Species
Disturbed Wetland habitat (permanently wet areas)	Allow natural recolonisation of the wetland to take place, supplemented where necessary by the planting of live plant plugs (*transplanting from adjacent areas/donor wetland sites) or souring live plants from local nurseries*	○ *Cyperus latifolius* ○ *Cyperus dives* ○ *Cyperus prolifer* ○ *Leersia hexandra* ○ *Ischaemum fasciculatum*	• Live plant plugs/sods/sprigs have high success rates. • Species suited for rapid establishment. • Plants that are known for vigorous growth, having strong roots, which are mat-forming and with high shoot density are preferable. • Plants suited at trapping sediments and assimilating nutrients.
Disturbed Wetland habitat (seasonally wet area)		○ *Cyclosorus interruptus* ○ *Imperata cylindrica* ○ *Cyperus sphaerospermus* ○ *Digitaria eriantha*	

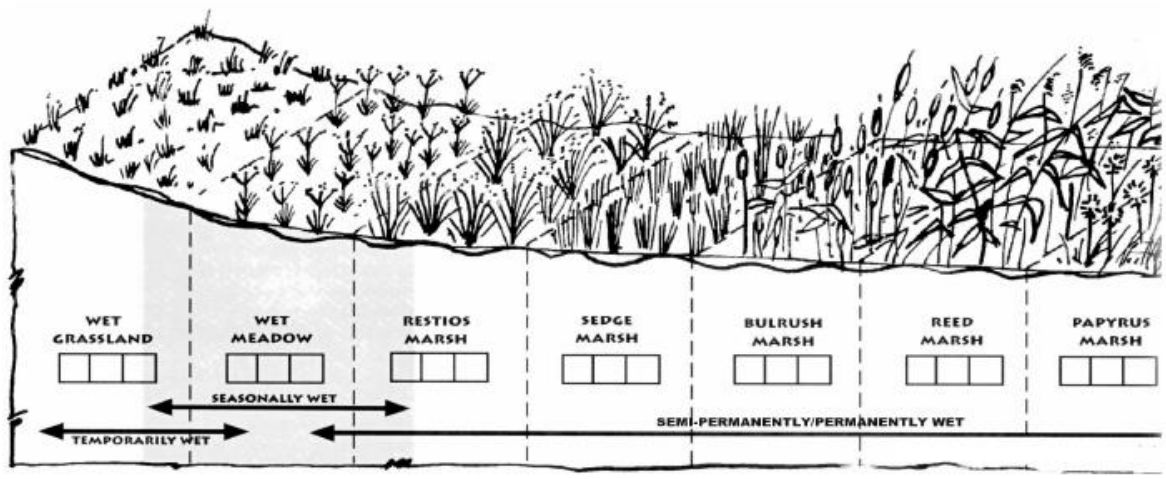

Figure 6 A conceptual diagram illustrating an idealistic continuum of the three wetland soil zones, from permanent to seasonal and temporary wetness (right to left) and the major wetland plant communities which may occur in these zones (after Wyatt, 1999.)

Re-vegetation for this project will need to consist of following tasks:

1. Establishing an initial protective vegetation cover using suitable rapidly growing grass species;

[3] Ollis, 2013. The freshwater Consulting Group. Portion 2 of Remainder of Erf 1, Mfuleni: Assessment of Impacts of Wetland Infilling And Provision of Rehabilitation Recommendations. Draft Report for Comment. July 2013.

2. Allowing natural recolonisation of the wetland to take place once the template, soils and hydrology of the system has been reinstated;
3. Sourcing of supplementary seed and/or plant material for propagation (i.e. seed harvesting, plant rescue, translocation, nurseries, etc.);
4. Sowing seed and/or active planting of wetland plant 'nuclei sites' from which clonal reproduction can take place; and
5. Maintenance (weeding and watering) and follow-up monitoring to ensure re-vegetation success.

Re-vegetation Strategy

Re-vegetation Constraints

In preparing the re-vegetation plan for the site, it was firstly important to provide a rationale for the re-vegetation method(s) and associated plant species selected as part of the re-vegetation strategy, taking into consideration the key constraints present at the site.

The key risks and constraints of the re-vegetation that needed to be taken into account in the formulation of the re-vegetation strategy are briefly outlined below:

Land management history:

- Due to the targeted areas being under fill and historically under cultivation for many decades, three issues / constraints needed to be taken into account:

    i. Extensive alien and weed seed banks are present within and surrounding the rehabilitation areas as well as extensive alien and weed propagule sources. For the saturated areas (seasonal and permanent wetlands) this will likely not be a problem once the level and natural saturation levels are reinstated or enhanced and obligate wetland plants will be able to outcompete with many of the weeds and alien plants which are intolerant of saturated soil conditions. However, for the drier areas, such as temporary wetland zones and buffer zones, outcompeting the residual alien and weed seed banks will be difficult without the application of pre-emergent herbicides and continuous weed control. The problem is that the use of pre-emergent herbicides may also preclude the use of the cheaper seeding methods like hydroseeding and broadcast seeding which may make the cost of re-vegetation unacceptably high for such large areas.

    ii. Limited indigenous seed banks are present within the areas to be rehabilitated and there is a lack of propagules to recolonize the site due to the high level of habitat transformation and fragmentation. This means that active re-vegetation will likely be required to 'kick-start' recolonization and successional processes rather than allow for natural recruitment and succession to take place only.

    iii. The topsoil at the site may have high nutrient levels and may have high toxicity levels, given the agricultural history and dumping that characterized the site in the past. This will have an influence on the selection of the preferred species for re-vegetation i.e. might have to

preclude desirable species that thrive in low nutrient conditions. Please note that no data is available on the soil fertility. The toxicity/contamination levels in the soils have been tested by Umvoto Africa (2021), in ground water by Geomeasure (2022) and in the surface water by GroundTruth (2022). The studies concluded that there are no toxicants/contaminates within the fill material of concern.

Practical management constraints:

- Large area of re-vegetation – If it is decided that pre-emergent herbicides are necessary for re-vegetation success, the costs of active re-vegetation using sprigs[4], plugs[5] or sods[6] will be high. Similarly, active re-vegetation will likely be required across most of the study area due to a lack of natural seedbanks and propagules, which will also contribute to the increased costs of re-vegetation. Alternatives approaches that don't include the use of pre-emergent herbicides will need to be investigated.
- Commercial availability of desirable plant species – Only those species that are commercially available and can be propagated at large volumes (or required volumes) can be selected. Some species may need to be specifically cultivated and propagated for the purposes of this project which will be costly. Therefore, re-vegetation of the larger areas (e.g. wetland and buffer zones) would be best using suitable seed mixes that are readily and commercially available to reduce the need and costs of cultivation and propagation by a nursery.
- Related to the above constraints, it is also important to note that few nurseries maintain large quantities of the desired species – The following will need to be considered in this regard:
    i. The nursery(ies) sleeted to provide the vegetative material will need to have the skills, capacity and experience in producing the required quantities and types of plants.
    ii. Careful planning and coordination with the appointed nursey(ies) will be required to ensure that there is sufficient time to harvest and produce propagation material and that the rate of supply of the required quantities of the specified species coincides with the rate at which they can be planted. Failure to achieve this coordination may result in rehabilitation being set back by a year or more.
- Use of fire to maintain targeted plant communities – Fire is a natural feature in this landscape, and regular disturbance is necessary in order to maintain healthy herbaceous plant communities. Given the urban context of the site, fire as a management tool to control alien plants/weeds and moribund vegetation has not been recommended due to health and safety factors and to comply with municipal bylaws (this should be considered along with GroundTruths grassland rehabilitation recommendation).

[4] A very short (typically ca. 20cm long) piece of a stolon (a stem which creeps across the surface of the ground) or a rhizome (an stem which grows more or less horizontally below the soil surface), which are the vegetative parts of creeping grasses and some grass-like wetland species, and may be used to establish such plants by planting of sprigs.

[5] A plug is a young plant, produced from seed and/or vegetative material and grown in growing medium in a multi-cavity plant propagation tray.

[6] A sod is a rectangular block of living vegetation which may either have been grown in a specialized container or cut out of growing vegetation which comprises one or more species which are required to be established on a particular area. Sods must be sufficiently thick as to comprise as much live root (and where relevant rhizome) material so that when the sod is placed on the area where it is required the roots grow rapidly to anchor the sod to its new substrate.

Wetland-specific constraints:

- High intensity rainfall leading to flood events and disturbance regime, particularly during the wet season – Vegetation cover will therefore need to be established quickly or undertaken during the dry season.
- High nutrient inputs are expected within the short to medium term given land use in the upstream catchment. This will likely favor the rapid growth of certain species such as *Typha capensis* and *Echinochloa pyramidalis* which can quickly out-compete other indigenous species, forming low diversity monospecific stands.
- High levels of the sedimentation are anticipated at the entry into (at the head) of the low gradient wetlands that will be un-channeled – Vegetation will need to be of a suitable height and robust to withstand some episodic smothering and burial by sediment.

Proposed re-vegetation strategy

In light of the above constraints, the uncertainties regarding re-vegetation success in highly disturbed soils (fill areas), and the fact that plant diversity maintenance is not the main objective of the offset, **a functional re-vegetation approach is recommended** that aims to establish a good low diversity indigenous cover across the entire wetland over the first 0-5 years that is effectively outcompeting weedy and alien invasive plant species. The focus is on restoring a vegetation that resembles the pre-infilling wetland state, which was likely to have been already degraded due to the disturbance regime (decades under cultivation, etc.). Therefore, a focus on biodiversity planting has not been considered necessary and achieving a reference / semi-pristine state is not advocated nor is this likely to be practically attainable in this context:

- For the wetlands where permanent and seasonal saturation / wetness is going to be reinstated, some active revegetation will be required as limited seed banks and propagules of desired obligate wetland species are present in the landscape and re-vegetation will need to be as rapid as possible to reduce wetland erosion. Furthermore, alien and weedy seed banks lying dormant in the cultivated cane land are unlikely to survive once the soil wetness regime is reinstated, thus not posing a threat to the success of wetland plant plug and sod establishment.

- In contrast there are significant uncertainties and constraints to the successful re-vegetation of the drier environments including the temporary wetlands and buffer zones across the site. This issue is made even more significant by the substantial cost required to actively revegetate these aeras. Presently, grassland restoration research and successful case studies on old cane lands in KwaZulu-Natal are limited. To date it is understood that much of the secondary grassland is dominated by perennial weedy grasses like *Panicum maximum*, *Paspalum urvillei* and *Sorghum discolor*. To effectively control these competitive weedy grass species in the short to medium term, pre-emergent herbicides would need to be used to exterminate the weed seedbanks. However, such an approach would preclude the use of seeding methods and would require active planting of sprigs, plugs and sods that would not be affected by the pre-emergent herbicide. However, although there is higher confidence and certainty in the efficacy of this approach to produce desirable grassland species composition, the large area to be re-vegetated makes this option prohibitively costly.

- With regards to seeding methods to establish an initial vegetative cover in the cleared areas (bare soils), hydroseeding[7] may be a more successful option and may strike a better balance between cost and establishment success. Some of the key advantages of hydroseeding over other seeding methods like broadcasting and drill seeding are:
    - (i) A quicker and more even germination is achieved as the wood fibres used provide moisture retention for the seed and the spray application ensures an even distribution of seed;
    - (ii) The seed is embedded in the fibres that insulate the seeds from sun scorch and protect them from washing away and birds;
    - iii) The fibres can hold up to 10 times their weight in water, creating a favorable environment for germination;
    - (iv) The mulch eventually biodegrades and acts as a fertilizer.

In light of the above constraints, risks and options, and the need to avoid financial losses, **we recommend that a conservative but flexible and experimental approach be adopted for the temporary wetlands and buffer zones with passive recovery and hydroseeding used as the two main approaches to re-vegetation.**

As part of the initial phase, we recommend that hydroseeding be tested at selected sites whilst passive recovery be allowed to continue through the remainder of sites. Monitoring will then be required to compare and contrast the effectiveness of rehabilitation using the two alternative approaches – this should be undertaken over least two to three seasons in order to have some confidence in the findings. If it is found that hydroseeding is largely ineffective at outcompeting the weedy grass and herb species, then the passive successional approach with prescribed management and future active planting will need to be implemented for temporary wetland areas and buffer zones as and when conditions become suitable. If hydroseeding is found to be successful however, then this option should be integrated into the rehabilitation strategy for the area. The manner in which hydroseeding is integrated into the rehabilitation plan will need to be reviewed following testing. This could entail soil preparation and subsequent hydroseeding across all target areas or could perhaps include a less intensive approach where selected areas (e.g. strips) are treated in this manner.

Please note that the above recommendations will need to be aligned with the grassland rehabilitation plan being prepared by GroundTruth (2022).

[7] Hydroseeding is the mixing of a slurry of water, fertilizer, seeds and a binding agent that is sprayed onto soil surfaces to protect the soils from erosional processes (Russel, 2009).

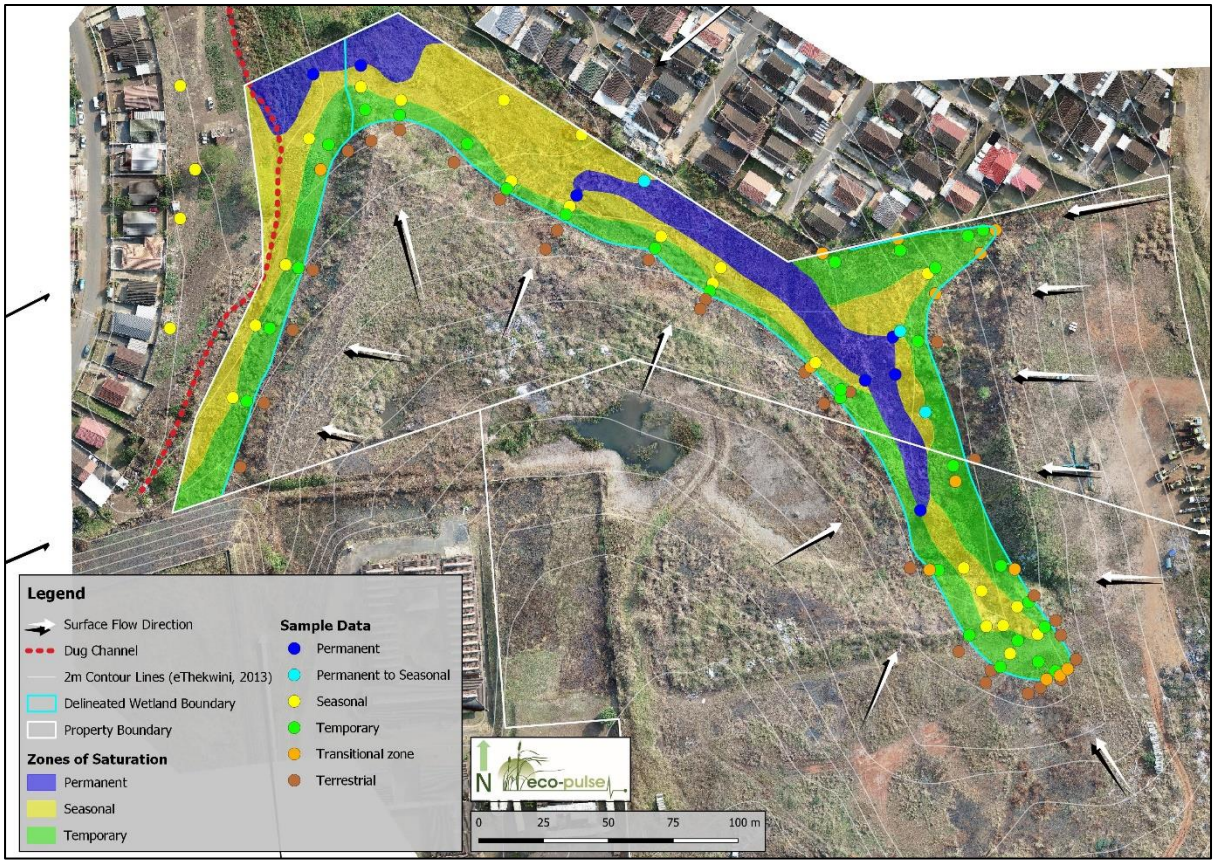

Figure 7 Delineated zones of saturation targeted for wetland rehabilitation.

The distinct re-vegetation zones with their applicable re-vegetation strategy and rationale have been summarized in Table 9 (over the page).

Table 9. Proposed re-vegetation strategy for targeted wetland rehabilitation 'zones' (Figure 7).

Wetland Rehabilitation 'Zones'	Proposed Re-vegetation Method & Species	Rationale
Permanent Wetland	Re-vegetation of disturbed or bare soils using sods of *Phragmites australis* (Common Reed), *Cyclosorus interruptus* (Marsh Fern), *Cyperus sexangularis* (Star Sedge), *Cyperus prolifer* (Dwarf papyrus) and *Leersia hexandra* (Wild Rice Grass). Edges (outer 5m) to be re-vegetated using sods of *Cyperus dives* (Giant Sedge) and *Cyperus latifolius*. To be planted in single rows (strips)or as clusters. Plants should be spaced at 1m intervals along rows and rows should be 3m apart (planting density of 1 plant per m^2) or roughly 35% of the wetland zone. Re-vegetation to commence within 1 week of completion of reshaping.	**Rationale for Species Selection:** Robust emergent wetland plants with extensive root and rhizome networks that maximize soil binding and valley floor stabilization have been selected with some finer, less robust species to add to the structure and plant diversity that is important to local frog species. Furthermore, local reference species composition is well known in the area represented by the Lake Victoria and Froggy Pond wetlands. These wetlands are dominated by *Phragmites australis* and *Cyclosorus interruptus,* with low to moderate abundances of the remaining species with the exception of *C. sexangularis*. *C. sexangularis* has been recommended as an additional robust emergent species to add to the diversity. The robust sedges *Cyperus dives* and *Cyperus latifolius* are recommended along the edges to buffer the core wetland from adjacent disturbances and that can withstand higher water table / soil saturation fluctuations that is more prevalent along the edges. **Rationale for Planting Method:**

Wetland Rehabilitation 'Zones'	Proposed Re-vegetation Method & Species	Rationale
		The use of plugs or sods will result in the most rapid establishment of local populations for the purpose of wetland stabilization and reduce the risk of valley floor erosion and uprooting. This is important as the valley floors will be at risk of erosion once the hydrology of the wetlands is reinstated and water starts to spread out over the valley floor.
Seasonal Wetland	Re-vegetation of bare or disrturbed soils using plugs of *Cyperus dives* (Giant Sedge), *Cyperus latifolius*, *Cyperus sexangularis* (Star Sedge), *Ischaemum fasciculatum* (Hippo Grass) and *Paspalum scrobiculatum* (Veld Paspalum). To be planted in a single row (strips). Plants should be spaced at 1m intervals along rows and rows should be 3m apart or roughly 25% of the wetland zone. Re-vegetation to commence once desired soil saturation regime has been established.	**Rationale for Species Selection:** Robust emergent wetland plants with extensive root and rhizome networks that maximize soil binding and valley floor stabilization have been selected with some locally common seasonal wetland grass species that also known to spread laterally via rhizomes and stolons. All of the selected species can withstand seasonally saturated conditions and are relatively robust once fully grown which will mitigate against burial and smothering by sediment. **Rationale for Planting Method:** The use of plugs or sods will result in the most rapid establishment of local populations for the purpose of wetland stabilization and reduce the risk of valley floor erosion and uprooting. This is important as the valley floors will be at risk of erosion once the soils and hydrology of the wetlands is reinstated and water starts to spread out over the valley floor.
Temporary Wetland	The rehabilitation of the bulk of the temporary wetlands should involve the removal of fill material and then allowing for successional processes to take place under controlled burning and alien plant control. The only active re-vegetation within these areas will occur within the hydroseeding test sites and propagation sites. **Hydroseeding Test Sites:** At least 0.5ha of temporary wetland should be selected as hydroseeding testing site(s). These hydroseeding testing sites should be monitored together with other passive rehabilitation sites for at least three years to measure the relative abundances of desirable and non-desirable species. The hydroseed grass mix should include the following species: • *Eragrostis tef* (sterile) • *Cynodon dactylon* (Couch Grass) (NB. Permit will be required) • *Digitaria eriantha* (Smuts Finger Grass) • *Aristida junciformis* (Ngongoni Grass) • *Chloris gayana* (Rhodes Grass) • *Setaria sphacelata var. sericea* (Golden Bristle Grass)	**Rationale for Species Selection:** Only locally sourced seed that is commercially available was selected to avoid the need to harvest local grass seed at additional cost. Also, the species selected comprise a mix of plants known to be highly competitive with existing weedy seedbanks as well as species that can withstand slightly higher soil moisture conditions. It is also important to note that a sterile variety of *Eragrostis tef* is included in the mix to act as an annual nurse plant that would establish first and create the necessary soil conditions for the successful germination of the rest of the seeds and assist in protecting the soil against erosion during the establishment phase. Also, the number of species in the mix has been kept relatively low due to the uncertainty around exact soil moisture conditions, nutrient condition and how the selected species will fair against the existing weed seedbank. **Rationale for Planting Method:** Although re-vegetation with sprigs and plugs would enable the use of pre-emergent herbicides to remove the alien and weedy seedbanks, would result in the quickest establishment of vegetation cover and have the highest establishment success rate. The next best alternative is hydroseeding (or hydromulching) and testing and implementation of such an approach is recommended for the re-vegetation of this area. Some of the key advantages of hydroseeding over other seeding methods like broadcasting and drill seeding are: (i) A quicker and more even germination is achieved as the wood fibres

Wetland Rehabilitation 'Zones'	Proposed Re-vegetation Method & Species	Rationale
	• *Stenotaphrum secundatum* (Buffalo grass) **Propagation Sites:** Two (2) propagation sites of 100m² size are proposed to be strategically located within the temporary wetland areas onsite. A detailed revegetation plan for the propagation sites will need to be compiled separately to this report / plan by a suitably qualified and experienced specialist plant ecologist or horticulturalist.	used provide moisture retention for the seed and the spray application ensures an even distribution of seed; (ii) The seed is embedded in the fibres that insulate the seeds from sun scorch and protect them from washing away and birds. (iii) The fibres can hold up to 10 times their weight in water, creating a favorable environment for germination; (iv) The mulch eventually biodegrades and acts as a fertilizer.

It is important to note that the above re-vegetation strategy (Table 9) should be considered the first or initial phase of re-vegetation where the objective is to establish a dense cover of relatively low diversity, locally occurring indigenous vegetation that would create the conditions for desirable successional processes and provide the foundation for all future re-vegetation interventions. The duration of this phase is predicted to be 0-5 years, although this may be longer if these objectives are not achieved. Once a good cover of indigenous vegetation is established and management interventions are effectively controlling the proliferation of undesirable weedy and alien plant species, it is recommended that a second phase of planting commence where desirable forbs and grasses are actively planted in propagation patches and strips as plugs, sprigs or sods. Such interventions would focus on seasonal and temporary wetland areas together with riparian areas and buffer zones. This re-vegetation plan does not include details on the second phase of re-vegetation beyond what is proposed in Table 9.

General site preparation guidelines (prior to re-vegetation taking place)

Prior to commencing with any re-vegetation activity (e.g. natural colonisation, planting/seeding), it is important that wetlands areas requiring planting are adequately prepared in advance. The following are general land preparation requirements for all wetland and riparian areas where rehabilitation/re-vegetation is planned and will take place prior to any planting taking place:

- All rubble, litter, foreign materials and waste products needs to be removed from wetlands and disposed of at proper local waste disposal/landfill facilities. *Minimise additional disturbance by limiting the use of heavy vehicles and personnel during clean-up operations.*
- Any large plumes of sediment washed into the wetland from upslope must be removed, taking care not to remove or disturb the natural soil profile.
- All Invasive Alien Plants (IAPs) and weeds must be removed from target sites, preferably by uprooting. Herbicides should be utilised where hand pulling/uprooting is not possible. ONLY herbicides which have been certified safe for use in wetlands/aquatic environments by an independent testing authority may be considered.

- Where significant soil compaction has occurred, the soil may need to be ripped in order to reduce the bulk density of the soil such that vegetation can become established at the site. Rip and / or scarify all disturbed and compacted areas of the construction site. Do not rip and / or scarify areas that are saturated with water, as the soil will not break up.
- For seeding, the soil needs to be prepared to optimise germination. This is typically undertaken by hand hoeing to loosen the soil in the seedbed but should be firm enough to facilitate good contact between the seeds and the soil.
- In general, fertilizer/lime is not necessary, nor is it recommended for re-vegetation in wetlands/riparian areas (particularly in wetlands that have inherently lower nutrient levels, as this may promote increased weed growth).
- A weed-free mulch is recommended to help retain moisture for germination. Mulch should be crimped in if possible, to limit floatation if flooding is likely to occur. It is very important that mulch not be derived from stands of invasive exotic species or weeds.

The following are land preparation requirements may need to be taken into account in addition to the general land preparation measures described above, specifically for steeply sloping areas:

- Where slopes are gentle, general land preparation requirements will apply but where slopes are steep, soft intervention techniques may need to be employed to provide sufficient slope stabilisation.
- As a principle, soft interventions should be favoured over hard interventions wherever possible to ensure streams/wetlands retain their natural flow regimes and habitat.
- The following soft interventions are recommended for steep slopes:
    - Soil savers;
    - Vegetation blankets or mats;
    - Geo-cells; and
    - Fibre rolls or bags.
- It is important to note that bioengineering interventions are vulnerable to failure if not adequately implemented or poorly maintained.
- Retaining structures such as silt fences, sandbags, hay bales, brush packs, timber logs placed in continuous lines following the slope contours or cut-off trenches can be used across the entire slope to retain eroded sediment.
- Use sandbags or timber logs place at regular intervals along the contour of slopes to retain sediment and stabilize the soils.
- Temporary sediment barriers will need to remain in place until such time as re-vegetation and stabilization of disturbed areas is judged to be a success and the risk of erosion/sedimentation has been reduced to a respectfully low level.
- *Note that care must be taken not to disturb the vegetation, soils or in-stream areas during site clean-up.*

Recommendations for Sourcing Seed / Plant Material for Planting

When sourcing seed and live plant plugs for broadcasting and plug planting it is important to consider the recommendation outlined below:

- When looking at transplanting* live plants, select nearby 'donor 'wetland vegetation at the site that is dense and indigenous that can be selectively harvested.
- Tubers and rhizomes of wetland species can be collected and replanted where required.
- If seed is to be used it should be harvested from plants which are growing as close as possible to the site where the seedlings are to be planted (to minimise the risk of contaminating local gene pools).
- Harvesting of plants must be done with caution so as not to unduly disturb the donor wetland. Material from within stream channels, flow concentration zones or in any other areas susceptible to erosion should not be targeted for plant harvesting.
- Collection should limit habitat destruction by implementing a "mosaic collection" method to ensure limited disturbance and adequate recovery of the donor site.
- Use individuals of local species taken from surrounding areas, in order to avoid or reduce genetic pollution. Collection of plant material should be well-documented (locality specifically) such that plant origins are known.
- Plant/seed collection should be undertaken under the strict supervision of a qualified botanist who is able to recognize the various wetland plant species in the field.
- Wetland plant harvesting should be sustainable by ensuring that plants can still recover where cuttings are taken and that at least 50% of seeding material is retained to allow plants to complete their life-cycles (Kerry Seppings, 2011).
- For whole/growing plants, ensure that plants are dug up with as much of their roots intact and such that the soil around the roots is not disturbed (i.e. intact root ball). Care also needs to be taken that weeds/alien plants are not transplanted with the donor plants.
- Collected plants should be replanted as quickly as possible following removal (i.e. within a day or two of harvesting).
- Large clumps of plants can be carefully separated into smaller clumps or into several individual stems with attached roots, known as slips.
- Whenever sourcing plants from nurseries, it is important to consider the genetic origin of the plants. It is considered best to use small regional nurseries that breed plants from the region, instead of large commercial nurseries that are likely to obtain stock from large regional suppliers. It is also important to note that few nurseries maintain the quantities of plugs that are needed for the proposed re-vegetation. Therefore, it is essential that the following recommendations be implemented (after Granger, 2014):
    - A nursery that has the experienced staff and facilities capable of producing large quantities of the recommended species in the format required is identified and notified prior to construction commencing.
    - The proposed species are perennial and therefore produce seed once a year. Therefore, it is essential that the nursery which is to supply the plugs be appointed as soon as possible so that they have sufficient time to harvest seed and other propagation material.

- Because plants grown as plugs in plastic or polystyrene trays have a limited lifespan in these trays (about 3 months depending on time of year and some other factors), it is essential that there is close and frequent communication between the nursery who is to supply the plants and the contractor who is to undertake the planting. It is extremely important that the rate of supply of the required quantities of the specified species coincides with the rate at which they can be planted. Failure to achieve this coordination may result in rehabilitation being set back by a year or more.

STEP 6: Aftercare/maintenance, monitoring & evaluation

Aftercare, maintenance, monitoring and evaluation of rehabilitation and re-vegetation efforts must be undertaken during and after rehabilitation has been completed. The monitoring and evaluation of rehabilitation activities and outcomes is critical in assessing the extent to which the rehabilitation plan has achieved what it set out to accomplish (see **Chapter 4: Ecological Monitoring Plan**).

Monitoring the condition of the re-established vegetation cover will be necessary to assess particular aftercare or plant maintenance requirements. Visual monitoring of the site must be carried out in accordance with the rehabilitation plan at regular intervals during the rehabilitation process. The benefit of regular monitoring will be that problems can be quickly identified and easily addressed during the process whilst rehabilitation teams are busy at the site.

2.7 General oversight

Given the sensitive nature of wetlands and the need to minimise potential impacts during project implementation, oversight of rehabilitation activities is required. In this regard we recommend that the following actions be taken:

2.7.1 Pre-Rehabilitation Phase

- All required environmental approvals, licenses and/or permits for the wetland rehabilitation must be obtained before project implementation can be initiated.
- Civil engineering (Nelson Allopi) and planting contractors will need to be appointed separately and their tasks carefully coordinated.
- Detailed bills of quantities will need to be finalised by both the civil engineering and planting contractors prior to rehabilitation activities commencing.
- An ECO should be appointed to monitor all intervention construction activities.
- The ECO and contractors should be briefed on the rehabilitation plan by the rehabilitation engineer and wetland ecologist prior to project implementation to ensure that the rehabilitation plan is appropriately understood and interpreted.
- The location of planned interventions must be shown to the ECO and contractor by the engineer who must also address any queries regarding design and practical implementation of rehabilitation interventions.

- Proposed access routes to each intervention must be verified and approved by the wetland ecologist and ECO prior to commencement of activities.
- Where applicable, the rehabilitation engineer must set out the intervention sites for the benefit of the appointed contractor prior to construction commencing.

2.7.2 Post-Rehabilitation Phase

- All interventions must be inspected and signed off by the wetland ecologist and engineer following completion.
- Once signed-off, the rehabilitation interventions (reshaping and re-vegetation) must be monitored monthly for the first wet season after completion. Such monitoring should be undertaken by a qualified and experienced wetland ecologist.

3. WETLAND MANAGEMENT PLAN

3.1 Introduction

Chapter 3 of the document presents the wetland management plan for the target properties and wetlands, to be implemented during and after rehabilitation of the wetlands.

3.2 Key concepts & guiding principles of wetland management

According to Kotze *et al.* (2007), a system for the effective management of wetland ecosystems should be underpinned by a number of guiding principles. The preparation of the 'management' plan component of the document has been guided by the following principles:

3.2.1 Strategic Management

Wetland management should be strategic in the sense that it is guided by a vision and objectives and the implementation of actions necessary to achieve these (i.e. it should have '*direction*'). Strategic management is commonly put into operation through an 'objective's hierarchy', which begins with an overall management vision from which a series of management objectives are derived and are then translated into a set of specific management actions. Some typical objectives of wetland management may include:

- Conserving or restoring the diversity and structure of wetland vegetation;
- Conserving or restoring the diversity of habitats for plants and animals;
- Protecting and improving the quality of surface water through bio-filtration in wetlands; and
- Securing and maximising the range of ecosystem services provided by wetlands.

3.2.2 Adaptive Management

Wetland management should be adaptive in the sense that there is an '*on-going process of monitoring and evaluation and adjustment*'. '**Adaptive management'** is a structured process of 'learning by doing', essentially, which involves adjusting the type and direction of management or intervention actions as new information becomes available. This is achieved through monitoring the outcomes of management actions, reflecting on these outcomes and then adjusting future actions accordingly (see explanatory diagram in Figure 8). In essence, a management plan that is regularly used and periodically updated to account for new understanding will make a greater contribution to effective wetland management than a static management plan. In this way, decision making is aimed at achieving the best outcome, whilst accruing the information needed to inform and improve future management of the site. This can and usually does lead to the revision of a part or if necessary, the entire management plan, to better suit the needs of the site and the stakeholders engaged in the process. Active review and refinement of the plan is generally encouraged so long as updates are clearly identifiable and communicated to the relevant stakeholders.

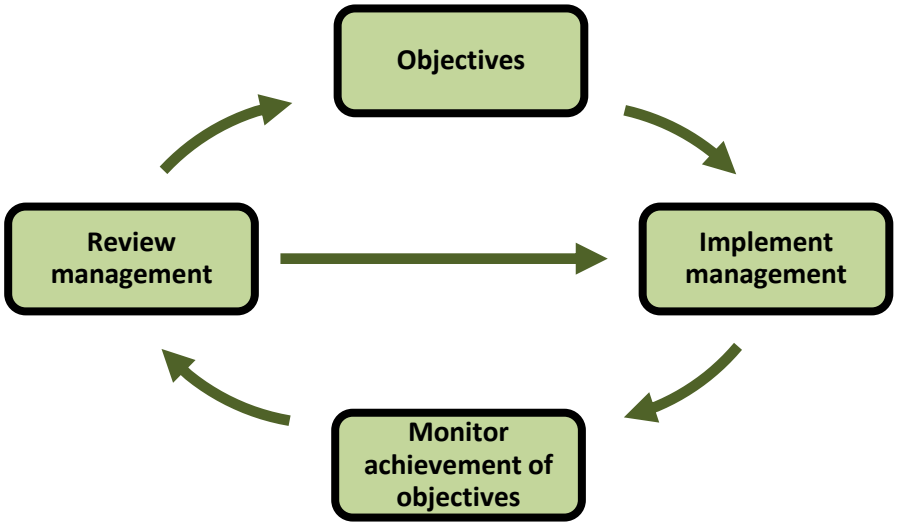

Figure 8 The adaptive management cycle (after Ramsar Convention Secretariat, 2010).

3.2.3 Collaboration and Transparency

Active stakeholder involvement and support is recognized as an important aspect of effective wetland ecosystem management. The Plan should therefore be inclusive of key stakeholders that may affect and/or are affected by the aquatic ecosystems targeted for management. Clear management objectives that reflect stakeholder interests provide a critical point of reference against which management can be assessed to determine its effectiveness. This management plan is therefore intended to be a public document that is freely available to interested and affected parties. On-going interaction with interested and affected parties throughout the implementation and future management review processes is actively encouraged.

3.3 Aim and Objectives

The overall Aim of the Wetland Management Plan were developed and defined through a process of considering both the present state and functioning of the wetlands and the future requirements for the area, both in terms of legislative requirements and functional requirements within the catchment (i.e. demand for ecosystem services at the local level in particular). In accordance with these requirements, the following Aim for the project has been formulated which defines the overarching intent of the management plan:

AIM:

To promote the effective management and sustainable use of the wetlands for the benefit of both humans and the environment and to ensure that any identifiable threats, risk and impacts are appropriately mitigated and managed in order to maintain and even enhance, where possible, the condition and functioning of the target wetlands on the properties.

In considering opportunities to maintain and even improve the condition and functioning of wetland resources, managing the wetland system to support the proposed 'Aim' would require that management objectives (broad statements) be developed. These specific management objectives are defined below in Table 10. These management objectives will ultimately be realized through the implementation of a series of practical management measures, recommendations and guidelines that aim to target specific aspects of wetland management.

Table 10. Summary of key wetland management objectives and required actions to meet these objectives.

MANAGEMENT OBJECTIVES	ACTIONS REQUIRED
3. To inform the proper management of existing and potential future impacts within the wetland and the respective catchment area	**2A**. Implement appropriate best practice management measures and onsite mitigation of impacts during both the construction and operational phases of development. **2B**. Undertake appropriate monitoring of wetlands and catchment areas to identify problems requiring immediate attention.
4. To manage wetland buffer zones in an appropriate way so as to maximise and ensure their continued long-term functioning	**3A**. Implement appropriate buffer zone management in accordance with best practice guidelines for buffer zone management. **3B**. Undertake appropriate monitoring of buffer zones to inform their management, particularly the identification of issues requiring immediate remedial action.

3.4 Management of Impacts during the Wetland Rehabilitation Phase

While the intention of wetland rehabilitation should always be to benefit the environment and society through the protection or improvement of wetland ecosystems and the goods and services that they provide, poorly planned rehabilitation interventions can often cause more harm than good (Armstrong, 2008). Rehabilitation interventions vary considerably in terms of their potential to cause environmental impacts both in terms of the type of impact caused as well as the magnitude of the impact. Thus, it is appropriate that all wetland rehabilitation projects are scrutinized for their potential to cause unintended, negative environmental impacts (Armstrong, 2008). Potential negative impacts associated with wetland rehabilitation projects are highlighted in Armstrong (2008), and those most relevant to the wetland rehabilitation plan (contained in this report) have been summarised in Table 11 below, together with means of avoidance or impact mitigation also included in the table.

Table 11. Key potential negative environmental impacts associated with wetland/riparian rehabilitation activities and interventions and means of avoiding or mitigating these impacts (after Armstrong, 2008).

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
1	**Sloping of steep slopes and any erosion features**	Exposure of soils to risk of erosion, which may impact negatively on the wetland and downstream aquatic habitats.	Assess whether bioengineering will be adequate. Ensure re-vegetation takes place as rapidly as possible. Provide supplementary support (e.g., biomats, ecologs, etc.) to the vegetation, where required.
2	**Planting of vegetation**	Introduction of alien species that spread beyond the site. Use of plant material of indigenous species that is genetically different to that occurring locally, resulting in 'genetic contamination'.	Do not use species with invasive potential. Use local material only.

Item	Rehabilitation Interventions/Actions	Potential negative environmental consequences	Means of avoidance or mitigation
3	**Access to the site during rehabilitation by workers and equipment**	Soil compaction and disturbance and vegetation disturbance.	As far as possible, use existing roads and tracks. In very wet areas obtain foot access using boards. Rehabilitate access paths when work is complete (e.g. loosen compacted areas).
4	**Temporary storage of materials**	Disturbance of vegetation. Visual impact.	Remove all material on completion of the work. Rehabilitate site when work is complete.
5	**Human waste associated with toilets**	Contamination of soil and water.	Locate toilets outside of the wetland.
6	**Disturbance associated with the noise and presence of workers**	Disturbance of fauna, particularly breeding Red Data species.	Consider timing of activities. Screening with shade-cloth, if required.
7	**Fuel spills or leaks**	Contamination of soil and water.	Maintain any machines (e.g., pumps) being used at the site in good working order, and any stored fuel should be located well outside of the wetland.
8	**Collection of rocks and material from the local environment**	Loss of habitat from rock/soil removal.	Do not collect rocks or sediments from a wetland or stream channel bed.
9	**Collection of local sand**	Disturbance of vegetation, possible increase in risk of erosion.	Collect sand where risk of erosion is low and in areas where pioneer vegetation dominates.
10	**In all cases of disturbance of soil or vegetation, the opportunities for invasive alien species to invade are increased**	Competition and displacement of native vegetation, loss of biodiversity, increased soil erosion/fire risk, increased water consumption (depending on species of IAPs).	Control alien plants and weeds through an on0going programme.

3.5 Long-term management of wetlands

Recommendations for the long-term management of the wetlands on Erven 1086 and 1661 are included below. These will become largely relevant post-rehabilitation.

Wetland management will be on-going for the property (essentially in perpetuity as long as the current catchment land use prevails).

A. Environmental awareness

Environmental awareness around the sensitivity of wetlands and the dangers and implications of polluting and impacting on these freshwater environments will be important amongst all residents, employees and workers accessing the property and those undertaking activities on the property. To this end, the following is recommended:

- All residents, employees and staff accessing the property are to be informed of the sensitivity of the wetlands/rivers and the need to avoid damaging/polluting these sensitive aquatic environments, as well as their buffer zones.
- Appropriate signage around the wetlands could also be erected to raise awareness amongst residents and employees/staff.

B. Management and maintenance of aquatic buffer zones

A **20m wide grassed wetland buffer zone** is to be established from the edge of the delineated wetlands. In light of the limitations of buffer zones and the need to maximise their effectiveness through proper maintenance and management, buffer zone management recommendations and guidelines have been developed and are as follows:

- While buffer zones are known to work well at trapping sediments and nutrients, the potential to reduce impacts such as point source pollution and sedimentation is strongly dependent on the site-specific characteristics of the buffer (such as vegetation cover, slope of the buffer, etc.);
    - In order to maximise their effectiveness, buffer zones will need to be established and maintained with indigenous vegetation cover (without erosion features/concentrated flow paths) as open space natural grassland areas with appropriate alien plant control and/or slashing to maintain grass cover;
- For impacts involving the concentration of surface flow (e.g. storm water discharge, etc.), buffers have a limited capacity to function at attenuating flows and trapping sediment/nutrients/pollutants;
- Activities that promote erosion, heavy compaction of soils, or the significant deterioration of vegetation within buffer zones should not be permitted; and
- Dumping, stockpiling, excavation, borrowing of material and any temporary storage of equipment is to be strictly prohibited within the buffer zone.

Note this should align with GroundTruths Terrestrial Grassland Plan.

C. Incursions into and disturbance of wetlands and buffer zones

Any intentional or accidental incursions into wetlands and their respective buffer zones and/or disturbance of such areas will need to be addressed immediately through onsite rehabilitation of the disturbed areas *(as per the **Wetland Rehabilitation Plan** contained in **Chapter 2**)*.

D. Waste management and pollution prevention

The management of potential waste streams and pollutants/contaminants on the property during will be critical for ensuring that downstream freshwater environments do not become polluted and degraded. Whilst potential pollutants/contaminants are likely to be very limited, key water quality threats include salinization (increased salt concentration in the soil as a result of irrigation), increased nutrients as a result of fertilizer application to cultivated lands and composting. The following is recommended:

- A culture of "conserve, reduce, reuse & recycle" should be promoted with regards to the use and disposal of products to minimise resource consumption and reduce the amount of potential waste.
- No release of any untreated domestic waste into the environment may be allowed under any circumstance.
- Correct emergency procedures and cleaning up operations should be implemented in the event of accidental spillage of any fuel, oils or other pollutant/contaminants on the property.

- Provide adequate rubbish bins and waste disposal facilities at regular points on the property and allow for the regular collection and disposal of domestic waste.
- Control and limit the use of the following substances:
    - Excessive use of fertilizers is not recommended due to the potential risks of increased nutrients in the downstream aquatic environment;
    - Environmentally harmful herbicides, insecticides and pesticides; and
    - There shall be no use of harmful chemicals to treat diseases and pests where possible to avoid.

E. Management of soil erosion and sediment

Soil erosion problems are primarily the result of poor land use and exposed ground cover as well as concentrated flow paths and disturbance by animals/humans. Soil erosion and the resultant sedimentation of downstream wetlands and dams is considered a key impact in this environment based on the relatively steep hillsides occurring on the property and the potential for heavy rainfall to exacerbate soil erosion risks. In addressing soil erosion risk, the following guiding management measures and principles should be applied to the site in the long-term:

- Areas susceptible to soil erosion or showing early signs of soil erosion such as loss of vegetation cover, must be stabilised and revegetated as soon as practically possible to prevent loss of soil and sedimentation of downslope areas.
- Dryland erosion must be addressed through the appropriate shaping and revegetating of eroded areas to prevent further erosion and sedimentation. Where necessary and relevant, hard options involving some form of engineered intervention (such as a gabion retention structure or earthen plug/rock packing) may be considered necessary where erosion impacts are large.
- Earthen/soil berms and grassed cut-off drains should be constructed (where necessary) to capture sediment and any contaminated runoff and promote the settling and infiltration of water. Drains and berms should follow the contours of the slope to ensure proper drainage and retention. *These are not to be established within the delineated wetlands.*
- Cut-off drains must be maintained free of sediment or erosion in order for them to be functional. This would require regular check-ups and if problems are detected they must be fixed immediately.
- After every major storm event, all erosion and sediment control structures or interventions should be inspected for damage immediately after a significant rainfall event and repaired accordingly.

F. Controlling alien/exotic vegetation and weeds within wetlands and buffer zones

It is the responsibility of the landowner to eradicate and control alien invasive plants that invade the wetlands and associated buffer zones. In terms of Section 75 of the National Environmental Management: Biodiversity Act (NEM:BA), the following applies to the control & eradication of invasive species (key species have been identified in Section 2.6: Step 4):

- The control and eradication of a listed invasive species must be carried out by means of methods that are appropriate for the species concerned and the environment in which it occurs.
- Any action taken to control and eradicate a listed invasive species must be executed with caution and in a manner that may cause the least possible harm to biodiversity and damage to the environment.
- The methods employed to control and eradicate a listed invasive species must also be directed at the new growth, propagating material and re-growth of such invasive species in order to prevent such species from producing offspring, forming seed, regenerating or re-establishing itself in any manner.
- It is recommended that alien plant monitoring, clearing and control be undertaken by the landowner on a regular basis to control and prevent the risk of infestation problems.

Note that key IAP species are likely to recolonise the site during and after rehabilitation, recommended control methods should be applied and follow-up control should usually be 3-6 months.

There are various means of controlling IAPs in South Africa. The suitability of control methods depends on a number of factors, including practical constraints, economic constraints and applicability of methods for particular species of alien plants. Due to the low diversity and abundance of IAPs on the property, it is generally advised that mechanical and mycoherbicides be used in controlling IAPs. These methods have been discussed below in Box 2.

Box 2. Alien Plant Control Methods

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

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

- **Hand pulling/uprooting:** The hand-pulling should be reserved for small plants and shrubs with shallow root systems (not recommended for trees with a stem diameter of more than 10cm). Grip the young plant low down and pull out by hand (using gloves). Uprooting is similar but is undertaken on slightly older individuals with the major drawback being that a relatively large area can be disturbed with the soils being altered and opening the area up to re-infestation.
- **Chopping/ cutting/ slashing:** This method is most effective for plants in the immature stage, or for plants that have relatively woody stems/trunks. An effective method for non re-sprouters or in the case of re-sprouts (coppicing), it must be done in conjunction with chemical treatment of the cut stumps. Cut/slash the stem of the plant as near as possible to ground level. Paint re-sprouting plants with an appropriate herbicide immediately after they have been cut.

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

3 Mycoherbicides

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

4 Disposal of alien plant material
Treated/removed alien plant material will need to be removed from the site and disposed of through burning in a controlled environment.

G. Wildlife Management

The wetland habitat on the site is likely to attract local wildlife such as small mammals, reptiles, amphibians and birds, including both terrestrial and aquatic biota. The following measures apply to the management of any wild animals found within open space wetland and buffer zone areas on the property:

- No wild animal may under any circumstance be hunted, snared, captured, injured, killed, harmed in any way or removed from the site. This includes animals perceived to be vermin (such as snakes, rats, mice, frogs, etc.).
- The handling and relocation of any animal perceived to be dangerous/venomous/poisonous must be undertaken by a suitably trained individual.
- Any fauna (frogs, crabs, etc.) that are found within active working areas, and which may be killed or harmed (for example during operation of heavy machinery), must be moved to the closest point of similar habitat type and quality.

H. Fire Management

To ensure that accidental and intentional fires are appropriately managed to avoid impacts to wetlands and the broader environment, the following is recommended:

- No open fires to be permitted within wetlands or their buffer zones. Fires may only be made at designated sites such as private residences and public/clubhouse/braai facilities for example.
- Ensure adequate, basic fire-fighting equipment is available at the site offices and/or access points, etc.
- Ensure that all staff are aware of the proper procedure in case of a fire occurring on site.
- Provide local emergency numbers (including fire department) at key locations on the property.
- Smoking must not be permitted in areas considered to be a fire hazard.
- No refuse wastes are burnt on the property. Waste is to be removed from the site and disposed of at a Municipal Landfill site.

3.6 Review

It is recommended that the Wetland Management Plan is reviewed annually, in line with the principle of 'Adaptive Management' (*described in Section 3.2.2 and shown in Figure 8*). The purpose of undertaking an annual review of implementation of the management plan will be to:

i. Determine how effectively the management plan has been implemented.
ii. Assist in determining the focus for the annual plan of operation and the setting of appropriate time frames and budgets.
iii. Enable effective adaptive management by identifying changes and modifying management interventions.
iv. The review process should include:
    a) Any recommended minor amendments to the plan that do not affect the substance of the vision and objectives.
    b) The results of an evaluation of the management effectiveness achieved.
    c) Any proposed significant changes to the Wetland Management Plan that are likely to result in amendment to the vision, objectives, wetland zonation plan and monitoring requirements must be supported by the DFFE and the DWS and evaluated against the requirements and conditions of any issued Environmental Authorisation (EA) and Water use License (WUL).

The annual review should also be submitted to the relevant competent authority (DWS / DFFE) for relevant comment/endorsement.

4. WETLAND MONITORING PLAN

4.1 Introduction

It is essential to know, and to be able to demonstrate to others, that both the Rehabilitation Plan and the Management Plan (for wetlands) has been successfully implemented and that the vision and objectives have been achieved within permissible limits. It will also be necessary to evaluate whether the aims, objectives and targets of the plan have been successfully achieved. Monitoring forms the basis for evaluating the performance of any wetland management/rehabilitation activity, which is defined as the extent to which the project has achieved what it set out to do. Without appropriate monitoring, it will be impossible to gauge the level of success of the wetland rehabilitation and management planned for the project. Furthermore, natural ecosystems such as wetlands are known to be inherently dynamic systems that may not always respond predictably to impact mitigation and management measures. It is therefore also important to recognize that wetland rehabilitation and management should be viewed as a "process", driven by ecological knowledge and research rather than simply the "product" of specific rehabilitation and management activities (Cooke and Johnson, 2002). In this regard, monitoring can assist greatly in identifying any potential unforeseen problems that may occur during the implementation process, which if left uncorrected could undermine the success of wetland management for the target properties.

Monitoring will generally be required during all phases of the project, to ensure that wetlands are not negatively impacted such that their current ecological state and functioning is maintained and possibly even improved or enhanced. Monitoring will assist with identifying any problems requiring further management/mitigation and addressing these timeously and appropriately through the implementation of the relevant management recommendations and guidelines presented in this document.

4.2 Aim and Objectives

The main aim of the ecological monitoring plan is to assess to what degree anticipated ecological outcomes are being achieved Monitoring objectives should be aligned with the objectives of the management plan which are presented in Table 12, below.

Table 12. Wetland monitoring objectives for the site.

MANAGEMENT OBJECTIVES	MONITORING OBJECTIVES
1. ***To inform the proper management of existing and potential future impacts within wetlands and their respective catchment areas***	Monitor activities to ensure that management and mitigation measures are adequately implemented to limit the potential impact on wetlands.
2. ***To manage wetland buffer zones in an appropriate way so as to maximise and ensure their continued long-term functioning***	Monitor activities and impacts within wetland buffer zones and address issues accordingly.

4.3 Monitoring Plan

4.3.1 Establishing a suitable 'baseline'

Baseline monitoring is a critical component of the monitoring programme that documents the status quo of the ecosystems prior to activities being initiated. Without such information, the improvement in the supply of ecosystem services delivered and ecosystem condition cannot be determined.

4.3.2 Indicators

Key performance indicators to monitor and report on management effectiveness in the long-term (using the scheme in Table 13) have been summarised for the wetland areas on the property and are included in Table 14, below. In this case the main indicators to be measured are (i) wetland morphology and any significant sedimentation and erosion, (ii) indigenous vegetation cover; and (iii) alien invasive plant cover/abundance.

Table 13. Key performance areas to monitor and report on management effectiveness.

No.	Performance Indicators	Description
1	**Implementation of the rehabilitation plan**	*Have rehabilitation activities been implemented successfully?*
2	**Wetland condition**	*How has the condition of habitat changed?*
3	**Wetland functioning**	*How has the functioning of wetlands changed?*
4	**Alien plant levels**	*What are the levels of alien infestation?*
5	**Vegetation composition**	*Are the correct species occurring in the desired locations as per the rehabilitation and landscaping plan?*
6	**Erosion & sedimentation risks**	*Are there any erosion/sedimentation risks?*
7	**Water quality**	*Are there any water quality issues/risks?*

Table 14. Example of a rating scheme used in monitoring wetland management effectiveness.

Level of Management Effectiveness	Outcome of Monitoring of Management Intervention(s)	Recommended Action(s)
5: Excellent	Management and/or rehabilitation is generally progressing as expected.	***No action required***
3: Good	Management and/or rehabilitation progress is slower than expected but will probably meet the objectives within a reasonable amount of time. Additional intervention may be required to keep management/rehabilitation on course.	***Maintenance of objectives***
2: Poor	Significant changes in parts of the implemented management plan might be needed. These might entail revisiting the overall plan as well as considering changes in the design of individual components and types of intervention planned.	***Modifications to management plan elements***
1: Very Poor	Monitoring might indicate that management/rehabilitation is not progressing towards meeting the objectives but is progressing toward a system that has other desirable functions or goods and services. In this case, the most cost-effective action may be to modify the management objectives rather than to make extensive intervention changes to meet the original objectives.	***Modification of objectives***
0: Non-compliance	Monitoring indicates that management and/or rehabilitation activities are currently not currently fulfilling the management objectives. Revisiting the overall plan as well as considering changes in the design of individual components and types of intervention planned will be necessary.	***Assess and refine management plan***

A monitoring performance review template for potential use for monitoring in the long-term has been included as Box 3, below.

Box 3. Monitoring Performance Review Template (adapted from USACE, 2008)

1. **Overview of Monitoring Requirements:**
   - Description of monitoring undertaken, timing and frequency.
   - Map showing the location of interventions and monitoring points (where applicable)
   - Photographic record of the site with accompanying map showing location of -point photos.

2. **Summary of Monitoring Results:**
   - List of performance indicators and success standards.
   - Table of monitoring results compared with baseline data (where applicable).
   - Summary of success standards including an evaluation of whether management is successfully achieving these standards or trending towards success. Examples of key questions to ask include:
     - Were the **outputs of wetland rehabilitation** achieved or completed to specification and in the appropriate time?
     - Were any **problems during implementation** of rehabilitation and site management identified and corrective actions appropriately implemented?
     - To what degree **were success standards met**?
     - Were the **outcomes in relation to the defined management objectives** achieved?
     - Was **project risk** dealt with adequately?
     - To what degree were **existing and potential future threats** identified and were these threats catered for in the management of the site (i.e. were they monitored and accounted for)?
   - Summary of any problems or significant events that occurred on the site that may affect the long-term success of wetland management.

3. **Describe Management Interventions/Remedial actions**:
   - Concisely describe any management/remedial actions done during the implementation and post-implementation phase monitoring to meet the success standards – actions such as removing debris, replanting, controlling invasive plant species, etc.

4. **Summary of Progress and Way-Forward**:
   - Summary of progress made in wetland management and what needs to be done going forward to meeting the objectives of the plan based on monitoring outcomes.
   - Outcomes to feed into management and review of the management plan where necessary.

4.3.3 Methods

The methods proposed to monitor the aforementioned indicators are as follows:

Fixed-point photography & Visual Monitoring

Fixed-point photographs are proposed to provide a coarse visual 'measurement' of each of the four indicators. The following guidelines should be followed when locating photographic points across the floodplain for fixed-point photographs:

- photo-points should be selected at various locations throughout the rehabilitation site and at points that will be easily accessible at all times; and
- record the geographical co-ordinates of each point using a GPS, preferably accurate to within 3m. This provides any individual with the information required to navigate to the exact location of each photo point.

The following guidelines should be followed when implementing fixed-point photography for monitoring purposes:

- the orientation of the photographer should be recorded;
- use of the same zoom ratio each time. If this is not possible, record the settings used. The camera should preferably be located on a tripod at a fixed height;
- when the frequency of monitoring increases to an annual interval, photographs should be taken at roughly the same time of year and at the same time of the day, and under similar weather conditions. This would limit the variability of the wetland habitat associated with vegetative and hydrological changes linked to seasons;
- a standard object, such as a soil auger or a metre rule should be included in the photograph as a reference for scale; and
- record relevant information about factors that may influence features in the photograph (e.g. a recent fire, late or early rains, etc.), especially those relating to the appearance of the site.

The recovery of disturbed areas that have been rehabilitated should be assessed for at least the first 3 months following rehabilitation completion to assess the success of rehabilitation actions. Any areas that are not progressing satisfactorily must be identified (e.g. on a map) and action must be taken to actively re-vegetate these areas. If natural recovery is progressing well, no further intervention may be required. The ECO should assess the need / desirability for further monitoring and control after the first 6 months and include any recommendations for further action to the relevant environmental authority.

Table 15 provides a basic visual monitoring framework and checklist of the rehabilitation aspects to be monitored.

Table 15. Description of basic visual monitoring requirements to assess the success of wetland rehabilitation.

Aspect	Description	Frequency of monitoring
Solid waste and construction rubble	Has all solid waste, litter and construction rubble been adequately cleared from the site and disposed of at a registered site?	Weekly
Salvaged indigenous species	Are salvaged indigenous species being watered twice a week? Are there any mortalities?	Bi-weekly
Watering/maintenance requirements of planted grass, trees and shrubs	What is the plant survival rate? Are there areas of bare soil/poor growth? Is there a need for follow-up re-vegetation?	Weekly
Response of planted grass, trees and shrubs	What is the progress of re-vegetation planting? Are there areas of bare soil/poor growth?	Bi-weekly
Alien plant control and eradication (including follow-up control	Are there dense infestations of alien plants within and around the rehabilitated site? (Seedlings, shoots, coppice growth, etc.) Is there a need for further follow-up control?	Weekly during and immediately after rehab, thereafter on a monthly basis
Sediment barriers/traps and erosion control measures	Are sediment/erosion controls functioning adequately? Have these been properly maintained? Are there signs of erosion/sedimentation?	Daily during rehabilitation

Water Quality Testing

Surface water collection and laboratory analysis must be undertaken to inform water quality driver effects and trends. The sampling sites must be sampled twice a year during the wet and dry seasons and analysed for the following constituents at a certified laboratory:

- Ammonia
- Nitrate / Nitrite
- Orthophosphate
- E. coli
- Chemical oxygen demand (COD)
- Dissolved oxygen (DO)
- Conductivity
- pH
- Temperature

The above should also be aligned with GroundTruths initial surface water monitoring testing.

Vegetation Sampling and Analysis

Vegetation is a major component of biodiversity found in wetlands and provides habitat for a myriad of aquatic and terrestrial biota. Wetland plants are those plants that are specifically adapted to growing in a substrate that is (at least) for part of the year deficient in oxygen (anaerobic conditions) and affected by the altered soil chemistry in reduced environments. Plant species occurring in wetlands are considered useful indicators that can assist with the interpretation of environmental conditions and changes within wetlands due to a number of reasons, including:

- plants typically have a high level of species richness and rapid growth rates (Sieben *et al.,* 2013);
- plants have a number of attributes that are easily measured and quantified (Miller *et al.,* 2006);
- plant communities are immobile and therefore susceptible to physical, chemical, and biological changes in the surrounding environment (Miller *et al.,* 2006);
- plants communities and individual species respond quickly to environmental changes with the two most important environmental factors affecting wetland plant communities and their composition being water quantity and quality (Sieben *et al.,* 2013).

Individual species of plants may be used as indicators because they show a differential tolerance to environmental conditions. Those plants that are regarded as characteristic of certain wetland environments can be monitored in the long term to see whether significant changes in the wetland environment are taking place (Sieben *et al.,* 2013). Different approaches were taken for collecting baseline data for areas targeted for the reestablishment of herbaceous and forested habitat types as detailed below.

A. <u>Sampling methods</u>

a. Wetlands

Vegetation sampling for herbaceous wetlands should be informed using an adapted version of the US EPA approach (Kentula *et al.,* 2011). The following protocol is proposed:

- 2m x 2m ($4m^2$) vegetation quadrats/plots must be placed at locations where significant changes are anticipated to take place. If possible these plots should be linked to the cross-sectional survey

transects. A single pin should be used to demarcate the NW plot corner and this point should be recorded using a GPS.

- The wetland hydrological zone for each plot must be established by investigating soil morphology by taking soil samples across each plot using a soil auger (across a diagonal at one plot corner and the opposite plot corner).
- Georeferenced photos must be taken for each plot documenting direction and height of the camera.
- Plant species within each plot must be identified within 1m^2 nested plots in the NE and SW corners of the plot initially, and then within the broader plot. A species list must be generated from this process.
- For each plant species, the following data must be collected:
    - structure (maximum and minimum height recorded and then average calculated)
    - % ground cover estimated
    - indigenous/alien status recorded for each species
    - hydric status for each species allocated (see Table 16, below)
- Additional surface attribute data for various biotic and abiotic surface materials that also needs to be collected include: surface water cover, water depth, bare ground, vegetative litter, etc.

Table 16. Descriptions of the five wetland indicator status ratings used to inform whether vegetation is hydrophytic (adapted from Macfarlane *et al*., 2008 and DWAF, 2005).

SYMBOL	HYDRIC STATUS[8]	DESCRIPTION/OCCURRENCE
OW	Obligate wetland species	Almost always grow in wetlands (>99% occurrence)
F+	Facultative positive (facultative wetland) species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas
F-	Facultative negative (facultative dry-land) species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)
D	Dryland/terrestrial species (non-wetland)	Almost always grow in non-wetland/terrestrial areas

WET-Health Assessment

As part of long-term monitoring, the wetland habitat condition of selected wetlands receiving and affected by the rehabilitation interventions should be assessed using version 2 of the Level 2 WET-Health tool (Macfarlane *et al*., 2021). The focus should be on the vegetation component or module of the WET-

[8] Note: Field guides for wetland plants are still under development in South Africa. The following guides are available for identifying wetland plants and assigning hydric status to species identified:

- Van Ginkel *et al.* 2011. Easy identification of some South African Wetland Plants (Grasses, Restios, Sedges, Rushes, Bulrushes, Eriocaulons and Yellow-eyed grasses). WRC Report No TT 479/10.
- Van Oudshoorn, F. 1992. Guide to grasses of South Africa. Briza Publikasies Cc, Arcadia.
- Macfarlane *et al.* 2007. WET-Health: A technique for rapidly assessing wetland health. WRC Report No TT 340/08, Water Research Commission, Pretoria.
- Lichvar, R.W. 2013. The National Wetland Plant List: 2013 wetland ratings. Phytoneuron 2013-49: 1–241. U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory. Published 17 July 2013. ISSN 2153 733X.

Health assessment tool only rather than undertaking a full Wet-Health assessment, as this is the component used for assessing biodiversity gains and wetland rehabilitation. This approach relies on a combination of desktop and on-site indicators to assess vegetation structure and plant species composition. Essentially, the extent to which anthropogenic changes have impacted upon wetland vegetation was assessed, with a strong focus on compositional changes in plant species assemblages using the results of vegetation survey plots to refine impact ratings (i.e. the extent of deviation from a perceived "reference wetland state") using a standardized scoring system to facilitate the interpretation of results (Table 17). Scores range from 0 indicating no impact to a maximum of 10 which would imply that impacts had totally destroyed vegetation.

Table 17. Guideline for interpreting the magnitude of impacts on wetland integrity.

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

Impact scores obtained for each of the modules reflect the degree of change from hypothetical natural reference conditions. These scores are subtracted from 10 to obtain an intactness or health score for the wetland system evaluated. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table 18. This classification is consistent with Department of Water and Sanitation (DWS) categories used to evaluate the present ecological state of aquatic systems.

Table 18. Health categories used by WET-Health for describing the condition of wetland vegetation.

HEALTH CATEGORY	DESCRIPTION	RANGE
A	Vegetation composition appears natural.	0 – 0.9
B	A very minor change to vegetation composition is evident at the site.	1 – 1.9
C	Vegetation composition has been moderately altered but introduced alien and/or ruderal species are still clearly less abundant than characteristic indigenous wetland species.	2 – 3.9
D	Vegetation composition has been largely altered and introduced alien and/or ruderal species occur in approximately equal abundance to the characteristic indigenous wetland species.	4 – 5.9
E	Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species.	6 – 7.9
F	Vegetation composition has been totally or almost totally altered, and if any characteristic species still remain, their extent is very low.	8 – 10

Functional Assessment

As part of long-term monitoring, functional assessments should be undertaken for selected wetlands receiving and affected by the rehabilitation interventions using an updated version of the WET-EcoServices tool (Kotze *et al*., 2020). This will essentially require a review and refinement of predicted post-rehabilitation scores in order to record the actual level of functionality attained as rehabilitation continues.

4.3.4 Frequency, Interval and Timing of Monitoring Activities

With regards to time frames for monitoring it is important that monitoring take place during the both the construction phase of the rehabilitation project as well as the operational / recovery phase, for each of the three phases. During the construction phase, practical oversight and monitoring should be more regular to identify issues quickly and have them remedied i.e. weekly by an ECO and every second week by specialists (e.g. wetland ecologist).

The frequency and nature of the monitoring will allow for accurate assessment of the various stages of the project to help guide the long-term success of the rehabilitation. During the recovery phase, monitoring will make sure that the interventions are performing well and that there are no fundamental flaws in the rehabilitation process. A monitoring schedule for the interim rehabilitation plan is summarised in Table 19.

Table 19. A basic framework for rehabilitation monitoring.

Phasing	Frequency	Duration	Assessment Requirements
Pre-Rehabilitation	Once-off	Before intervention construction commences.	• Ensure all required environmental approvals for rehabilitation acquired. • Pre-construction meeting with contractor and ECO. • Review of detailed bill of quantities. • Baseline assessment as per ecological monitoring programme i.e. setup fixed-point photography, water quality tests and vegetation plots.
Rehabilitation Implementation	Weekly (Weekly reports).	Duration of rehabilitation.	• Reshaping, structure construction and re-vegetation monitoring by ECO/wetland ecologist according to compliance with this plan.
	During construction	Duration of rehabilitation.	• Site visit by Engineer & wetland ecologist every second week to review progress and identify any concerns.
	Post-construction	On completion.	• Close-off inspection to sign off on construction activities
Post-rehab, Recovery Phase	Monthly visits for first year after completion.	First year after completion provided that no serious issues are identified.	• Rapid site walkovers.
	Annually after first year of establishment for 3	Long-term monitoring (indefinitely).	• Undertake ecological monitoring as per ecological monitoring programme:

Phasing	Frequency	Duration	Assessment Requirements
	years. Thereafter, every 3 years.		o Fixed-point photography of key areas as identified in baseline photos. o Water quality testing. o Vegetation surveys. o WET-Health & WET-EcoServices assessments.

Upon completion of the planned wetland rehabilitation, an evaluation of the success of the rehabilitation project will need to be undertaken in order to facilitate the dissemination of lessons learnt and provide a means of reporting on the success of specific rehabilitation initiatives. In order to evaluate project success, the following attributes/rehabilitation indicators need to be clearly defined and understood:

i. Aspects/values of interest referred to herewith as 'concerns';
ii. Level of achievement required to consider the rehabilitation exercise successful; and
iii. Quantitative performance level used as a desirable target.

Table 20 below, provides for basic rehabilitation evaluation guidelines useful for evaluating the success of the wetland rehabilitation project. The evaluation process can be conducted by the developer, Competent Authority, I&APs or an independent ECO after a period of 3-6 months post-completion of the rehabilitation process. An external audit report on performance should ideally be provided as part of the rehabilitation project success evaluation process.

Table 20. Summary guideline for evaluating the success of wetland rehabilitation projects.

Item	Aspect to Evaluate	Performance indicator	Desired Target
1	**There should be low levels of Invasive Alien Plants**	IAP species cover/abundance	<10% IAP cover
2	**Indigenous vegetation should be re-instated**	Indigenous species cover/abundance	>90% indigenous cover
3	**Erosion and slope instability should be managed appropriately**	Signs of soil erosion and slope/bank instability	No signs of erosion
4	**Wetlands should be adequately re-planted**	Indigenous tree/shrub cover/abundance	No large gaps in the vegetation structure or bare soils
5	**Sedimentation of water resources must be limited**	Signs of sedimentation in downstream channel	No signs of major sedimentation/turbidity in water column
6	**There should be no foreign solid waste materials or waste within rehabilitated areas**	Solid waste/litter levels	No solid waste remaining

5. FURTHER RECOMMENDATIONS & CONDITIONS

No matter how detailed the rehabilitation and management plan may be, the success of a wetland rehabilitation project is often determined by the contractual documentation / project specifications which have been compiled for appointing the contractor who undertakes the rehabilitation. The rehabilitation which requires to be undertaken is essentially civil engineering works (earthworks and soil preparation) with subsequent re-vegetation. Therefore, it is recommended that the contractual documentation/ project specifications which is to be compiled for the appointed contractor to undertake the rehabilitation, be based on the relevant components of the Standard Specifications for Civil Engineering Construction (SANS). It is further recommended that the appointed engineers (Nelson Allopi & Associates) be involved in the adjudication and implementation phases of civil engineering works to ensure the success of the project.

It is also important to note that the success of the proposed rehabilitation is dependent on regular proactive and adaptive monitoring typically undertaken by an Environmental Control Officer (ECO) / Specialist Wetland Ecologist who understands both the Rehabilitation Plan and the terms of the contractual documentation / project specifications and will ensure that the terms of the contract are adhered to.

6. CONCLUSION

This document contains the wetland rehabilitation, management and monitoring plans for the two wetlands and buffer zone rehabilitation plan for the Brookdale Assessment Centre located on Erven 1086 and Erven 1661, Phoenix, eThekwini Municipality (KZN). This will be the primary working document to inform the implementation of wetland rehabilitation interventions and activities and short- and long-term wetland management and ecological monitoring at this project location specifically. Details on the practical rehabilitation interventions to achieve the desired rehabilitation objectives including plans and programmes together with monitoring requirements are presented.

It is believed that where the aim and objectives of the various plans are adequately realised, wetland rehabilitation and long-term management (with monitoring) will achieve an improved wetland condition and functioning for both wetlands concerned and this should adequately address residual impacts to the wetlands as a result of the recent infilling.

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8. ANNEXURES

Annexure A: General Construction Notes.

- **Occupational health and safety is a priority!** All necessary precautionary measures must be undertaken to ensure safety of the team.
- Check all dimensions on site to determine if any amendments to the designs are necessary. Note the required final height of any structure relative to the original ground level. The responsible engineer must be consulted before any changes are made to dimensions.
- Excavation must be carried out to the final levels. Soil must be placed in areas best suited for re-use, for example, when building an earthen diversion embankment, the soil excavated should be used immediately in building up the embankment (on condition the excavated soil is of suitable quality). The excavated soil should alternatively be stockpiled immediately upstream of the site of the proposed wall. The topsoil must be stockpiled separately from the subsoil.
- Where soil is to be the foundation for non-soil structures (for example gabions), all sand deposits must be removed and the floor well compacted while the soil is at optimum moisture content.
- When the final level of the soil construction has been reached the previously stockpiled topsoil must be added as an extra height and planted to suitable vegetation (unless other provision for protection of the structure has been specified).
- All cut off walls/heels are to be founded on firm impermeable material.
- When backfilling soil against gabion work, extra care must be taken to ensure that a waterproof join with the structure is, as far as possible, achieved. Compaction must be carried out in 150mm layers. Material containing organic matter must not be used for this backfilling purpose.
- The standard procedures for the opening up and wiring together of gabion baskets and mattresses are well documented, and supplied with every delivery of the products. They must be strictly adhered to in all respects. Ensure that the lids of the final (top) baskets are always folded down and wired in a downstream direction.
- Where rock-filled gabion baskets are used for the construction of keywalls, the trenches be dug wide enough so that sufficient access is available to properly backfill and compact all the way around them. Making the trench only wide enough to receive the baskets is not acceptable, as water will eventually find its way around the structures.
- Geofabric (AG200 or equivalent) material to be placed on all contact surfaces between gabions baskets and earth material
- The orientation of all wetlands and interventions is to be taken facing downstream (i.e. left bank and right bank are to be identified facing downstream in the direction of water flow).

Annexure B: Standard checklist for visual assessment of rehabilitation interventions.

STRUCTURE TYPE	SPECIFIC MONITORING FOCUS
Gabion structures	• Correctly packed rock • Correctly sized rock • Lacing and bracing correctly implemented • Evidence of rusting • Evidence of sliding, tilting, slumping of structures • Evidence of undercutting • Scouring downstream of structures • Evidence of outflanking • Evidence of tunneling • Dimensions according to specifications • Authorized deviations from plan
Earthworks	• Hydrological monitoring wells located and demarcated prior to excavations • Work areas and "no-go areas" clearly demarcated • Vegetation to be used in re-vegetation removed prior to excavations • Re-shaping undertaken in line with profiles included in the wetland rehabilitation plan • Backfilling and compaction of soil in main drains • Erosion control measures • Authorized deviations from plan

Annexure C: General Health & Safety Issues.

The following occupational health and safety guidelines apply to construction activities associated with wetland rehabilitation in general:

- All site workers to undergo specific safety training before undertaking this work so that they are aware of the various risks and measures to be taken in emergency situations
- Each project manager and contractor shall have a copy of the Occupational Health and Safety Act No. 85 of 1993 (OHS). All relevant OHS standards will be fully implemented.
- An adequately equipped first aid kit shall be easily accessible at all work areas and needs to be kept fully stocked. All first aid treatment and usage shall be recorded. The first aid kit shall be under control of a trained and competent first aid officer.
- PPE (Personal Protective Equipment) prescribed in the agreement between the rehabilitation implementer and contractor shall be worn at all times during work. PPE shall meet the minimum prescribed standards of quality (SABS approved). PPE shall be replaced when it becomes ineffective through wear and tear.
- Workers should be encouraged not to drink water directly from any wetland or watercourse and suitable drinking water in adequate quantities will need to be provided to workers.
- Project managers and contractors will need to be sensitive to the potential dangers of floods when working in wetland areas. Rainfall in the catchment above the wetland, and flow within the wetland should be visually monitored by project managers and contractors. In high rainfall events where there is an increased risk of flash floods, work should ideally cease within wetland areas to limit risks to personnel, equipment and the environment.
- All vehicles (including trailers) used shall comply with all legal requirements in terms of roadworthiness and licensing. Daily pre-trip vehicle checks should be done and recorded by the driver on a suitable checklist. Trailers also form part of the daily checklist. Any faults affecting the roadworthiness of the vehicle shall be repaired immediately or alternative transport used. Vehicles used for transporting workers shall have suitable passenger facilities.
- All hand tools and machinery is to be suited to the nature of the work and are to be maintained in safe working order.
- All machinery will need to have the required safety guards to enclose dangerous working parts.