WET-REHABEVALUATE
VERSION 2:
AN INTEGRATED MONITORING AND EVALUATION FRAMEWORK TO ASSESS WETLAND REHABILITATION IN SOUTH AFRICA

Report to the
Water Research Commission

by

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EXECUTIVE SUMMARY

Background to the framework

Despite the many ecosystem services supplied by wetlands, the majority of these ecosystems have been subject to considerable degradation within South Africa, as in most countries. One of the globally accepted responses to this degradation is ecological rehabilitation. Wetland rehabilitation refers specifically to the process of assisting in (1) the recovery of a degraded wetland's health and ecosystem service delivery by reinstating the natural ecological driving forces, or (2) halting the decline in the health of a wetland that is in the process of degrading, so as to maintain its health and ecosystem service-delivery. A wetland rehabilitation project refers to a set of interventions designed to achieve rehabilitation of one or more specific wetland sites. Here it is important to distinguish between the outputs, which are the specific interventions (e.g. a gabion weir) and the outcomes, which is what the interventions are designed to achieve (e.g. halt the advance of major erosion in a wetland in order to secure the integrity of an intact portion of the wetland under threat from erosion).

Rehabilitating wetland ecosystems is potentially very complex given the many interacting biophysical and social factors affecting wetland functioning and the ultimate outcomes of rehabilitation projects. Furthermore, wetland rehabilitation in South Africa is a fairly new field of science and practice. This emphasises the importance of monitoring and evaluating (M&E) wetland rehabilitation in South Africa.

Monitoring is the systematic collection of data based on observations and measurement of change, in relation to a pre-defined state/objective/hypothesis. Evaluation is a determination of whether the agreed pre-defined state/objective/hypothesis is achieved, and often also includes a determination of reasons why, particularly when the results were not as expected. Evaluation is usually based on the results of monitoring, and thus M&E are most often usefully placed together in a framework where each supports the other.

M&E is a process that should be initiated at the outset of a wetland rehabilitation project; it should not only be undertaken following the implementation of a rehabilitation plan. It is a continuous process of adaptive learning and can:

- Help timeously identify problems and their causes, particularly during the planning and implementation of a project;
- Raise questions about assumptions concerning how the wetland is likely to respond to the rehabilitation strategy and the particular interventions employed;
- Support learning as it encourages one to reflect on where one is going and how one is getting there;
- Better assess and report on outcomes;
- Better account to funders; and
- Add to the body of knowledge relating to wetland rehabilitation thereby supporting and improving practice.

Aims of the study

The aims of the study relating to the wetland rehabilitation were to:

1. Develop (through iterative application and testing) a monitoring and evaluation framework for the socio-ecological outcomes of wetland rehabilitation in South Africa
2. Skills development within the Working for Wetlands programme to allow an evaluation of a sub-set of rehabilitated wetlands (8 sites)
3. Deepening our understanding of wetland socio-ecology in terms of rehabilitative management
4. Contextualise the value of the wetland rehabilitation when viewed as an investment in ecological infrastructure

Development of the framework

WET-RehabEvaluate was developed as a framework to guide the application of M&E during wetland rehabilitation projects, but further experience and recent research have identified several potential improvements required for evaluating wetland rehabilitation efforts. In an attempt to capture these improvements, this Water Research Commission (WRC) research project sought to compile a framework that is a user-friendly guide for implementing M&E for wetland rehabilitation in South Africa. *WET-RehabEvaluate* was used as the starting point for the improved framework, although significant changes were incorporated to address identified shortfalls. Once a draft framework was compiled, which reflected recent experience and research, it was assessed through an iterative process that applied the framework (or parts thereof) to eleven cases during a research process. Lessons learnt after each application were fed back into the framework development process. The case studies are referred to throughout the framework to provide practical examples of what is described in the framework. It is recommended that the framework be read in conjunction with the case study reports.

Purpose, overall structure and intended users of the framework

The purpose of this M&E framework is to provide structured guidance for M&E of wetland rehabilitation projects.

The framework comprises four components (**refer to Chapter 1 Figure 1.1**). The first two components, the key concepts and principles and criteria, underpin the framework. The step-by-step procedure is the core of the framework, which directs the user to a series of detailed modules for monitoring specific, important aspects relevant to wetland rehabilitation.

The technical requirements of applying the framework would depend greatly on the emphasis of the evaluation and the indicators selected for that project. Often, expertise may be required across several specific disciplines, including ecological, social and economic assessments as well as engineering input, therefore requiring a multi-disciplinary team. The framework has been designed for application by a range of different users, including the following:

- A programme, such as Working for Wetlands (WfWetlands), which intends to assess the ecological outcomes of the programme and wishes to improve its practice of wetland rehabilitation;
- A consultant required to check whether a rehabilitation project has attained specified rehabilitation outcomes, e.g. as specified in the mitigation and/or offset requirements of an approved development; and

- Managers who need to determine the contribution that a rehabilitation project may have made to the overall conservation goals within the landscape.

The rationale underlying the framework

The following suite of rationales form the basis for how the practice of wetland rehabilitation and M&E are understood within the framework, forming a "lens" through which wetland rehabilitation and M&E of wetland rehabilitation can be viewed. The following topics, explored in more detail in the main document, were included:

Understanding wetlands as social-ecological systems: A Social-Ecological System (SES) is a complex adaptive system whereby the ecological and socio-economic aspects interact with each other at multiple spatial and temporal scales. In SES cause-effect interactions are often non-linear, which means that M&E must include interventions (outputs) and outcomes and find ways to capture both the intended and unintended outcomes of rehabilitation interventions.

Resilience and its role in wetland rehabilitation: Resilience refers to the ability of a system to absorb disturbance and undergo change while retaining structure, functionality and feedback, thus retaining the ability to provide a similar magnitude and type of ecosystem service. Resilience is considered an important objective of ecosystem rehabilitation, where the goal of a resilience-based approach is not some fixed ideal or optimal state but rather flexibility. Designing for resilience requires that rehabilitation strategies focus on restoring natural geomorphic, hydrological and biological processes by which ecosystems maintain resilience. Once reinstated, these processes should allow the system to perpetuate in the desired state with minimal intervention from humans.

The value of ecosystems: Ecosystem rehabilitation implies a choice between alternatives, specifically whether to undertake rehabilitation or not. Any choice between alternatives implies some form of benefit valuation to ascertain which alternative would be more highly 'valued'. However, valuing ecosystems, and the contribution of rehabilitation, is challenging. Firstly, 'values' are often context specific and are influenced by the setting (cultural, institutional, economic, and ecological) within which they are expressed. Secondly, valuing the benefits of ecosystem rehabilitation requires relating the change in ecosystem condition to attributes that may be valued by society. The ecosystem services concept has emerged as a useful framework for articulating the relationship between ecosystems and human well-being. In an economic valuation, the economic value of an ecosystem service relates to the contribution it makes specifically to human financial well-being.

Adaptive Management: Adaptive management responds to the challenges of dealing with uncertainty when managing complex ecosystems, such as wetlands. Adaptive management can be broadly defined as a management approach which employs learning-by-doing in a systematic way as to allow for the adaptation of behaviour and overall management direction should new information become available. For the purposes of this document, the term adaptive management has been used in such a way as to be analogous with Strategic Adaptive Management (SAM). SAM is a management approach that combines the iterative learning dimension of adaptive management and the mutual learning dimension of adaptive, participatory co-management. This management approach aims to facilitate action with foresight and purpose, learning-while-doing, and engagement and empowerment of stakeholders. Strategic adaptive management provides a structured way for improving our understanding of a system through an iterative process of setting objectives, implementing management decisions and evaluating the implications of the outcomes for future decision making.

Adaptive: Lessons from adaptive management which may arise during and after rehabilitation implementation should be well communicated to project role players and stakeholders so that the project may adapt, improve and learn from both successes and failures. In addition, it is important that wetland rehabilitation project teams learn from one another across multiple projects, develop their capacity and improve the practice of wetland rehabilitation at both a project portfolio scale and more broadly.

An evidence-based approach: Evidence should be collected to determine how well wetland rehabilitation worked within different circumstances, providing the basis for learning what had/hadn't worked and why, and what interventions were likely to be most effective in which context.

Principles guiding M&E

While there is no single ideal recipe for carrying out M&E, the framework recommends the following general principles to guide the application of M&E:

Relevance: M&E should be planned and conducted with a view to serving the information and decision-making requirements of its intended users. Evaluation recommendations should flow logically from findings, be actionable and be presented in a clear and timely manner with the intention of incorporating results into learning and decision-making processes.

Accuracy and credibility: M&E should be conducted with the necessary expertise and be based on the principle of impartiality. Evaluations should be supported by evidence that can be appraised as to its accuracy, validity and reliability. Findings should be open to reporting strengths and weaknesses as well as what worked well and what did not.

Feasibility: M&E should be as practical and cost effective as possible. It should take into consideration time, financial and human resource requirements and have the support of the relevant governing bodies.

Participation, access to information and transparency: M&E should be conducted in a transparent manner with stakeholder participation and access to relevant information. In this regard, feasible stakeholders should be engaged and be afforded the opportunity to contribute to the evaluation process. The stakeholders' views should be reflected in the evaluation report in an impartial and balanced way. Those undertaking an independent evaluation should have unrestricted access to information of the concerned programme, project or undertaking that is subject to evaluation, including project documents; terms of reference; training material; beneficiary views; results of existing evaluations; and financial statements and reports, unless such information is considered to be sensitive and/or confidential.

Learning: Following participation, M&E should facilitate learning which brings people, from different backgrounds/disciplines, together in a 'safe space' to share knowledge and experience, and to further develop knowledge, ways of thinking and possibilities (i.e. social learning).

Propriety: M&E should be undertaken in a legal and ethical manner with regard to the rights and welfare of those involved in and affected by the assessments. Stakeholders contributing to evaluation processes should be made aware of the purposes for, and potential consequences of, the evaluation, and their consent should be sought prior to their taking part in any evaluation exercise.

Criteria against which to evaluate wetland rehabilitation

The framework presents the following criteria, which may vary depending on the particular situation, for evaluating wetland rehabilitation projects:

Appropriateness: The degree to which the project planning and implementation accounted for and responded to the context of the site.

Relevance: The extent to which the rehabilitation addressed the needs and priorities of the beneficiaries, the funding agent, mandated departments and other stakeholders.

Efficiency: The cost effectiveness of transferring inputs into outputs (the interventions) and outcomes, i.e. is it good value for money, taking into consideration alternative approaches/strategies? It is important to distinguish between output-efficiency and outcomes-efficiency, and to note that high efficiency in terms of outputs does not necessarily translate into high efficiency in terms of outcomes.

Effectiveness: The extent to which the project has achieved its stated objectives.

Impact: The outcomes of the rehabilitation project viewed from a long-term and/or broad-scale perspective, which may produce positive or negative, intended or unintended changes.

Adaptability: The degree to which the rehabilitation process served to strengthen the adaptive capacity of the stakeholders in terms of their ability to manage resilience of a system.

Sustainability: The sustainability of the functionality and/or benefits derived from the interventions in the rehabilitated wetland, which will continue in the long term following the completion of the interventions.

Resilience: The degree to which the project supports the resilience (or not) of the SES, while considering key drivers of system change

A step-by-step procedure

A key aspect of the step-by-step procedure of the M&E framework (**refer to Chapter 4 Figure 4.1**), which includes both formative and summative evaluations, is that M&E is an integral part of the entire rehabilitation project life cycle, from planning through implementation to aftercare. A formative evaluation refers to an evaluation that takes place before or during a project's implementation in order to improve the project's performance. A summative evaluation, on the other hand, refers to an evaluation that takes place once a project has been completed and reflects back on how well the project performed.

Once the key role players have been engaged and an evaluation brief prepared, the procedure begins with an evaluation of the initial conceptualization of the project, followed by a biophysical and social contextualisation of the site. Next the rehabilitation strategy, objectives and plan are evaluated, and revised where required, and a detailed plan for M&E of the project outputs and outcomes is developed, including the identification of suitable indicators. Guided by the M&E plan, implementation of the outputs is then evaluated, and finally the outcomes of this implementation are evaluated.

There are several feedback loops in the project cycle (**Chapter 4 Figure 4.1**) and results of the evaluation play a key role in deciding whether a feedback loop is required or not. For example, site contextualisation may reveal the need to reconceptualise the project, while evaluation of implementation may reveal the need to return to the rehabilitation plan and address shortcomings in the original designs. It may be that, in revisiting the designs, a further step back is required to revise the rehabilitation strategy. Thus, the evaluation process is not a single-loop, once-off practice, but may require one to go back and forth, in an adaptive way, during the course of the project cycle.

The extent to which the final summative evaluation feeds into another project cycle may vary. In a long-term programme, this would be expected to occur to a high degree, but less so in the case of a once-off project, e.g. as an offset required as part of the environmental authorisation for a single development. However, even in the latter example the regulating authority may derive important lessons from the project's evaluation which may, in turn, improve the manner in which future offset applications are handled.

All the M&E components in **Chapter 4 Figure 4.1** could potentially be applied to a new or current project. In such evaluations it can be seen that several of the initial steps in the project cycle (including the conceptualisation of the project, the selection of sites, the rehabilitation strategy and objectives, and the rehabilitation plan) are evaluated in a formative manner. These same components in the overall project are then potentially reviewed again during the summative evaluation at the end of the project. This review would specifically address questions of how effectively the plan was implemented (which generally relates to how the achieved outputs compare with the planned outputs) and how well the project addressed the original strategy and objectives (which generally relates to how the achieved outcomes compare with the intended outcomes). Finally, the review may return to the original conceptualisation of the project and the selection of the site/s in an effort to answer questions, such as whether or not it was a good idea to intervene at the site in the first place, referring to the results of all preceding summative evaluations, as well as taking a step back and scrutinising the relevance of the strategy and objectives themselves.

In some cases, a retrospective evaluation, the evaluation of an already complete project, may be required. In such cases, the summative evaluation steps described above would apply, but the formative evaluation steps undertaken during the project would not be possible because the project would have already been completed.

M&E is generally also required to determine if satisfactory aftercare is taking place and to identify any maintenance requirements timeously which may arise after completion of the project. Thus, although **Chapter 4 Figure 4.1** shows M&E of aftercare and maintenance taking place before the final summative evaluation, it is important to emphasise that aftercare and maintenance may be required to continue for many years after completion.

Detailed modules for M&E of specific aspects of wetland rehabilitation

The final component of the framework comprises a series of modules covering different aspects of M&E for wetland rehabilitation outputs and outcomes. While not exhaustive, it includes what were considered to be some of the key aspects.

Assessing the maintenance and adaptation requirements of a rehabilitation project: A wetland's period of recovery, which may require maintenance and aftercare activities, usually extends for many years beyond the so-called completion of the project. M&E is generally required to timeously identify any maintenance requirements before they develop into major, more costly, issues. The module provides a comprehensive checklist of specific integrity issues for a variety of different intervention types. For example, one of the checkpoints for gabion structures is the rusting through of gabion basket wire. Guidance is also provided for assessing the identified maintenance priority. This priority is based on the integrity issues as well as the context of the intervention's role in relation to all other interventions at a site (i.e. high vs. low priority structure). In addition to identifying maintenance requirements, the framework may assist in identifying adaptations to interventions in order to improve the effectiveness of the rehabilitation.

Assessing the engagement of stakeholders and land users in wetland rehabilitation and aftercare: A key aspect of how the rehabilitation is undertaken relates to the engagement of various stakeholders. It is recognised that sustaining the outcomes of wetland rehabilitation may be strongly dependent on those individuals (particularly the landholders) who would be responsible for the management thereof. Therefore, as part of the M&E of wetland rehabilitation outcomes, it was important to collect data to determine how the landholder perceives (1) the wetland and the wetland rehabilitation project; (2) his/her engagement in the rehabilitation; and (3) his/her responsibilities in relation to monitoring, aftercare and maintenance of the interventions and the wetland. This module provides a series of prompts to help guide a discussion with the landholder and some suggested methods for conducting discussions with stakeholders. Ultimately, the evaluator should attempt to develop an understanding of how well the landholder/owner is able to perform what would be expected of them in the aftercare period of the rehabilitation.

Valuing the outcomes of wetland rehabilitation: The valuation of wetland rehabilitation outcomes is concerned with well-defined changes in the ecosystem and the consequent changes to human well-being. It is the value associated with an incremental change in the ecosystem service/benefit as a result of the rehabilitation rather than the total value of the ecosystem that is being rehabilitated. This module provides a four-stage process to guide the economic valuation of the outcomes of wetland rehabilitation. Stage 1, the study specification, involves defining and contextualising the valuation assessment, including a delineation of the spatial and temporal boundary of the assessment. Stage 2, a system analysis, involves assessing the capacity of the wetland to provide the identified ecosystem services. Stage 3, an assessment of the demand for ecosystem services for both current and future (with rehabilitation) scenarios. Stage 4, involves the comparison of the supply and demand of priority ecosystem services for both 'with' and 'without' rehabilitation interventions. To better explain the four-stage process, examples derived from selected case studies have been included in the framework.

Assessment of wetland condition and ecosystem services provision: Evaluating the ecological condition (integrity) and the provision of ecosystem services is necessary during the site contextualisation and in the monitoring of the wetland rehabilitation outcomes. This module provides guidance for carrying out such assessments at a rapid level based on the WET-Health and WET-EcoServices assessment tools.

Additional technical guidance: Additional modules are included with guidance for monitoring vegetation, water levels and erosion in the rehabilitated wetland. Particular focus is on sampling the vegetation and the use of vegetation as an indicator of: (1) wetness using the Wetland Index Value (WIV), and (2) habitat integrity using the Floristic Quality Assessment Index (FQAI).

Conclusion and Recommendations for further research

The framework encourages the user to develop M&E as an integral part of the life cycle of the wetland rehabilitation project rather than only after implementation. The general process described begins with the evaluation of the initial conceptualisation of the rehabilitation project, followed by an evaluation of the context, rehabilitation strategy, objectives and plan. Thereafter, the implementation of the plan is evaluated and finally, the outcomes of this implementation are considered, firstly in relation to the strategy and objectives of the rehabilitation and secondly, the initial conceptualisation and selection of sites is evaluated in the light of the outcomes. Reporting is considered an important aspect of M&E and guidance is provided in this regard, as an integrated evaluation report serves to provide the reader with the evaluation's findings, supported by collected evidence.

The framework, developed as a set of principles and criteria, a step-by-step guide, and a series of modules for monitoring specific components of wetland rehabilitation, was designed to plan and implement M&E of projects with a focus on adaptive management. The user is cautioned against using the framework as a recipe and deviations from the prescribed steps are likely to be needed to accommodate the requirements of specific projects and objectives. Furthermore, the details of the modules for monitoring of wetland rehabilitation are also likely to change over time, especially if one considers that the WRC is currently funding amendments to WET-Health and WET-Ecoservices assessment tools.

The development of the framework highlighted the need to further understand the regional variation in the indicator status and coefficients of conservatism for wetland plant species to be used in the recommended indices. This could be achieved either through a focussed research project or through collation of expert opinion on a per project basis. With the continued interrogation of the Wetland Management Series, it is evident that WET-RehabPlan and WET-RehabMethods would both need to be updated in the short to medium-term to account for changes in the field of practice and to accommodate the adaptive management approach prescribed by the M&E framework.

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FEEDBACK

In order to have improved this framework, it was revised by including the experience of those individuals involved in wetland rehabilitation within South Africa, particularly practitioners who have applied the framework. Although this framework is considered to be sufficiently developed in order to be applied, any comments or suggestions may be sent to:

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ACRONYMS

Acronym	
AM	Adaptive Management
AWARD	Association for Water and Rural Development
BMP	Best Management Practice
DEFRA	Department for Environment, Food and Rural Affairs
DPSWR	Drivers Pressures State Welfare Response
DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EPA	Environmental Protection Agency
EPWP	Expanded Public Works Programme
FQAI	Floristic Quality Assessment Index
GEM	Greater Edendale Mall
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature
M&E	Monitoring and Evaluation
MEA	Millennium Ecosystem Assessment
NGO	Non-Governmental Organisation
PM&E	Participatory Monitoring and Evaluation
PVC	Polyvinyl Chloride
SAM	Strategic Adaptive Management
SASS5	South African Scoring System Version 5
SER	Society for Ecological Restoration
SES	Social-Ecological System
SMART	Specific, Measurable, Achievable, Relevant, Time-Framed
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Valuation
UNITAR	United Nations Institute for Training and Research.
VSTEEP	Values, Social, Technology, Economy, Environment, Political
WBCSD	World Business Council for Sustainable Development
WfWetlands	Working for Wetlands
WIV	Wetland Index Variation
WRC	Water Research Commission
WTA	Willingness to accept compensation
WTP	Willingness to pay

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1 INTRODUCTION

1.1 Background and purpose of the framework

Nearly two-thirds of the globe's ecosystems are considered degraded as a result of damage, mismanagement and a failure to invest and reinvest in their productivity, health and sustainability (McDonald et al., 2016). One of the globally accepted responses to this degradation is ecological rehabilitation, which is the process of assisting the recovery of a degraded ecosystem (Nelleman and Cocoran, 2010; McDonald et al., 2016). South Africa faces a number of challenges relating to water resources specifically due to semi-arid conditions, which are expected to be exacerbated by changing climate, continuing degradation of water resources and a rising demand for water and other ecosystem services. Wetlands are important features within the landscape due to the recognised ability of these systems to provide an array of ecosystem services, particularly services related to water quantity and quality. It is estimated that there has been a loss of between 35% and 60% of wetlands across the major catchments in South Africa, and of the remaining systems, 48% are classified as critically endangered making these systems the most threatened ecosystems (Nel and Driver, 2012).

The continued degradation of South Africa's wetlands is an issue that requires immediate consideration and action through wetland rehabilitation in order to minimise and/or mitigate any negative impacts of further degradation. Wetland rehabilitation refers to the practice of assisting in either (1) the reclamation (full or partial) of a degraded wetland's health, and thus the ecosystem service delivery by reinstating the natural ecological driving forces, or (2) preventing the further decline in health of a wetland by halting the degradation, so as to maintain its health and ecosystem service delivery (Kotze et al., 2007). The definition of (wetland) rehabilitation used in this publication includes the definition of (ecosystem) restoration, rehabilitation and repair as defined by McDonald et al. (2016). A wetland rehabilitation project refers to a set of interventions, both physical and management related, designed to achieve rehabilitation of one or more specific wetland sites.

Over the past decade or so, the implementation of rehabilitation initiatives has become more prevalent in South Africa. However, wetland rehabilitation, as a field of science and practice, has been largely undertaken for a period of less than 20 years in South Africa and the means by which success has been measured has proven to be problematic. These facts, together with a paucity of M&E activities, has led to a dearth of knowledge on the outcomes of rehabilitation projects implemented within the country. Furthermore, many rehabilitation initiatives have been reliant on international (mainly northern hemisphere) research findings to guide their design and implementation, even though novel knowledge and technologies have been developed in South Africa through rehabilitation projects (Russel, 2009). However, little of this has been documented and shared, nor has the validity thereof been tested. It is imperative that M&E techniques appropriate for South Africa be developed to support and strengthen the implementation and science of wetland rehabilitation in South Africa.

Monitoring and evaluation are two critical components within ecosystem rehabilitation projects, contributing to learning and improved practice (McDonald et al., 2016; Ramsar Convention Secretariat, 2002). While "monitoring" and "evaluation", which strongly support one another, tend to get grouped together as if they were a single activity they are, in fact, two distinct sets of activities.

According to Finlayson (2003), Butcher (2003) and the Water and Rivers Commission (2002), monitoring is the systematic collection of data based on observations and the measurement of change in response to a pre-defined state/objective/hypothesis. It is essential for the evaluation of the cause, means and extent of the ecological change, and can be used for the implementation of management requirements. As will be elaborated in Chapter 2, evaluation is also undertaken for specific elements in the planning phase, before any implementation. In terms of outcomes, evaluation is the comparison of what was achieved (and how this was accomplished) against the agreed pre-defined state/objective/hypothesis, and is usually based on the results of monitoring (Rutherford et al., 2000). Thus, monitoring and evaluation are most often usefully placed together in a framework where each supports the other in its objective.

It is important to note that M&E is a process that should be initiated at the outset of a wetland rehabilitation project, and is a continuous process of adaptive learning. Monitoring and evaluation can:

- Help timeously identify problems and their causes, particularly during the planning and implementation of a project;
- Help inform possible solutions to identified problems;
- Raise questions about assumptions regarding how the wetland is likely to respond to the rehabilitation strategy and the particular interventions employed;
- Support learning as it encourages one to reflect on where one is going and how one is getting there;
- Provide one with information and insights;
- Encourage one to act on the information and insight;
- Increase the likelihood that one will make a positive difference;
- Better assess and report on outcomes;
- Better account to funders; and
- Add to the body of scientific knowledge relating to wetland rehabilitation, thereby supporting and improving practice.

The planning, prioritisation and implementation of wetland rehabilitation within South Africa has often been focussed on achieving one goal: improving the ecological integrity of the affected wetland. However, through practice and advances in understanding of the system, it has been recognised that an ecological system is an extremely complex system and is also influenced by social and economic factors and should, therefore, be recognised as a social-ecological system (SES). Recognising this fact, a M&E framework would need to incorporate the social and ecological aspects of wetland rehabilitation within a South African context. In an attempt to consider wetlands as social-ecological systems and capture other suggested improvements (as described in Chapter 1.2 below), this WRC research project sought to compile a framework that is a user-friendly guide for implementing M&E of wetland rehabilitation in South Africa.

1.2 Improvements on previously published wetland rehabilitation monitoring and evaluation guidelines

When evaluating wetland rehabilitation projects, it is necessary to distinguish between outputs, which describe specific interventions (e.g. a gabion weir to control erosion), and outcomes, which are what the interventions are designed to achieve (e.g. major gully erosion halted in the wetland, thereby securing the integrity of an intact portion of the wetland under threat from erosion). This distinction was introduced in a South African context by *WET-RehabEvaluate* (Cowden and Kotze, 2009), a framework that was developed as a component of the WRCs Wetland Management Series (Dada et al., 2007) to guide the application of M&E during wetland rehabilitation projects at that time. With the increase in implementation of rehabilitation initiatives in South Africa since the publication of *WET-RehabEvaluate*, further experience and research (e.g. Cowden et al., 2013) has identified several potential improvements required for evaluating wetland rehabilitation efforts. These efforts should:

- Incorporate adaptive management into wetland rehabilitation projects, especially if corrective actions are required as a result of monitoring of project outputs. This should include the option to amend the original rehabilitation strategy and/or incorporate additional interventions to optimise system response.
- Place greater emphasis on the collection of a detailed measure of the effect of wetland rehabilitation on the delivery of ecosystem services, with more explicit guidance in accounting for ecosystem service delivery, including both the supply and the demand for the services.
- Promote the collection of detailed monitoring data, particularly vegetation, to highlight trends in system response over time and avoiding the situation where hectare equivalents are the sole means of showing the benefits of wetland rehabilitation. In this regard, promote the adoption of indices, such as Wetland Index Value and Floristic Quality Assessment Index described by Cowden et al. (2013), to assist in analysing and interpreting collected vegetation data.[1]
- Incorporate guidance for including an appropriate control area within the rehabilitated wetland or within a comparable wetland area nearby which has been subject to similar impacts to the area being rehabilitated but would not be influenced by the proposed rehabilitation efforts. This allows the monitoring programme to establish whether any measured changes are as a result of the rehabilitation interventions themselves rather than as a result of some external influence.
- Recognising wetlands as social-ecological systems requires the framework to incorporate aspects of ecological, social and economic influences on wetland rehabilitation within a South African context rather than to focus solely on ecological responses.
- Recognising the above, incorporate specific guidance for assessing the engagement of stakeholder/landholders in planning, implementation and aftercare of wetland rehabilitation, based in particular on revealing the perceptions of landholders, who generally have the most direct influence over the long-term sustainability of wetland rehabilitation outcomes.
- Further recognising the above, incorporate specific guidance for identifying the appropriateness of conducting an economic valuation and what key factors to account for in designing and carrying out such an evaluation.
- Include additional criteria and improved explanations of terminology for monitoring structural outputs.

[1] It should be noted that further research relating to these indices would still be required, including the derivation of regional wetland plant species lists with the indicator status and coefficients of conservatism recorded for each species as this was beyond the scope of this particular research project.

- Incorporate guidance in terms of considering if structural interventions are achieving their specific objectives (e.g. redirect surface flows) and thus contributing towards the overall project objectives.
- Incorporate guidance in terms of identifying and accounting for unanticipated consequences of the wetland rehabilitation interventions.

Although *WET-RehabEvaluate* was used as the starting point for the improved framework, *WET-RehabPlan* (Kotze et al., 2007), which provides a framework for wetland rehabilitation planning in South Africa, was also considered. Adapting one's approach relies on M&E to inform required changes, and as such, this research aimed to introduce a M&E framework that can be applied as a learning tool, becoming an integral part of the adaptive management cycle. This framework therefore attempts to apply evaluation more broadly to include site prioritisation evaluation and the assessment of the most appropriate, effective and efficient methods to be used to rehabilitate specific systems.

As highlighted by the abovementioned suggested improvements, it is important to recognise that, while rehabilitation interventions are designed to influence the ecological state of the wetlands, the rehabilitation takes place within a broader SES. Thus, M&E of wetland rehabilitation requires that relevant social and economic aspects be taken into account, and this framework aimed to provide some guidance in this regard. Monitoring and evaluation should take on a reflective approach which encourages the implementer to identify areas that should be strengthened for future applications and possible gaps in the rehabilitation approach. These gaps may limit, or may have limited, the success of a project. The process of reflection is somewhat incomplete without reporting on the lessons learnt. Documenting these lessons can often become tedious and uncomfortable, particularly in instances that require acceptance if an intervention failed. However, reporting where the issues arose and identifying the means to counteract these issues in the future is a necessary component to achieving adaptive, flexible and sustainable wetland rehabilitation.

Once a draft of the framework was compiled that reflected recent experience and research, the framework was tested and improved through an iterative process that applied the framework (or parts thereof) to 11 varying case studies. The two initial case studies (Deliverable 9) produced important lessons learnt that were fed back into the framework development process. The framework was subsequently modified in an iterative manner as the next nine case studies were completed (Deliverable 13). A synthesis of the 11 sites, including the lessons learned, are referred to in Appendix 1, however, it is strongly recommended that the framework be read in conjunction with the case studies (Deliverable 9; Deliverable 13).

1.3 An overview of the framework

The framework comprises four overall components (**Figure 1.1**). The first two components, the key concepts, and the evaluation principles and success criteria, underpin the framework. The step-by-step procedure, the third component, represents the core and directs the user to a series of detailed modules (the fourth component) with the relevance of each module varying according to the specific site/project.

The M&E framework aims to encourage the adoption of best practice as an integral part of the process from the outset. As indicated in the underlying rationale for the framework (Chapter 2), the guide was closely aligned with an adaptive management approach. The objectives and strategy of the rehabilitation project were critical in identifying the intended outcomes and indicators against which to monitor and evaluate rehabilitation activities. In addition, the guide prompts the user to take a step back to review the objectives and strategy in light of the wetland rehabilitation success criteria. This reflection would afford the assessor the opportunity to determine whether the rehabilitation efforts accounted for the drivers of degradation within the system or whether the rehabilitation objectives specified in the rehabilitation plan were overlooked during implementation.

A description of **the rationale underlying the framework**, which relates particularly to rehabilitation within the context of a social-ecological system and following a strategic adaptive management approach

A **set of practical principles and criteria** to guide the M&E of wetland rehabilitation

A **step-by-step procedure** to help assessors structure their assessment

A series of **detailed modules for monitoring specific key components** potentially relevant to wetland rehabilitation, including templates to assist in the collection of data

Figure 1.1: Key overall components of the M&E framework

1.4 The intended users of the framework

This framework has been designed to be implemented by a practitioner, or team of practitioners, with previous experience in the general assessment of wetland ecosystems. However, in many cases specialist expertise may be required across several specific disciplines. These may include ecological, social and economic assessments, as well as engineering input, thus requiring a multi-disciplinary team. The technical requirements of applying the framework will depend greatly on the particular emphases of the project, and the indicators selected for that project. It would therefore be inappropriate to prescribe the specific disciplines and level of expertise required by the assessor/s applying the framework.

The framework was designed for application by a range of different users, although it was envisaged that the Working for Wetlands (WfWetlands) programme would be one of the key users, as WfWetlands aims to use wetland rehabilitation as a vehicle for both poverty alleviation and to encourage the wise use of wetlands. As with any ecosystem rehabilitation programme, there is a need for WfWetlands to provide information and feedback regarding the nature and success of their operations. In addition to WfWetlands, the following users of the framework are envisaged:

- Any programme that intends to assess the ecological outcomes of the programme and wishes to improve their practice of wetland rehabilitation;

- A consultant required to check whether a rehabilitation project has attained specified rehabilitation outcomes, e.g. as specified in the mitigation and/or offset requirements of an approved development;
- Managers of state conservation land who need to determine the contribution that a rehabilitation project has made to overall conservation goals;
- Managers of private land;
- Non-governmental organisations (NGOs); and
- Authorities that may stipulate rehabilitation as part of an environmental authorisation and who may therefore specify certain monitoring requirements.

In a South African context, it is often the case that the planning, implementation, monitoring and evaluation of wetland rehabilitation is undertaken by the same practitioner or consultant. While this is 'undesirable' in terms of impartiality of the evaluation, it can often lead to improved project outcomes as adaptive management decisions are informed by a direct understanding of the project objectives. In addition, project history, to inform the evaluation, is readily available (even if poorly documented). As such, it is important that an objective means of monitoring and evaluating wetland rehabilitation and suggested reporting requirements are available to practitioners. In addition, it is important to recognise that data and information generated by application of the framework may have potential use beyond wetland rehabilitation. Of particular note is their potential contribution to the National Wetland Monitoring Programme. Thus, the framework sought to facilitate links with this programme, for example, by advocating the programme's structured manner for reporting on individual indicators.

1.5 Rehabilitation M&E: Completed versus new projects

The framework has been designed to evaluate 'completed' wetland rehabilitation projects and to guide the application of M&E in projects that are yet to be implemented or planned (new projects). Completed projects may require a review of the rehabilitation plan in order to identify the rationale for the approaches implemented, and the aims and objectives of the rehabilitation, should these not have been clearly stated. It should be noted that, in some regards, the wetland rehabilitation planning process may have changed fundamentally over the past few years, and as such the evaluation of an existing project should take into consideration best practice at the time of the project planning and implementation. In comparison, a new project allows for best practice to be integrated into the wetland rehabilitation from the outset, guided by both the WET-RehabPlan (Kotze et al., 2007) and the M&E framework. However, given that wetland rehabilitation best practice continues to develop, once a project has been implemented and time allowed for ecological outcomes to be achieved best practice may have advanced significantly since the project inception.

1.6 Worked examples

As mentioned previously, as part of developing the framework it was applied to 11 sites (**Table 1.1**), which provide practical demonstrations of the use of the M&E framework. Users of the M&E framework are referred to in Appendix 1, which was summarised from Kotze and Cowden (2018) and Cowden et al. (2018) where these cases are described in detail. In addition, the M&E framework itself makes several references to these cases in the text in order to illustrate different aspects of the framework.

Table 1.1: Overview of the 11 sites included in the evaluation (Deliverable 13; Deliverable 9)

Wetland Name	Province	Method used	Land use Context
Manalana	Mpumalanga	Wetland ecosystem service valuation Wetland ecological integrity and functioning	Communally-owned land bordering the Kruger Park
Greater Edendale Mall	KwaZulu-Natal (KZN)	Wetland ecological integrity and functioning Water quality Vegetation	Private retail development
Baynespruit	KZN	Review of site selection criteria	Municipal land within an urban setting
Dartmoor	KZN	Rehabilitation intervention maintenance and adaptation Land owner engagement	Privately-owned conservation area
Hlatikulu	KZN	Rehabilitation intervention maintenance and adaptation	Privately-owned commercial agriculture
Kromme River	Eastern Cape	Water levels	Privately-owned commercial agriculture
Kruisfontein	KZN	Landowner engagement	Privately-owned commercial agriculture
Monontsha	Free State	Rehabilitation intervention maintenance and adaptation	Municipal land within a peri-urban setting
Xharas wetland	Northern Cape	Wetland ecological integrity Wetland functioning Wetland ecosystem service valuation	Community land utilised for livestock grazing
Riverhorse Valley	KZN	Rehabilitation intervention maintenance and adaptation Wetland ecological integrity and functioning Vegetation	Commercially-owned private open-space within an urban setting

2 THE RATIONALE UNDERLYING THE FRAMEWORK

The concepts discussed below form the basis of how wetlands and wetland rehabilitation were considered in the framework. That is, the concepts form the theoretical understanding or a “lens” through which wetland rehabilitation, and the M&E of wetland rehabilitation, may be viewed. The level to which each of these concepts applies to the M&E process will depend on the aims and objectives of the particular project, as well as the social and biophysical context of the rehabilitation site. The underlying rationale described in this section was used, together with M&E best practice and practical experience with wetland rehabilitation, to identify key principles for wetland rehabilitation M&E, which are given in Chapter 3.

2.1 Understanding wetlands as social-ecological systems

A Social-Ecological System (SES) refers to a complex adaptive system in which the ecological and socio-economic aspects interact with each other at multiple spatial and temporal scales (Walker and Salt, 2006). A SES’s view of complex ecosystems recognises a number of characteristics that are not observed in simple systems, including non-linearity, uncertainty, emergence and self-organisation. These characteristics have implications for the management of environmental systems (Berkes, 2004). Traditional management is based on a linear cause-effect approach, whereby management seeks to reduce natural variation to enhance system productivity, predictability and controllability. However, loss of natural variation negatively impacts on the resilience of a system and its ability to respond to a crisis (Berkes, 2004). Non-linearity means that monitoring and evaluation must find ways to capture both the intended and unintended outcomes of an intervention. This requires monitoring of both the interventions (outputs) and outcomes of the interventions (Cundill and Fabricius, 2009).

Incorporating humans into the ecosystem requires an increased understanding and knowledge of ecosystem processes to effectively manage these systems (Berkes, 2004). Social-ecological systems are therefore defined as human-coupled ecosystems with an emphasis that humans must be seen as a part of, not apart from, nature and that the delineation between social and ecological systems is artificial and arbitrary (Holling et al., 1998; Walker and Salt, 2006). An important part of the social dimension of SESs is human well-being. Therefore, a key part of understanding a SES is to understand the relationship between well-being and the ecosystem. This may include how the social context of the SES influences the use of the ecosystem, thereby influencing the ecosystem services provided and the benefits of these services for human well-being. These relationships are elaborated upon in the following section.

Many wetland systems feature human-environment relationships where humans strongly influence wetland biophysical processes and characteristics while deriving benefits from them (MEA, 2005; Schuyt, 2005; Ten Brink et al., 2013). Thus, wetlands are typical considered social-ecological systems (Gunderson and Light, 2007; Walker and Salt, 2012). Social ecological systems are increasingly understood as complex adaptive systems (Levin et al., 2013) due to the unpredictable non-linear way in which these systems react to disturbance (Cumming and Collier, 2005; Levin, 1998; Walker and Salt, 2012). Furthermore, due to the complexities and unpredictable nature of these systems, there is often much uncertainty in managing them (Holling, 2001; Allen et al., 2011).

Management of complex adaptive systems, such as wetland ecosystems, therefore requires reflexivity and learning processes that allows for diverse people, with different perspectives, knowledge and experiences to be brought together to co-develop new and creative solutions (Wals et al., 2009) to address the wetland management issues being faced (see Chapter 2.3). Thus, there are no readymade solutions and people who influence the biophysical processes of SESs are often responsible for the development of management or rehabilitation solutions.

2.2 Adaptive management

In response to the challenges of dealing with uncertainty when managing complex ecosystems, such as wetlands, Holling (1978) put forward the notion of 'adaptive management'. The definitions of adaptive management range from a learning-by-doing through trial and error approach to active adaptive management using scientific experimentation that elicit results used to inform future management decisions (e.g. Kingsford et al., 2011). Adaptive management provides a structured way for improving our incomplete understanding of a system through an iterative process (**Figure 2.1**) of setting objectives, implementing management decisions and evaluating the implications of their outcomes for future decision making (Keith et al., 2011; Holling, 1978, 2001; Roux and Foxcroft, 2011). Explained further, in the words of Rogers and Biggs (1999:440), "The essence of adaptive management is that it treats management actions as potential learning opportunities that can feed back more reliable information to improve decision making".

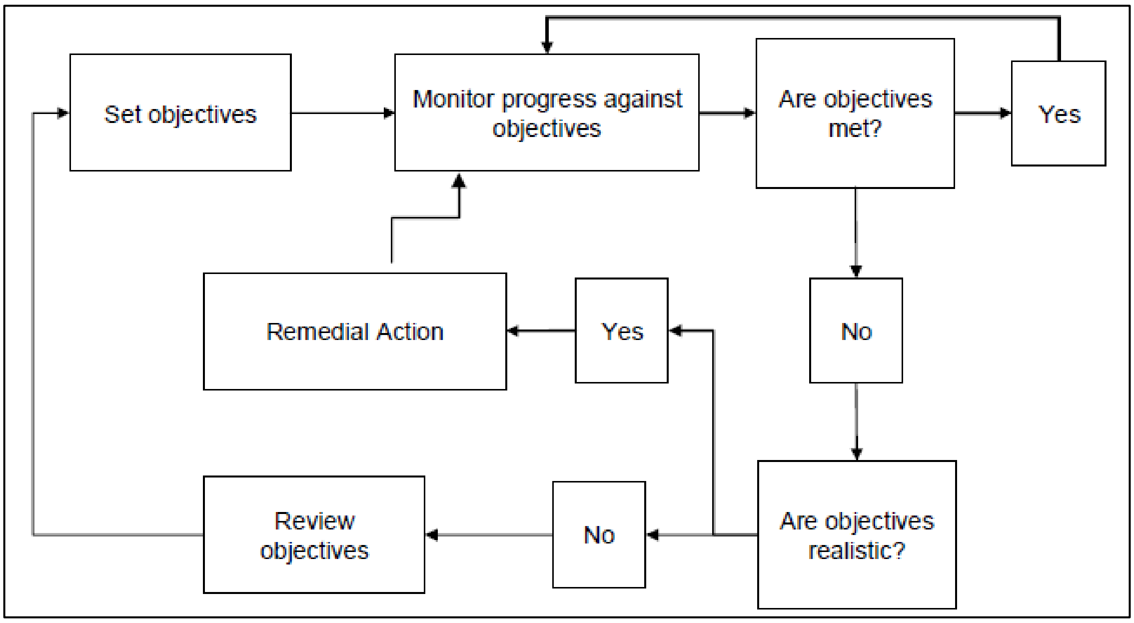


Figure 2.1: Adaptive Management: How the monitoring of 'progress against objectives' can be used to prompt remedial action or to review objectives to set more realistic ones if necessary (Adapted from Levendal et al., 2008)

The benefits for wetland rehabilitation created by stakeholders' learning in an adaptive management process, are evident. Adaptive management have inherent opportunities for learning that can result in better decision making, collaboration and practices. However, there is a need to ensure an understanding of how people learn, drawing on suitable learning theory in order to effectively facilitate adaptive management learning opportunities.

2.3 Learning as a means to strengthen practice

To continuously improve the practice of wetland rehabilitation in South Africa, and to minimise the risk associated with inherently uncertain environmental systems that arises from imperfect information about system response (Doremus, 2007; Keith et al., 2011) and system responses to new conditions (e.g. climate change), wetland project teams need to learn from project experiences. The recognition of the uncertainty of complex environmental systems has highlighted the need to develop approaches to undertake appropriate action.

The introduction of adaptive management provides a framework to facilitate learning. Learning, and particularly social learning theories, make a contribution to the framework. According to Keen et al. (2005:3205), social learning refers to the "collective action and reflection that takes place amongst both individuals and groups when they work to improve the management of the interrelationships between social and ecological systems". However, there is often a clear disconnect between what is required in terms of best practice and what is being implemented. Before social learning can be implemented, it needs to be determined what social change is, its dynamics and the role that social learning could potentially play in supporting environmental sustainability (Cockburn et al., 2015). The foremost consideration to understand is that social learning is directly related to social change; thus, without a sustainable approach to social learning, the changes required to protect livelihoods and environments will be limited.

To encourage active and collective learning, participants from different backgrounds should be urged to share experiences, knowledge and conflicts to develop an integrated understanding of the social-ecological context of the landscape (Cockburn et al*.,* 2015). Importantly, social learning should not focus on *what* people need to know, but rather on *how* people can collectively learn from each other's experiences. Social learning should be used as a tool to engage people who will deliberatively and collectively determine a course of action (Hiestermann, 2015).

Learning for improved wetland rehabilitation should be facilitated on two scales: the project scale and the programme scale. On a project scale, the Strategic Adaptive Management (SAM) approach should be applied, which involves contextualising the project site (conditions and threats), developing a set of aims and objectives to address the threats and developing a monitoring plan. The results of the data collected during and after rehabilitation implementation should be communicated to all stakeholders so that the project may adapt, improve and learn from both successes and failures (Salafsky et al., 2002). Learning at the programme scale should involve pooling the knowledge learnt and the tools used across multiple wetland rehabilitation projects so that wetland rehabilitation teams can learn from one another, develop their capacity, undertake effective wetland rehabilitation and improve the practice of wetland rehabilitation (Salafsky et al*.,* 2002).

The inclusion of adaptive management in the planning, management and monitoring phases associated with a M&E project is important to safeguard the success of a project. Since adaptive management aims to achieve a learning-by-doing approach it is important to: (1) determine what may have caused the project to fail, and (2) readdress suggested interventions and the project goals and outcomes. If project goals and outcomes have not been met, it does not necessarily mean that the project has failed. An ecological failure may be regarded as a learning success. However, this will require that the implementers correctly identify some of the causative factors that led to a perceived failure.

A learning success is as valuable in adding insight into the weaknesses in rehabilitation implementation. However, a learning success can only be a viable option provided that one willingly admits failures and openly communicates results in order to understand the reasons for project failure and to learn from the weaknesses in the implementation (Kondolf, 1995). Both failures and successes work towards improving system management and intervention processes (Bash and Ryan, 2002). Encouraging learning within complex social-ecological systems provides a means to understand how adaptive and resilient a system can be (Pollard et al., 2009). Learning has a vital role in ensuring that feedback loops have an impact on self-regulation and that self-organisation becomes a fundamental component of supporting the development of resilient, sustainable systems (Pollard et al., 2009).

2.4 Assessing the value of ecosystems

Ecosystem rehabilitation is regarded as an elective (optional) action (Clewell and Aronson, 2006), implying a choice between alternatives (whether to undertake rehabilitation or not). As with all choices, the decision to undertake (or enforce) ecosystem rehabilitation is informed by a particular set of values (Clewell and Aronson, 2007). These values stem from the ecological, socio-cultural and economic values of the ecosystem as well as the personal value systems and goals of the decision-maker (both as an individual and on behalf of society or a specific organisation) (Clewell and Aronson, 2007; Gómez-Baggethun et al., 2014). Any decision between competing alternatives implies some form of benefit evaluation to ascertain which alternative is more highly 'valued' (Costanza, 2000).

Rehabilitation: "1) the recovery of a degraded wetland's health and ecosystem service delivery by reinstating the natural ecological driving forces or 2) halting the decline in health of a wetland that is in the process of degrading, so as to maintain its health and ecosystem service-delivery" (Kotze et al., 2008:14). A system that is rehabilitated is not expected to be restored back to its reference state/benchmark.

Restoration: the action of intervening within a wetland habitat to achieve the reference or benchmark state (in terms of ecosystem processes, productivity, services and biological integrity).

In the context of ecosystem rehabilitation, it has been argued that there is a growing need to identify and value the benefits to society of rehabilitation activities to inform decision-making (Turner et al., 2003; de Groot et al., 2006; Bateman et al., 2011) and as a means of justifying increasing investment (often of public funds) in ecosystem rehabilitation (Weber and Stewart, 2009; Aronson et al., 2010; Pendleton and Baldera, 2010; Blignaut et al., 2013). Ecosystem valuation information is therefore regarded as being influential in promoting the conservation and management of ecosystems (Laurans et al., 2013). The underlying assumption is that ecosystems are valuable to society, that values influence our individual and collective decisions and that information about ecosystem value would be used in, and therefore guide, decisions towards more and better ecosystem conservation (Laurans et al., 2013). Several authors have noted that little attention has been given to how ecosystem management decisions are made and to what arguments are effective in promoting ecosystem conservation (Laurans et al., 2013; Primmer et al., 2015).

2.5 An evidence-based approach

Evidence-based feedback and decision making requires an understanding of system processes and mechanisms, and what worked and what didn't. This understanding should be used to inform management actions in order to achieve desired outcomes and identify gaps that need to be rectified (Day, 2008). Without evidence, decision-making is at risk of being poor, with limited opportunity to evaluate the evidence for effectiveness of different management options (Pullin and Knight, 2003).

Pullin and Knight (2001) developed a framework for evidence-based conservation that may be applied to the wetland rehabilitation M&E framework. Pullin and Knight (2001) suggest five steps that support evidence-based decision-making:

1. Ask answerable questions;
2. Appraise the evidence provided;
3. Modify action in response to the evidence;
4. Monitor and evaluate the new action; and
5. Actively disseminate knowledge and share learning.

3 GENERAL PRINCIPLES FOR MONITORING AND EVALUATION AND SUCCESSES CRITERIA FOR WETLAND REHABILITATION IN SOUTH AFRICA

While there is no single ideal recipe for carrying out M&E, some common key principles can be identified. The following principles, adapted from UNITAR (2012), are recommended by this framework to guide the application of M&E for wetland rehabilitation.

Utility: M&E should be planned and conducted to serve the information and decision-making needs of its intended users. Evaluations must be evidence-led, and recommendations should flow logically from findings, be actionable and be presented in a clear and timely manner with the intention of incorporating results into learning and decision-making processes.

Accuracy and credibility: M&E should be conducted with the necessary expertise and be based on the principle of impartiality. Evaluation should use appropriate data collection and analysis, and be supported by evidence that can be appraised as to its accuracy, validity and reliability. Findings should be open to reporting both strengths and weaknesses, as well as what worked well and what did not.

Feasibility: M&E should be as practical and cost effective as possible, taking into consideration time, financial and human resource requirements, and have the support of the relevant governing bodies.

Participation, access to information and transparency: M&E should be conducted in a transparent manner with stakeholder participation and access to relevant information. Where feasible, stakeholders should be engaged and contribute to the evaluation process by providing their views. These views should be reflected in evaluation findings in an impartial and balanced way. Consultants, and others undertaking independent evaluations, should have unrestricted access to information of the concerned programme, project or undertaking subject to evaluation. This information may be available from project documents; terms of reference; training material; beneficiary views; results of existing evaluations; and financial statements and reports, unless such information is considered to be sensitive or confidential.

Social learning: Following participation, M&E should not only encourage learning but should encourage learning which brings together people from different backgrounds/disciplines in a 'safe space', to share knowledge and experiences, and to develop new knowledge, ways of thinking and possibilities (i.e. social learning).

Propriety: M&E should be undertaken in a legal and ethical manner with regard to the rights and welfare of those involved in, and affected by, the assessments. Stakeholders contributing to evaluation processes should be made aware of the purpose and potential consequences of the evaluation, and their consent should be sought prior to their taking part in any evaluation exercise.

It is essential to emphasise that the relative importance of the above principles may vary depending on the particular situation. For example, the relative importance may depend on the context of the site being rehabilitated and the objectives of the rehabilitation project.

In addition to the above principles relating to the application of M&E, **Table 3.1** presents general criteria for evaluating wetland rehabilitation projects. These projects are generally comprised of a set of rehabilitation interventions undertaken at one or more individual wetland sites. For wetland rehabilitation, "interventions" refer to outputs which are designed to achieve wetland rehabilitation outcomes (e.g. the installation of an erosion-control weir (intervention) designed to halt the advance of an erosion headcut (outcome) through a wetland). Again, the relevance of these different criteria may vary depending on the particular situation. It is evident that there is a degree of overlap for several of the criteria (**Table 3.1**), and in some situations only a few of the criteria might be used to assess a project. The evaluation reports on each criterion by providing a finding, supported by evidence/data collected during the project implementation and aftercare, for each.

Table 3.1: Criteria for evaluating the success of rehabilitation projects (adapted from Palmer et al., 2005; UNITAR, 2012; Speed et al., 2016)

Criteria	Additional notes
Appropriateness: The degree to which the project (and how it was planned and implemented) responded to the socio-ecological context of the site	In evaluating the project and its interventions, it is important not to see the site context in narrow biophysical terms alone but more broadly as part of a dynamic SES.
Relevance: To what extent did the rehabilitation project address the priorities of the targeted beneficiaries, and the priorities of the funding agent, mandated departments and other stakeholders?	It may be challenging to identify who exactly the targeted beneficiaries are, particularly those benefiting from the indirect ecological benefits supplied by the rehabilitated system (e.g. downstream beneficiaries of enhanced water quality).
Efficiency: The cost effectiveness of transferring inputs into outputs (the interventions) and outcomes (i.e. is it good value for money), taking into consideration alternative approaches/strategies.	When assessing efficiency, it is important to distinguish between output-efficiency and outcomes-efficiency, and to note that high efficiency in terms of outputs does not necessarily translate into high efficiency in terms of outcomes.
Effectiveness: The extent to which the project has achieved its stated objectives	The scope and subject of the objectives may vary considerably from one site to the next. Effectiveness needs to be considered in conjunction with appropriateness.
Impact: The outcomes of the project interventions viewed from a long-term and/or broader-scale perspective, which may produce positive or negative, intended or unintended changes	This is closely related to effectiveness, but is generally considered over broad spatial- and long temporal-scales. This is often assessed from a broader point of view, removed from the specific objectives of the project, in a sense allowing the objectives themselves to be scrutinised.
Adaptability: The degree to which the rehabilitation process served to strengthen the adaptive capacity of the stakeholders. Adaptive capacity refers to the ability of the actors (people) within the system to manage resilience (Walker et al., 2004; Walker and Salt, 2010).	Adaptability is as a sub-component of resilience.
Sustainability: The benefits derived from the rehabilitated wetland will continue in the long term after their completion.	Sustainability is strongly affected by several of the above, including appropriateness, relevance and adaptability. In some instances, this often requires ongoing management aligned with the rehabilitation

Criteria	Additional notes
	objectives to address disturbance drivers (e.g. urban and agricultural areas).
Resilience: The degree to which the project supports the resilience (or not) of the SES, while considering key drivers of system change. Resilience refers to the ability of a system to absorb disturbances, while retaining its structure and function, and providing a similar quantum of ecosystem services.	This is closely related to sustainability, and may be considered as the unifying criteria used to assess sustainability.

It is important to emphasise again that the applicability of the possible criteria given in **Table 3.1** will vary greatly depending on the project or programme, with some criteria likely to be more widely applicable than others. It is anticipated that relevance, effectiveness and sustainability of the project are three criteria likely to be widely applicable.

Cowden et al. (2018) and Janks et al. (in Deliverable 13) demonstrate the application of the evaluation criteria (**Table 3.1**) in case studies and provide, as much as possible, an interrogated evaluation of their respective rehabilitation sites.

4 THE STEP-BY-STEP PROCEDURE

The core of the framework, namely the step-by-step guide (**Figure 4.1**), was designed to plan and implement M&E of wetland rehabilitation projects. Nonetheless, the adaptive approach to the framework allows deviation from the prescribed steps according to the requirements specific to the project and site/s. Thus, the framework has not been designed to be implemented as a 'recipe'.

A key aspect of the step-by-step procedure (**Figure 4.1**) is that M&E is not something which only happens after implementation but should rather be an integral part of the entire rehabilitation project life cycle (Nilsson et al., 2016). From **Figure 4.1** it is evident that the process begins with the evaluation of the initial conceptualisation of the rehabilitation project, followed by an evaluation of the context, rehabilitation strategy, objectives and plan, which can also be referred to as a clarificatory evaluation. Next, the implementation of the plan is evaluated, also referred to as a process evaluation. Finally, the outcomes of this implementation are evaluated, firstly in relation to the strategy and objectives of the rehabilitation (usually in terms of effectiveness and efficiency) and secondly, the initial conceptualisation and selection of sites is evaluated in the light of the outcomes (usually in terms of appropriateness of the rehabilitation project).

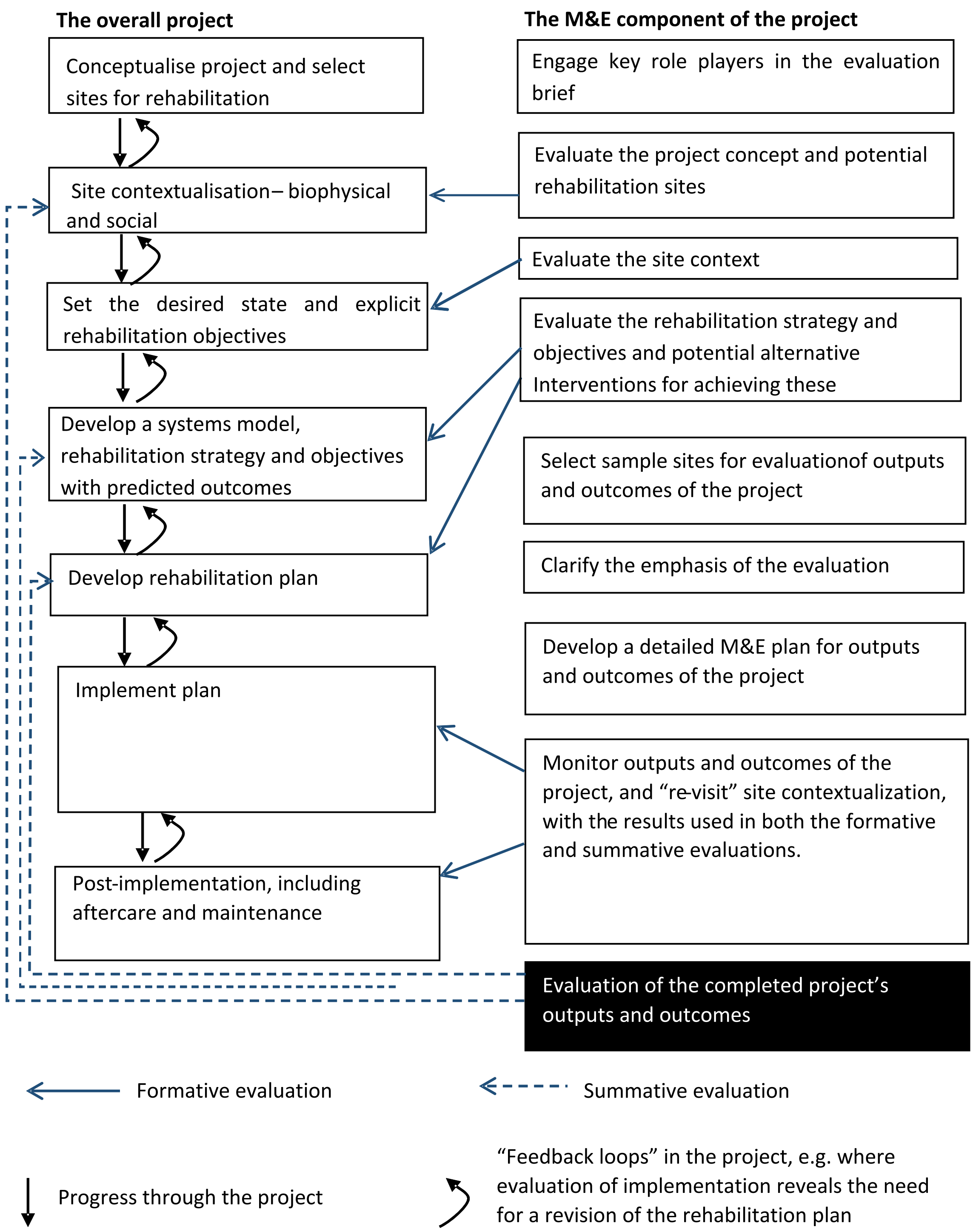
Figure 4.1 shows several feedback loops in the project cycle, and it is important to emphasise that the results of the evaluation play a key role in deciding whether a feedback loop is required or not. For example, site contextualisation may reveal fundamental problems with the governance of a site selected in the previous step, therefore requiring one to return to the site selection process in order to identify an alternative site. In another example, evaluation of implementation may reveal an important shortcoming in the intervention designs given in the rehabilitation plan (e.g. as a result of the site now receiving increased storm water), therefore requiring that the project cycle return to the plan and revise the designs, taking into account what has been learnt in the evaluation. Feedback loops may sometimes move back more than one step. For example, it may be that in revising the designs it is revealed that a further loop back is required to revise the rehabilitation strategy. Thus, as recommended by Nilsson et al. (2016), the evaluation process is not a single-loop, one-time practice, but instead evaluation can go back and forth in an adaptive way throughout the course of the project cycle.

Initially as a project is being conceptualised, planned and implemented, evaluation is primarily formative but following implementation it generally becomes more summative (**Figure 4.1**). Nevertheless, when viewed within the context of a long-term programme, even a summative evaluation of a project has a strongly formative aspect to it in that the evaluation has a key role to play in informing the way that the next project cycle will be implemented. Thus, the final evaluation of outcomes provides key guidance when entering the next overall cycle of a rehabilitation project. The final evaluation informs questions such as whether further rehabilitation project/s are appropriate and where they should be focussed given the evaluation findings from previous cycle/s. It is important to note that the extent to which the final summative evaluation feeds into another project cycle may vary depending on the situation. In a long-term programme this would be expected to occur to a high degree, but less so in the case of a once-off project. However, even in the latter case, the regulating authority to which the evaluation is reported may derive important lessons from the project's evaluation which can be applied to future offset approvals, thereby improving the manner in which offsets are handled when authorising development applications.

Figure 4.1 shows that the baseline information on the biophysical and social context of the site, collected during site contextualisation, is used to inform the strategy, objectives and rehabilitation plan, and is therefore located within the overall adaptive management project cycle. However, it also contributes to the M&E baseline, and given that the context may change over time, it is evident from **Figure 4.1** that the contextualisation may be revisited later in the M&E process.

Figure 4.1 distinguishes between (1) the selection of sites which are chosen for rehabilitation (the second step in the overall project cycle), and (2) the later selection within those chosen sites of which site/s is to be the focus of M&E (i.e. the sample sites). For example, it may be that 10 sites are chosen for rehabilitation, however, there are only adequate resources available to focus M&E on three of these as chosen sites and thus resources need to be focussed on the sites with the greatest M&E requirements and opportunities for learning. Alternatively, the project team may wish to focus M&E on those sites with the greatest potential for rehabilitation and likelihood of meeting the objectives (e.g. to show that mitigation and/or offset targets have been met).

Figure 4.1: Monitoring and Evaluation (M&E) as an integral part of an adaptive wetland rehabilitation project cycle



All of the M&E components in **Figure 4.1** potentially apply to a new/current project. In such evaluations it can be seen that several of the initial steps in the project cycle (including the conceptualisation of the project and selection of sites, the rehabilitation strategy and objectives, and the rehabilitation plan) are evaluated in a formative manner. These same components in the overall project may potentially be reviewed again during the summative evaluation process at the end of the project. This review would specifically address questions of how well the plan was implemented (which generally relates to how the actual outputs compare with the planned outputs) and how well the project addressed the original strategy and objectives (which generally relates to how the actual outcomes compare with the intended outcomes, as reflected in the strategy and objectives of the project). Finally the review may return to the original conceptualisation of the project and the selection of the site/s in order to address questions such as whether or not it was a good idea to intervene at the site in the first place, referring to the results of all of the preceding summative evaluations, as well as taking a step back and scrutinising the relevance of the strategy and objectives themselves.

In a retrospective evaluation of a completed project, the summative evaluation steps described above may be undertaken, but the formative evaluation steps undertaken during the project would not be possible as the project would have already reached completion.

Figure 4.1 illustrates that aftercare and maintenance are generally required once implementation of a rehabilitation project is complete in order to reinforce the completed project interventions. This is because a wetland's period of recovery usually extends years beyond the completion of the implementation phase of the project and therefore, any amendments to, or maintenance of, interventions may only come to light years after the completion of the rehabilitation interventions. Maintenance activities are generally much less costly than the original interventions. However, if issues requiring maintenance are not attended to timeously, they can develop into major issues with the potential to undermine the rehabilitation activities, which could become very costly to address. Thus, M&E is often pivotal in timeously identifying any maintenance requirements which may arise after completion of the project, especially where the risks to the interventions are high. Although **Figure 4.1** shows M&E of aftercare and maintenance taking place before the final summative evaluation, it is important to emphasise that they will often be required to continue well beyond this, potentially requiring an extension of the monitoring programme.

4.1 Step 1: Engage role players

Engaging the role players is aimed at identifying those who are/were actively involved in the project and determining their roles in terms of the wetland rehabilitation project. For completed projects, this may include the wetland rehabilitation planners and implementers, who may assist in determining why certain rehabilitation approaches were adopted. This information may be used during the evaluation process. For a new project, engaging with the rehabilitation planners is beneficial to document their thinking and approaches to understand the systems in which rehabilitation has been planned. This process is not aimed at 'pointing fingers' but rather it is undertaken to improve the competency of the project participants and encourage the sharing of experiences with all those to be involved in the project.

However, the evaluation process can become a very stressful experience for the organisation involved. It may be that the project team are quick to get defensive when discussing their work and the issues they faced and this in turn may result in them holding back potentially important information, which could compromise the evaluation process (Cowden and Kotze, 2009). Therefore, the evaluation should be approached in a positive light, as a learning experience to improve best practice and identify weaknesses in the approach as a whole. The most beneficial way of achieving this is through face-to-face meeting/s (typically referred to as pre-evaluation meeting/s) with those who were involved with the project. From experience, it has been noted that although it is often tempting to include only upper levels of management, it is important to consider individuals at lower levels since they are often more involved with the 'on the ground' work and may have an integrated understanding of the operational issues experienced throughout the project (Cowden and Kotze, 2009).

4.2 Step 2: Develop an evaluation brief

An evaluation brief is an overview of what is expected in the evaluation, including its purpose and scope, and the type of evaluation required. The brief assists in guiding both the evaluation and the communication regarding the evaluation. Although the specific content and format of the brief may vary depending on the organisation and the context of the evaluation, it should generally include reference as to how decisions will be made, during both the evaluation as well as thinking ahead in terms of how the evaluation findings are to be incorporated into decisions (Better Evaluation, 2018).

As discussed in Chapter 1.5, a distinction is made between a new project and a completed project. Completed projects, which in many cases may not have involved any formal M&E, would generally adopt a retrospective evaluation of the completed rehabilitation. New projects should however include M&E from the outset as an integral part of the rehabilitation project.

As part of the project brief, it is important to identify whether the emphasis of the evaluation will be formative or summative. A formative evaluation refers to the continued collection of data used to inform management decisions going forward and adjusting the project where it seems necessary. In a formative evaluation a wide focus on both the outputs (and details of implementation) as well as the outcomes is generally required. Summative evaluations refer to an assessment of the overall results and provide an overview of all changes that may have occurred within the system in a systematic way (Harlen and James, 1997). Therefore, in a summative evaluation when addressing the question "Did the project achieve what it set out to do?" the focus will be on the outcomes. In addition, when dealing with questions of why projects did (or did not) achieve their objectives in the summative evaluation, one is required to examine the outputs, implementation, and in some instances, the planning process.

It is noteworthy that, although development of the evaluation brief is represented as a step following the engagement of role players and pre-evaluation meeting/s, it is likely to be an important topic of such meeting/s.

4.3 Step 3: Select the sample site/s to assess

The process of selecting sample site/s will be dependent on (1) the nature of the project, and (2) whether there is one or multiple rehabilitated wetlands for evaluation. In many cases numerous wetlands require evaluation within a specific catchment or project area, but only a few can be assessed with the available resources. In carrying out the selection, it is important firstly to capture explicit criteria for selection of sites. If the focus of the assessment is what a programme has achieved overall, then some form of random selection will generally be required. However, if a formative evaluation is aimed primarily at improving practice, then the sites should be selected where the most valuable lessons could be learnt. Several criteria are proposed to assist in this selection of individual wetland sites (**Table 4.1**). In those instances where wetland rehabilitation has been undertaken as a condition of authorisation processes, site selection may be driven by the need to show the authorities that the mitigation and/or offset objectives have been met by focussing on those systems that achieve the objectives.

Table 4.1: Possible criteria to be used in the selection of wetlands for M&E (modified from Kotze and Macfarlane, 2014)

Criteria for selection	Rationale
Good reference/control areas are available	Wherever possible, a reference/control area should be sought which is inherently similar to the rehabilitated site but lacks rehabilitation interventions.
Sufficient time available to conduct a baseline survey before implementation of rehabilitation interventions	It is preferable to have started the monitoring at least a year before the interventions are put in place in order for before-and-after comparisons to be made.
New methods or contexts are being applied	The need is greatest to assess the outcome of new rehabilitation methods, approaches (notably "soft options") and/or contexts as opposed to those which are "tried-and-tested". Nonetheless, it is acknowledged that it may be useful to examine some of the assumptions underlying the tried-and-tested methods and approaches.
Good existing data is available for the site	Data are generally costly to collect from scratch. This includes data relating directly to the rehabilitation as well as supplementary data, e.g. weather data. Thus, all other factors being equal, a wetland which is in close proximity to a weather station with good long-term data would be preferable to one which lacks any such data. In the case of retrospective evaluations, a sound evaluation can best be made where good wetland information was collected during the initial rehabilitation planning process. At a minimum, this includes a wetland assessment report with an associated wetland rehabilitation plan. The availability of fixed-point photography and additional supporting data should also inform site selection.
Clear rehabilitation outcomes have been identified	Clearly articulated rehabilitation outcomes are required in order to identify a "target" against which change in ecological condition can be assessed.
Good learning opportunities are likely at the site	This includes situations considered likely to be successes as well as those considered likely to be failures, based on an initial subjective judgement.
Good opportunities for partnerships exist at the site	Recognising the high demand that monitoring has for resources, sites are preferable where partners are able to share responsibility for funding and carrying out and/or overseeing the monitoring.
Accessibility and cost	All other factors being equal, wetlands which are easily accessible and less costly to assess should be given preference. Nonetheless, it is recognised that in order to meet some of the other criteria it will be necessary to include some less accessible and more costly sites.

Criteria for selection	Rationale
Sufficient time has passed since the rehabilitation was completed	For those wetland rehabilitation projects with ecological outcomes reliant on ecosystem response, before the evaluation is undertaken, it is preferable to have an extended period of time (>5 years) having lapsed since the rehabilitation was completed.
Availability of the rehabilitation planners and implementers to participate in the evaluation process	Availability of the project team involved in the planning and implementation of the wetland rehabilitation allows queries and points of clarity to be easily addressed. In some instances, adaptive management and/or modified objectives may not have been documented and the availability of the project involved provides an opportunity to obtain relevant information.

4.4 Step 4: Site contextualisation

Site contextualisation is one of the most vital steps given that it provides a detailed description of the key ecological and social factors affecting the SES. Site contextualisation also provides good data to use when evaluating causative factors and what conditions may have contributed to a project's success or failure. Furthermore, this process assists in identifying relevant stakeholders and other role players who should be incorporated, from the point of site selection for new projects, in the M&E process. Site contextualisation provides an informed understanding of the social-ecological context of the site and identifies the drivers/indicators of change in terms of the social, ecological and economic components. Through such understanding it becomes possible to identify areas of potential risk and the viability of rehabilitation initiatives, which may also begin to guide the basis on which baseline data for monitoring can be determined.

Contextualisation is scale-dependant, generally requiring that different tools be used at different scales. An example of a tool which is potentially useful for broad-scale contextualisation is the Driver-Pressure-State-Welfare-Response (DPSWR) model (**Figure 4.2**). This tool is advocated by the National Wetland Monitoring Programme (Sustento Development Services, 2016) and provides a potentially useful basis to begin developing a conceptual model of the system of interest.

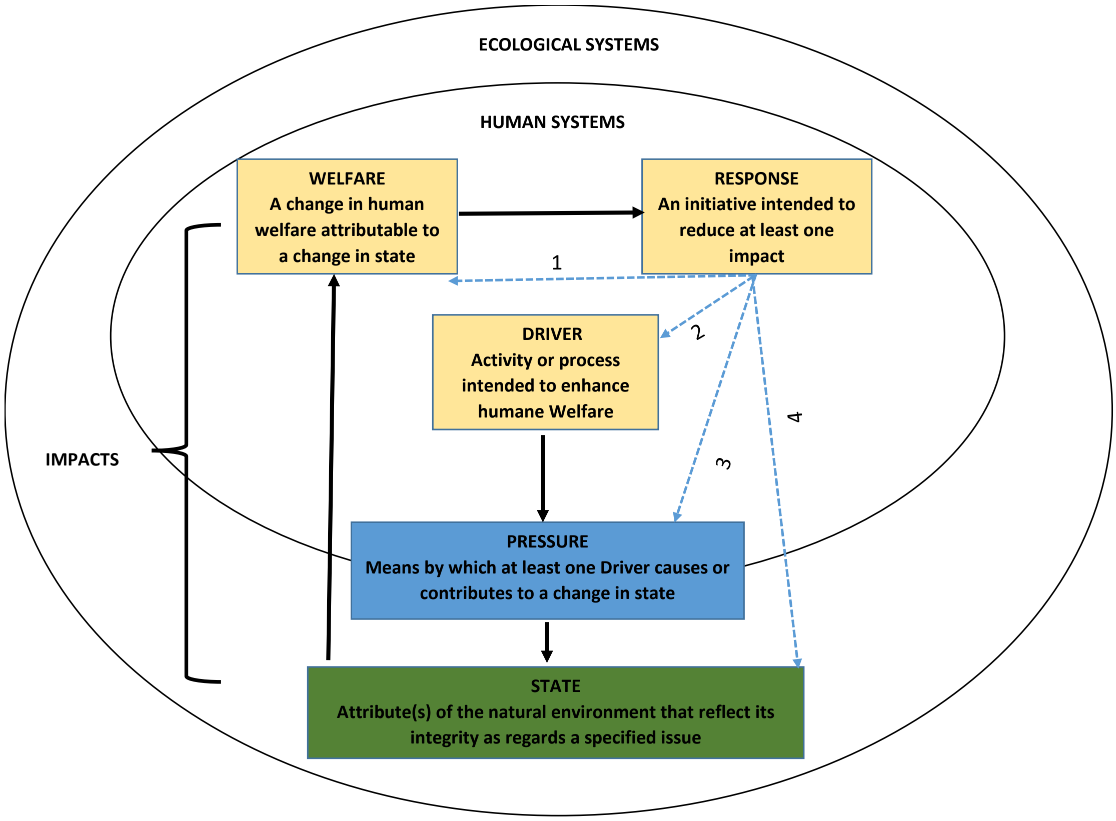


Figure 4.2: Outline of the DPSWR framework (modified from Cooper, 2013 and Spangenberg et al., 2015) with responses including 1 = Adaption, 2 = Prevention, 3 = Mitigation and 4 = Ecosystem rehabilitation/restoration

From **Figure 4.2** it can be seen that ecosystem rehabilitation, which represents only one of the responses directed at the state of the ecological system, may be one of several other required responses, e.g. directed at drivers and pressures. An understanding of how the social-ecological system "works" and how the different components are causally linked is likely to assist in deciding where in the system to intervene and how it will potentially affect the trajectory of the system. This will therefore affect where change is anticipated to happen and in what direction it is likely to change. This, in turn, will help inform what needs to be monitored and what indicators or attributes could best be used as proxies for change.

The 'VSTEEP' tool, which is a relatively new tool and often applied at a local scale, has proved to be a useful means of determining a contextual understanding of the Value, Social, Technical, Economic, Environment and Political drivers that underpin the functioning of the systems. This tool looks at whether wetland users and associated stakeholders have the social capital and governance systems to support ecosystem rehabilitation. The process will help people to envisage how they fit into the "bigger picture" or broad social-ecological context in relation to the perspectives of others (AWARD, 2014). Each of these drivers require a site-based interrogation and the types of questions and approaches that should be taken has been explained in detail below:

- Value:
    - Identify the benefits that the system is providing to the community (e.g. provision of ecosystem services supporting livelihoods); and
    - Assess the sustainability of this use in terms of the resource being affected.

- Social:
    - Identify the breadth of stakeholder engagement and determine whether all relevant stakeholders have been included;
    - Identify stakeholder willingness to engage and learn in future;
    - Determine whether there are mechanisms in place that control degradational activities within the affected systems (e.g. over-grazing, over-harvesting);
    - Assess how the effect of use on the wetland's environmental condition affects local livelihoods, and goods and services supplied by the wetland;
    - Identify the social structure, distribution of resources and distribution of power;
    - Determine the level of cooperation amongst the different parties;
    - Identify the reliance of the local people on the natural resources provided by the wetland; and
    - Identify the benefits that the system supplies to the local people.
- Technical:
    - Identify the management plan/rules that have been stipulated (if any) to ensure the protection of the wetland/s. This will inform whether any resources have been allocated to the managers of the wetland and the commitment and capacity for the managers to protect the wetland resources;
    - Has the manager responsible for the wetland achieved the stipulated management goals (e.g. does the wetland get burnt as frequently as stipulated in the management plan?);
    - Identify the various wetland rehabilitation outcomes and the rules and/or management that has been implemented to sustain these; and
    - Determine the frequency and degree of detail required for monitoring purposes.

- Environmental:
    - Assess the effect of the current uses and practices on the environmental condition of the wetland;
    - Use tools such as WET-Health (MacFarlane et al., 2009) and WET-EcoServices (Kotze et al., 2009) to assess the functioning and integrity of the wetland;
    - Determine the drivers of degradation;
    - Determine whether the wetland is part of formal protection (e.g. RAMSAR); and
    - Develop an explicit understanding of how the system works and document the evidence that supports that understanding. This allows one to then test that understanding and improve it as the rehabilitation measures are applied.
- Economic:
    - Retrieve facts about un/employment, housing and agricultural practices for the area as recorded by Statistics SA. This data provides an indication of the level of economic activity in terms of employment, number of dependants and household characteristics.
    - Identify priority ecosystem services associated with the wetland rehabilitation and determine whether economic valuation is appropriate and/or feasible (refer to Chapter 5.3). Considerations may include affordability, data availability, and available time frames to undertake processes that would allow for valuing the identified ecosystem services and benefits.
- Political:
    - Includes the process of stakeholder mapping, power and influence; and

- Assess any evidence of the mechanisms for controlling inappropriate activities, i.e. the role of authorities in making decisions.

Appendix 2 provides an indication of the types of questions and/or considerations which may be taken into account when undertaking VSTEEP. For completed projects, a retrospective VSTEEP is recommended to determine the social-ecological and economic characteristics of the site at the time of rehabilitation planning, in addition to undertaking a VSTEEP at the time of the evaluation.

Although site contextualisation may become an extremely onerous task if done comprehensively, it can prove to be extremely beneficial throughout the M&E process, particularly as it provides a comprehensive overview of the site and defines areas of risk while answering questions about the site that would be required later regardless. The relative importance of the components examined in the contextualisation will vary depending on the particular project or situation. This, in turn, will influence where the resources for carrying out the contextualisation should be focussed. For example, certain wetlands (e.g. in private land) will have simple tenure arrangements, which may be easily described, while others may be more complex, requiring more resources to gather the required information. Therefore, the area of emphasis for a VSTEEP assessment (or any other similar site contextualisation process) should be developed in accordance with the conditions specific to the site.

The site contextualisation data, and particularly any challenges around the wetland rehabilitation, should be shared with identified stakeholders and discussed in a facilitated space. This will aid in the verification of the data with the stakeholders and further strengthen their social learning. If practical, the identified stakeholders should also be brought together to collaboratively develop a common vision and objectives for the rehabilitation and monitoring**.** Awuah et al. (2018) provide an example of the evaluation of multiple candidate wetlands as part of a planning process while Cowden et al., 2018 demonstrate the importance of a changing context to the sustainability of already completed rehabilitation project (ten and four years since completion respectively). The latter two case studies demonstrate the importance of site contextualisation after a significant time period had passed since the completion of the rehabilitation projects. Both evaluations discovered significant changes to the context of the rehabilitation that threatened the ongoing functioning of the rehabilitation and thus the services enhanced by the rehabilitation of the wetland and as such prompted remedial action to address the threats.

4.5 Step 5: Review the rehabilitation objectives and strategy

The specific criteria used for reviewing the rehabilitation objectives and strategy are likely to vary depending on the project (see **Table 3.1**). Generally, however, this step addresses the question of whether the rehabilitation strategy and objectives adequately account for the key drivers affecting the wetland (how the wetland works) and the context of the wetland. Having undertaken a comprehensive site contextualisation, a reasonable understanding of the wetland system should have been attained, including the processes driving change and the factors impacting upon the system. It should be noted that this should also consider long-term drivers (e.g. fire and flood regimes), and thus contextualisation is key to undertaking the review.

According to Woodhill and Robins (1998) and Rutherford et al. (2000), the rehabilitation objectives, which provide a useful point of reference on which to build the rehabilitation strategy and plan, should be specific, measurable, achievable, relevant and time-framed (SMART). If the objectives are too vague it is not possible to review them properly. The rehabilitation strategy describes how the rehabilitation project intends to achieve the desired outcomes, without providing unnecessary detail about the specific interventions. It comprises a narrative, usually accompanied with maps and/or diagrams, describing the anticipated system response to the interventions (drawing from the contextualisation).

In some projects it may be necessary to compare the evaluation of alternative strategies against each other to identify which is likely to be the most effective/resilient/sustainable at a particular site. In other projects it may be necessary to compare the evaluation of the strategies and anticipated outcomes of different sites against each other, particularly where a specific rehabilitation objective applies across all of the sites, e.g. wetland rehabilitation to promote greater assimilation of pollutants in a particular catchment.

The review of the rehabilitation strategy may reveal that the objectives are insufficiently explicit, requiring that they be revised. In a retrospective assessment, if the objectives and strategy were poorly articulated or were not documented then it may be possible to contact the original rehabilitation planners to see if they are able to clarify these. This may be achieved through interviews and meetings with the respective rehabilitation planners, which may inform the evaluation at a later stage.

4.6 Step 6: Review the rehabilitation plan

The rehabilitation plan describes, in detail, the dimensions, materials, construction sequence, etc., of all of specific interventions required to carry out the strategy and achieve the objective/s. As described previously, for the purposes of M&E, the rehabilitation plan should include clearly defined objectives. Therefore, a key question to address in the review of the plan is whether the specific interventions were appropriate/effective at achieving the objectives. The review could also examine whether the plan accords with known best practice in terms of content of the plan and the process through which the plan was developed. Here refer to WET-RehabPlan (Kotze et al., 2009), which provides a comprehensive, step-by-step process for developing and undertaking wetland rehabilitation, based on the foundations of the general principles of wetland rehabilitation.

To encourage the co-development of the rehabilitation plan, the proposed plans should be circulated to all stakeholders involved in the project, ensuring that there is a common understanding of the anticipated system changes that may occur as a result of the rehabilitation. It is often necessary to explain the rehabilitation to the landowner and users to ensure that they have a comprehensive understanding of the intended outcomes of the rehabilitation. The rehabilitation plan should also identify those stakeholders who would be responsible for the long-term monitoring and maintenance of the wetland once the implementation of the rehabilitation has been completed. This is essential to ensure that any risks to the sustainability of the rehabilitation are identified. In some cases, this can be secured when the rehabilitation has been formalised as part of an environmental authorisation process, which should stipulate who should be involved in the management and monitoring of the wetland rehabilitation.

As indicated, when reviewing a rehabilitation plan, it is important to examine the content of the plan as well as how the plan was developed. There are numerous questions that can be asked to guide the evaluation. These should include:

- Were the strategy and objectives clearly stipulated?
- Were the strategy and objectives appropriate for the dynamics of the wetland system from a socio-ecological perspective (i.e. congruent with the prevailing hydrogeomorphic and social dynamics of the site)?
- Were the strategy and objectives relevant to the funder and beneficiaries?
- Did the rehabilitation plan include a set of stakeholders who assisted in the co-development of the rehabilitation?
- Were landowners and all land users informed about the rehabilitation and its implications for land use?
- Did the rehabilitation plan include a management and monitoring section, stipulating the type and level of monitoring that should be undertaken as well as clearly stipulating the person/s responsible for the monitoring? and
- Did the rehabilitation plan include a description of what the planners understood were: (1) the key biophysical and social drivers and attributes affecting the system; and (2) how the rehabilitation project intends to account for these drivers and how the system is expected to respond to the rehabilitation interventions?

The majority of these questions are often not reported on but may have been an integral aspect of the rehabilitation. Therefore, if this is the case, it may be necessary to contact the original rehabilitation planner/implementer to determine through an interview process the details that were not recorded. Further guiding questions, with a particular emphasis on aftercare, are provided in Chapter 5.2, and may also have relevance to this step.

4.7 Step 7: Clarify the specific emphases of the evaluation required

In Step 2, the broad type of evaluation was identified (i.e. a formative evaluation or a summative evaluation). Now the specific emphases of these evaluations need to be identified by referring to the contextual information (especially that relating to risks and opportunities) collected in Step 4 (site contextualisation) and the objectives and strategy reviewed in Step 5 (rehabilitation strategy). For example, if in the site contextualisation step of a formative evaluation it was identified that uncontrolled livestock movement posed a threat to the wetland and efforts to rehabilitate the wetland, then a strong emphasis on implementation monitoring may be required to ensure that the livestock do not impact on the integrity of the structures. Specifically, monitoring may be required to control this movement, particularly during implementation and shortly thereafter (when the wetland would be most vulnerable). Another example might be in a summative assessment of a project, where the reinstating of a target area of wetland was undertaken in order to meet the legal obligations of a development with offsets. In this example, a strong emphasis would be on assessing the overall ecological condition of the wetland for the pre- and post-rehabilitation scenarios, understanding the required outcomes to meet the offsets, and liaising with the role players.

When clarifying the purpose and the particular emphasis of the evaluation, it is generally important to inform all role players involved in the pre-evaluation meetings and provide them with opportunity to comment.

4.8 Step 8: Develop a detailed plan for monitoring rehabilitation outputs and outcomes

Having identified the broad type of evaluation in Step 2 and the specific emphasis of the evaluation in Step 7, a detailed M&E plan now needs to be developed. This will generally comprise the following key elements:

- Identify appropriate indicators, which reflect the intended outcomes;
- For each indicator, explicitly describe its relevance and, where appropriate, identify the threshold level of concern/success;
- Decide on frequency, interval and timing of monitoring;
- Decide on the sampling techniques to be used;
- Assign responsibilities for carrying out the sampling and reporting; and
- Determine budgets and funding source/s.

The above elements apply to ongoing M&E as well as retrospective evaluations, except that deciding on frequency, interval and timing of monitoring would not apply to a retrospective assessment. Key differences between a retrospective evaluation and ongoing M&E is that the retrospective evaluation lacks the purposeful collection of data before implementation of the rehabilitation and then at intervals thereafter. Nonetheless, in a retrospective evaluation there will often still be data available describing the pre-rehabilitation conditions, even though this may not have been collected specifically for monitoring purposes. Ecological condition assessments and photographs taken for planning purposes are often available, and it may also be possible to interview individuals with good local knowledge of how the site used to look prior to rehabilitation. Aerial photos and satellite imagery pre-dating the rehabilitation could also be sourced, but their usefulness will depend on the resolution of the imagery and the scale of change taking place within the wetland.

The above elements may need to be repeated. For example, it may come to light, at the end, that an inadequate budget was available and therefore the sampling techniques or the indicators would need to be revised in order to identify appropriate approaches and/or indicators that are less data-intense. A critical element of the plan is to know which indicators need to be measured in order to determine whether the intended outcomes have been achieved. This is best carried out by first referring to the rehabilitation objectives and emphases captured in Step 5 and 6, respectively. Next refer to the general guidelines given below to help in the selection of indicators which are appropriate and reliable.

The investment required in monitoring will depend strongly on the type and purpose of the data (how the data will be used) and thus the confidence one would have in the findings. In its strictest sense, adaptive management refers to a rigorous process where sound planning and experimental design are linked to a systematic evaluation process which links monitoring to management. Contrary to this, in its most loose sense, it can refer to a learning by doing approach that features a monitoring (or data collection) system based on observations and anecdote (Allen et al., 2016).

There is a continuum of complexity, need for expertise and cost from the observational and anecdote-based monitoring (learning by doing) through to the experimental design-based monitoring associated with adaptive management (**Figure 4.3**). Monitoring changes in vegetation composition as a consequence of rehabilitation can, for example, be done adequately through a before and after sampling. However, to be certain that the effects observed are a consequence of rehabilitation a replicated sampling coupled to a control site may be required. The former may be adequate for management purposes but the latter would be required from a "scientific certainty" perspective. The cost and effort difference between the two may be significant. The above therefore illustrates the importance of carefully considering what monitoring is required for any given rehabilitation project as the technical skill and resources required for monitoring can vary greatly.

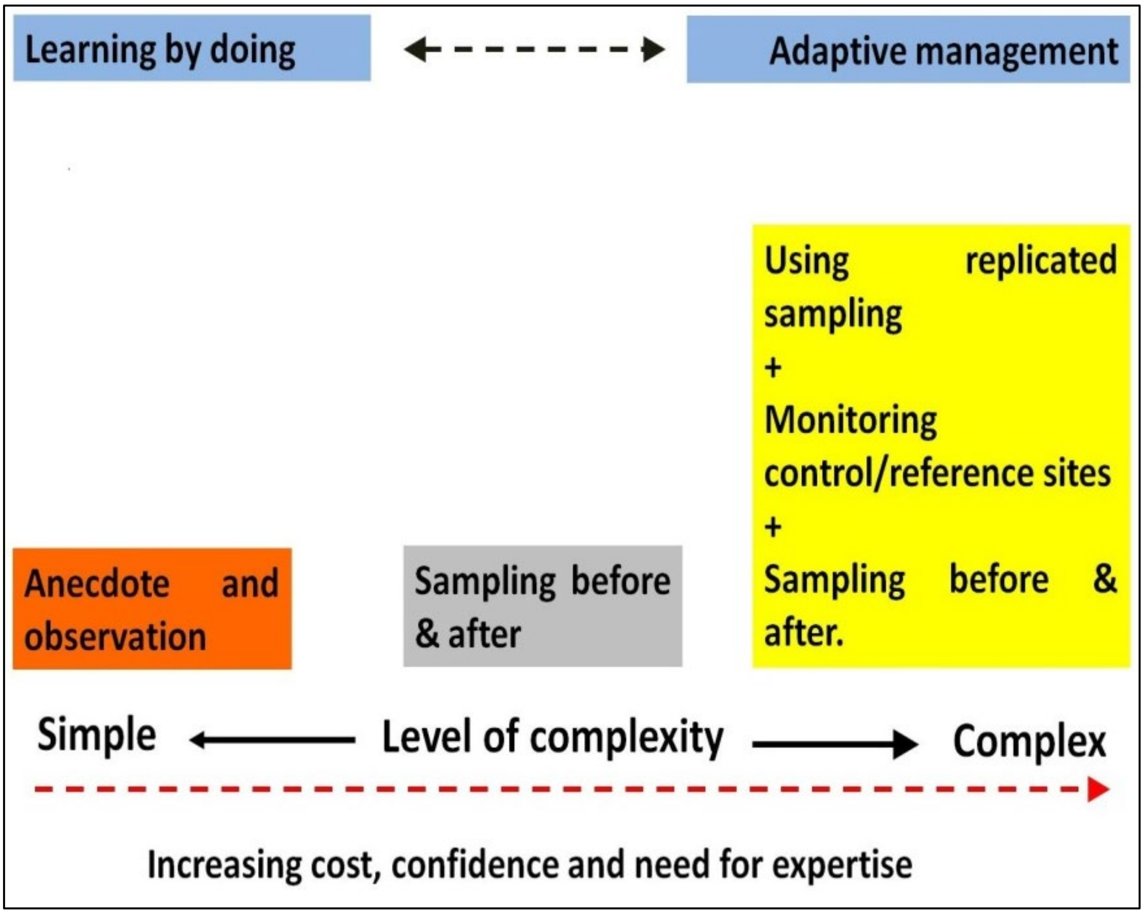


Figure 4.3: The continuum in the level of complexity between the learning by doing and adaptive management strategies

4.8.1 4.8.1 Guidance in structuring a monitoring programme for wetland rehabilitation in South Africa

Figure 4.4*Figure 4.4* provides guidance in structuring a monitoring programme for wetland rehabilitation in South Africa. Tier 1 (**Figure 4.4**) is the minimum monitoring that a rehabilitation project requires and consists of the two aspects, namely the structural integrity and functioning, and the landowner engagement and aftercare. Tiers 2 and 3 are strongly recommended while Tier 4 is discretionary and the application thereof would depend on the objectives of the project.

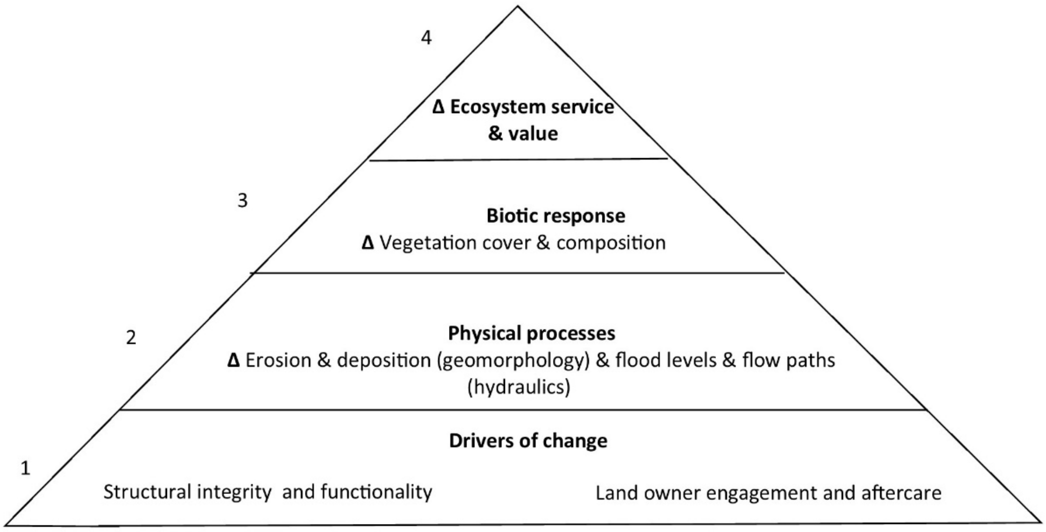


Figure 4.4: A schematic representation of the recommended monitoring focus for South African wetland rehabilitation projects

The first aspect of these guidelines (**Figure 4.4**) is monitoring of the integrity and functionality of the intervention used in the rehabilitation project and the second aspect is land owner engagement and aftercare. These two aspects form the foundation to additional monitoring of change within the wetland. The integrity and functionality of assessment of rehabilitation interventions provides the departure point for response monitoring in the wetland. Should the interventions be constructed and located according to the rehabilitation plan then the first step in halting or reversing degradation should be in place. The functionality part of the intervention assessment has significant overlap with Tier 2. The intervention functionality assessment is concerned with gathering evidence that the structure (or suit of structures) is, from a functional point of view, doing what it is meant to do. Examples of functions which structures may attempt to provide include, but are not limited to, trapping sediment, impounding water and diverting surface water flows (see Chapter 5 for more details). The Hlatikulu case study by Eggers et al. (in Deliverable 13) illustrates the application of the method and its results.

Landholder (and stakeholder) participation in ecological restoration projects is important to ensure the success of restoration in the long term (Cowling et al., 2008; Reed, 2008; Urgenson et al., 2013). The landholder engagement and aftercare seek to ascertain how the landholder perceives the rehabilitation project and their responsibilities in relation to monitoring, aftercare and maintenance of the rehabilitation interventions in the wetland. Chapter 5 provides an approach for assessing land holder engagement and the case studies by Walters (in Deliverable 13) and Janks and Cowden in Cowden et al. (2018) provide worked examples of the application of the method in two different contexts. Both reveal the importance of landowner engagement to the long-term success of wetland rehabilitation projects.

The second tier considers the physical responses of the wetland to the rehabilitation interventions and build on the findings of Tier 1 (specifically the structural integrity and functionality. In South Africa, rehabilitation interventions are often aimed at creating change in wetland hydrology and geomorphology (Russell et al., 2009). Typically, hydrologically focussed interventions impound water in gullies or drains in order to raise water tables while also seeking to direct surface flows in a desired direction – for example, towards a historically desiccated part of a wetland. From a geomorphic perspective, interventions generally seek to stabilise headcut and bank erosion, and capture and store sediment. These physical effects are dependent on the correct functioning of the interventions (assessed in Tier 1) and can be monitored at various resolutions. An example of suitable methods to monitor changes in geomorphology and hydrology are provided in Chapter 5 of this document. A case study by De Haan et al. (in Deliverable 13) provides a detailed assessment evaluation of the hydrological outcomes of rehabilitation of Companjesdrif area of the Kromme River wetland.

Tier 3 is focussed on the biotic response within the wetland that can be attributed to the rehabilitation interventions. Typically, in South Africa, the emphasis is placed on changes in the wetland vegetation community. An example of this is a focus on the changes brought about in a wetland vegetation community as a consequence of rehabilitating the wetland hydrological regime such as when an area of previously drained wetland is restored to its natural patterns of saturation and inundation with a concomitant change in vegetation from terrestrial to wetland species**.** See Kotze et al. (2018) for examples monitoring the change in wetland vegetation communities as a consequence of rehabilitation. It is important to note the importance of suitable baseline data (i.e. pre-rehabilitation), allowing quantitative comparisons post-rehabilitation, irrespective of the degraded condition or disturbance of the site prior to the rehabilitation activities.

Finally Tier 4, which is unlikely to be utilised frequently in South Africa due to resource constraints, involves monitoring changes to the ecosystem services and their value. Chapter 5 provides a detailed discussion about the valuation of ecosystem services and the case studies of Walters and Browne in Cowden et al. (2018) and Kotze and Browne in Kotze et al. (2018) demonstrate the application of ecosystem service and valuations.

An important feature of the monitoring triangle is that starting at the base and working upwards, each subsequent tier relies on and is supported by evidence collected by the previous tier. The integrity and functionality of interventions provides the basis to the physical response to those interventions which in turn supports to the biotic response and lastly, all the aforementioned provide evidence and support to measuring changes in ecosystem service provision due to biotic and physical responses to the interventions in the wetland.

4.8.2 Select indicators

An indicator is a measurement of impacts, outputs and outcomes that may be monitored before, during and/or after rehabilitation implementation to assess the progress towards the project objectives (Convertino et al., 2013). Selecting indicators should always be site/project specific and will depend on the nature of the project objectives, and in most instances, would be informed by the site contextualisation. Dale et al. (2000) refer to this as 'principle of place', reiterating that every habitat has a relationship with the surrounding landscape and site-specific data should therefore be interpreted within spatial and temporal perspectives (Innis et al., 2000). Indicators should be easily measurable, be sensitive to stresses on the system, demonstrate predictable responses to stresses, and be integrative (Palmer et al., 2005).

The selection of indicators is essential to the overall success of any monitoring program. These indicators need to capture the complexities of an ecosystem yet remain simple enough to be readily and routinely monitored. In order to create a sustainable environment, the management efforts of a wetland rehabilitation project need to be based on the assessment of all relevant factors influencing it. This requires incorporating both physical and social data (Sullivan and Meight, 2007). Social indicators may sometimes be more indicative of a process rather than an outcome. Examples of such indicators could include understanding that certain rehabilitation problems are made up of many ecological variables; better understanding of the site's history and context; specific skills that have been developed; indicators of trust; indicators of responding to a rehabilitation problem; and developing a solution.

Without developing a comprehensive understanding of the system, it becomes difficult to determine which indicators may be useful and/or relevant to monitor the changes occurring within the system as a result of the rehabilitation. Dale and Beyeler (2001) highlight some of the main challenges with selecting relevant indicators, which have been listed below:

- When focussing on a small range of indicators it may often lead to oversimplification of system conditions;
- Vague long-term goals and objectives critically cripple the process of identifying relevant indicators; and
- Management and monitoring programmes generally lack scientific rigour since they fail to adopt robust procedures for identifying relevant ecological indicators. This makes it difficult to validate the information that the indicators provide.

Further to this, Dale and Beyeler (2001) suggest criteria that should be used to select potential indicators:

- Easily measurable, without limiting the quality of data collected;
- Sensitive to anthropogenic stressors on the system, whilst preferably having limited response to the natural variation;
- Predictable response of indicators to stressors and should be within the threshold of response prior to any observable changes to the system;
- Should signify measurable changes occurring within the system prior to the system crossing any resilience threshold;
- Social-ecological set of indicators should be selected that provides a systems view across all spatial scales of concern;
- The indicators should have a well-documented, known response to an array of anthropogenic stressors to ensure that a clear pattern of ecological responses can be attained;
- Low variability in response to allow for changes to be better distinguished and understood; and
- Clearly defined response time for each set of indicators influencing the intervals at which monitoring will take place.

Once the indicators have been selected, it is important that they are clearly defined, their relevance explicitly stated, and that they are systematically reported on. The National Wetland Monitoring Programme (Sustento Development Services, 2016) provides a useful, structured manner for carrying this out. A template is provided below (**Figure 4.5**), with each element clearly explained.

Name: Provides a short concise name for the indicator

Definition: Provides an explanation stating exactly what the indicator measures, giving more detail than the name

Underlying Definitions: Provides definitions for any terms used in the indicator that may require further clarification

Relevance: An explanation of why the indicator is important in the broader context. What issue is it telling us about and why that issue is important?

Drivers-Pressure-State-Welfare-Response Framework: Provides details on the drivers and pressures of change in the indicator and the impacts of this change on human welfare

Current trends: Provides examples of how the indicator may be communicated in future

Units: The unit of measure for the indicator

Data required: Outlines the data required to report the indicator

Method: Provides the suite of methods which are currently being considered to capture and report an indicator

Target: Provides targets for the indicator if they are available

References: Provides the references linked to the indicator

Figure 4.5: A template of the guidelines used for reporting on the indicators of wetland rehabilitation as provided by the National Wetland Monitoring Programme

When assessing the indicators chosen for a completed project, the above guidelines should be adopted retrospectively to infer the relevance of the indicators initially chosen for a project. Questions of whether the indicators were developed to measure the objectives is important in assessing the approach of the initial project and whether it was appropriately designed in accordance with the predefined outcomes. When assessing a completed project, in accordance with the framework guidelines, reflection is key to determining the gaps in the approaches and where it could have been better implemented. All lessons learnt should be clearly reported on to assist in strengthening the approaches of rehabilitation implementation and M&E of a project.

4.8.3 Defining the level of detail of monitoring of the chosen indicators

The level or detail of monitoring adopted to evaluate the progress and changes within a system as a result of a rehabilitation project depends on how accurately the indicator needs to be measured, the resources available and the level of training and expertise amongst those involved in the project. The level of detail at which monitoring occurs is, therefore, likely to be influenced by the type of monitoring techniques, the frequency of monitoring and the subsequent planning of the budget. Cowden and Kotze (2009) noted that cost allocations for monitoring, performance evaluation and reporting are often not included in the planning process and should be considered within the initial rehabilitation planning. To ensure that accurate budget allocations are made, and to avoid budget shortfalls, the number and type of indicators, and the frequency of monitoring and reporting should be described in detail.

Monitoring at different scales (e.g. at a catchment, wetland and land use scale) will contribute to developing a systematic understanding of the system. During the monitoring, should the level or detail of monitoring be deemed as unreliable in terms of identifying and monitoring the drivers of change within a system, they should be improved accordingly. The benefits of this framework is that it allows for reflection to inform the adaptation of the current approach to something which allows for the required changes to be made accordingly, thereby strengthening the approach and the outcomes going forward.

Turner et al. (2008) described several different contexts within which economic valuation may be required; each context differed in terms of the level of detail required in the valuation process. The type of economic valuation approach adopted depended on the type of environmental change that was expected or desired (Turner et al., 2008). Similarly, Suding (2011) describes various goals of rehabilitation, which included the guidance of a system to recovery, using rehabilitation as compensation and to ultimately allow a system to optimally deliver ecosystem services. Each goal was likely to require the monitoring of different parameters to assess progress towards its achievement. As such, goals should be clearly defined from the outset of the project (Holl and Cairns, 2002).

4.9 Step 9: Implementation of the detailed rehabilitation and monitoring plan

For new projects, the implementation of the rehabilitation plan should be undertaken in conjunction with elements of the monitoring plan, as shown in **Figure 4.1**. **Figure 4.1** illustrates how specific sub-components of the M&E link to specific sub-components in the overall project cycle. The first step in implementing the detailed M&E plan is the collection of baseline data in alignment with requirements defined in Step 8. It is important to ensure that baseline data collection is undertaken prior to any rehabilitation implementation activities so that an accurate representation of the pre-rehabilitation situation is documented.

Following the collection of baseline data, the rehabilitation implementation should begin in accordance with the detailed dimensions, materials, construction sequence, etc. described in the wetland rehabilitation plan. At this point, the focus of M&E is usually on whether the interventions (i.e. the outputs) have been completed to the specifications given in the rehabilitation plan, and where deviations occur, to respond in an adaptive way. It may be that some work needs to be redone in order to meet the specifications. For example, it may be necessary for a spillway to be raised in order to be at the correct height to flood back and thus create an adequate water cushion for the upstream headcut. In other cases, it may be necessary to adjust the original plan. For example, during excavation it may have been found that a slightly deeper foundation would be required than originally planned for. All such adjustments should be informed by the objectives of the wetland rehabilitation and be well recorded with justification (preferably in consultation with the practitioners responsible for the designs).

An additional factor which needs to be assessed during implementation is whether, in undertaking the rehabilitation (e.g. in transporting materials into the site), all negative environmental impacts associated with these activities had been minimized (see Table 3 of Armstrong, 2008). These potential impacts include:

- Vehicle access to and within the site – failure to remain within the designated area/s, which applies particularly to sites with sensitive vegetation, failure to rehabilitate compaction from vehicle tracks following completion of the implementation;
- Multiple access points – creating multiple tracks causing unnecessary damage to the environment;
- Vehicle leaks – contaminating the environment with hydrocarbons;
- Mixing of concrete at the site – failure to confine this to the designated area;
- Failure to remove all foreign material (remaining rock chips, plastic containers, etc.) after completion of the interventions;
- Stockpiling of material within sensitive areas – stockpile areas should be minimised and located away from the identified sensitive areas;
- Inadequate control of sediment wash from the site during construction;
- Inadequate application of herbicides within sites with sensitive vegetation; and
- Failure to deactivate temporary water diversions after completion of the interventions. In order to construct interventions required in areas of the wetland which are currently flooded, it is usually necessary to divert water away from these areas. These diversions need to be removed once the construction is complete.

It may be that the outputs have been completed to specification but that the necessary care was not taken in the implementation process, e.g. driving vehicles on sensitive vegetation outside of the designated transport area. Assessing whether environmental impacts have been minimised during project implementation is usually undertaken by a designated Environmental Control Officer (ECO) with specific experience in wetland rehabilitation implementation, and is facilitated by the following:

- A project implementation plan, which describes how the interventions specified in the rehabilitation plan should be implemented, e.g. it would specify on a site map exactly where the designated areas mentioned above should be located; and
- Best Management Practice (BMP) guidelines for implementing wetland rehabilitation projects. These guidelines provide general descriptions of how to minimise the negative environmental impacts potentially associated with each of a wide range of activities/interventions that might be required at a rehabilitation site. WfWetlands have developed BMP guidelines for implementing wetland rehabilitation projects, which are based on many years of experience. Although these BMPs are tailored for the requirements of WfWetlands, they are likely to be relevant beyond the WfWetlands programme.

Following the completion of the rehabilitation implementation, the collection of monitoring data should continue in accordance with the timeframes, frequency, indicators, sampling techniques, and budget described within the detailed monitoring and evaluation plan. A SAM approach should be applied throughout the monitoring process and those responsible should retain flexibility and recommend corrective action where required.

4.10 Step 10: Evaluation of Outputs and Outcomes

Chapter 1 highlighted the many benefits of evaluation, including timeous identification of problems during implementation and reporting on outputs and outcomes so as to better account to funders. As shown in **Figure 4.1**, formative evaluation may potentially occur at several points during the planning and implementation process, while a summative evaluation of outputs and outcomes generally takes place after a project has been completed. Depending on the project objectives and overall evaluation, this may include a specific evaluation of the contribution of the rehabilitation outcomes to human well-being. If required, then refer to Chapter 2.2 for background to evaluation and Chapter 5.3 for guidance on carrying out a valuation, which is likely to require specialised expertise in resource economics.

It is useful for the final summative evaluation to reflect back and review each step of the rehabilitation process along with any formative evaluations conducted for these steps, and to document lessons learnt, especially where failures had occurred. Although the practitioners may find it difficult to admit to failures, through the process of documenting such failures, the likelihood of such failures occurring again is potentially reduced.

Once the outcomes of rehabilitation have been determined through monitoring, it is critical to reflect on these in the light of the implementation plan, rehabilitation strategy and rehabilitation objectives. It is often also useful to pose a related question "Did the system respond as expected, and if not, why not"? To address these questions, it is useful to return to the contextualisation step which described how the system was understood to work. In particular, the key biophysical and social drivers and attributes affecting the system were described and how, given these drivers, the system was expected to respond to the rehabilitation interventions.

For example, the contextual description may have shown that the inherent vulnerability of the wetland to erosion was moderate given the natural discharge to the wetland and the wetland's longitudinal slope, but extensive impermeable surfaces of the urban development in its upstream catchment had greatly increased peak discharges, thereby increasing the wetland's vulnerability to erosion. Thus, catchment development was identified as a key factor contributing to the gully erosion which had begun to advance through the wetland. The rehabilitation of the wetland aimed to halt the advancement of the erosion with an erosion-control structure at the erosion headcut, while at the same time encouraging regulation of further developments to minimise additional increase in peak discharges. During the planning phase of the project, it was assumed that the erosion control structure would be effective given that the inherent susceptibility of the wetland was not high and that further urban developments would be controlled. However, post-implementation assessment showed that the erosion-control structure did not halt the erosion and thus the system did not respond as expected, and therefore a key question needing to be addressed in the evaluation is why this occurred. Was it, for example, primarily as a result of problems with design and/or implementation of the intervention or perhaps relating to the broader site context (e.g. because the impacts of further urban development in the catchment were not adequately controlled)?

From the above example it can be appreciated that the ultimate effectiveness (or not) of rehabilitation interventions is often a result of a combination of factors, and **Table 4.2** provides a series of guiding questions for conducting a ‘forensic investigation’ of why a project may have fallen short of achieving its intended outcomes. Chapter 5.1, which provides detailed guidance for identifying maintenance issues in different types of interventions, may also assist with this investigation.

Table 4.2: Key questions to guide reflection on a mismatch between intended outcomes and actual outcomes

Key questions	Further rationale and examples
Was implementation of the specific interventions according to the specifications in the plan?	If interventions do not meet specifications then they will potentially fail to achieve what they were designed for. For example: • A weir designed to flood back into a headcut is constructed lower than specified, thereby failing to provide the “water cushion” for which it was originally designed; and • The specified frequent watering of vegetation planted at a site is not carried out, resulting in most of the plants dying.
Were the specific planned interventions described in the rehabilitation plan (and how they work together) appropriate and sufficient to achieve the objective/s and strategy for the site?	Even a perfectly implemented plan is unlikely to achieve the strategy and objectives if there are problems with the strategy and/or design. For example: • An area of wetland was desiccated by a combination of artificial drains located onsite and upstream of the site, but the rehabilitation interventions only dealt with the onsite artificial drains. This is likely to only partially address the cause of wetland desiccation and is unlikely to be sufficient to reinstate a close-to-natural hydrological regime in the wetland.
Did the rehabilitation project deal flexibly and effectively with unanticipated responses of the system to interventions, requiring adjustments/additions to the original plan?	When carrying out the evaluation it is important to bear in mind that natural ecosystems are complex, and it is seldom possible to predict exactly how the system will respond to given interventions. Thus, during or shortly after implementation of a plan, it may become apparent that adjustments or additions are required to the plan. For example: • The natural recolonisation by vegetation which was anticipated to result from re-establishing a more natural hydrological regime may have been much slower than anticipated, requiring that additional measures (e.g. re-seeding) be included.
Were the objective/s and strategy aligned with the nature of the wetland and its specific context?	Examine the strategy in the light of the contextual description of the wetland. The objectives of the rehabilitation should generally be in accordance with the natural functioning of the system, ensuring that the driving forces of the system are accounted for, thereby allowing the system to be self-maintaining. For example: • If a wetland was highly dynamic, it would generally be inappropriate if the rehabilitation sought to try and lock the system into a fixed state, unless this was specifically acknowledged and the necessary measures taken to deal with the associated risks.
Did “shocks” which could not have been anticipated impact upon the outcomes?	The implementation and outcomes of a rehabilitation project may be profoundly affected by “shocks” beyond the control of a rehabilitation team or management. For example: • A 1-in-100-year flood during implementation, when the wetland was particularly vulnerable to impacts.

Table 4.2 **4.2** was designed particularly for projects which were not as successful as anticipated. However, it is important to note that the questions in the table can also be applied to successful projects in order to better understand why they were successful.

The description of how the wetland system works and how it is expected to respond to the rehabilitation interventions is generally based on fairly limited knowledge and understanding. Thus, this description is most usefully viewed as a hypothesis which is tested by undertaking a "rehabilitation experiment", thereby improving understanding (see further discussion in the section on Adaptive Management). As can be appreciated from the earlier example, the potential to improve understanding is often greatest when the system fails to respond as expected.

The evaluation should be used to document aspects of both success and failure. Aspects that were identified during the project evaluation as a failure should be considered to be a potential learning success. However, a learning success can only be viable provided the reasons and understanding for project failure have been highlighted and documented, as discussed earlier. Both failures and successes work towards improving system management and rehabilitation processes (Bash and Ryan, 2002). However, this requires openness to willingly admit to failures and communicate results to learn from the weaknesses in the implementation (Kondolf, 1995). Thus, once the weaknesses/failures and strengths/successes of a project have been identified, these need to be explicitly reflected on to see how future practice can be improved, both at the individual site being evaluated and more widely to other sites with comparable issues and/or context. In this way, adaptive learning is promoted (see Chapter 2.3).

The complexity theory, suggested by Capra (2007), proposes that SES derive their properties from the interactions between social, economic and ecological aspects, and are influenced by the interactions around events, communication and learning. Encouraging learning within complex social-ecological systems provides a means to understand how adaptive and resilient a system can be (Pollard et al., 2009). Learning has a vital role in ensuring that feedback loops have an impact on self-regulation and self-organisation, and become a fundamental component of supporting the development of resilient and sustainable systems (Pollard et al., 2009).

4.10.1 Writing an integrated evaluation report

The structure of an evaluation report can vary depending on its purpose. However, **Table 4.3** provides a generic scientific report type format that was used during this research project. Ultimately, an integrated evaluation report serves to provide the reader with the evaluation's findings which are supported by evidence collected during monitoring or during the evaluation itself. The structure and content of the report should be congruent with the evaluation principles described in Chapter 3. When writing the evaluation findings one should ensure each statement is supported by evidence or data and an explanation, if necessary, of how that evidence or data relates to or supports that finding.

The suggested model of argumentation to be used is based on that of Toulmin (1958) where the statement, evidence or data and explanation are analogous to the claim, grounds and warrant in his model. It is important to be careful and systematic in the formulation of evaluation findings and as such:

- The conclusions should flow logically from the evidence given;
- Facts and opinions should not intermingle;
- Care must be taken to guard against conscious or unconscious bias; and
- Limitation of the data/evidence should be clearly articulated.

Table 4.3: A table of contents for an integrated evaluation report

Section	Content
Title	Includes what was evaluated, how and where/in what context was it studied. Must be brief, concise and descriptive.
Summary	Provides a condensed and concentrated version of the full text. Uses an introduction-body-findings structure. Can be understood without reading the paper. Will include any recommendation or lessons learnt emanating for the evaluation.
Introduction	Provides context to the evaluation. Gives the purpose of the evaluation.
Overview of the project/s	Provides a summary of the rehabilitation plan – interventions and objectives. Give an overview of the location and biophysical context of the site.
Methods	Provides step – by-step details about how the evaluation was performed. This would include the site contextualisation, literature consulted and any ecological, social, economic, hydrological and geomorphic assessment methods used. The type and origin of any data (from monitoring for example) used in the evaluation. Should provide enough detail so the evaluation can be repeated. Describes how you will analyse the data.
Results	Presents and describes analysed data Reports facts. Expresses the data appropriately in figures or tables
Evaluation Findings/Discussion	Uses the evaluation criteria as the basis to the evaluation. Provides a series of evaluation statements for each criterion supported by results. Provides a qualitative measure of the confidence you have in the evaluation findings. Clearly stated conclusion.
Recommendations and lessons learnt	Explores the implications of your findings, articulates any lessons learnt, adaptations required and potential limitations of evaluation. The implications of the findings could often include a statement as to any risk to the project that may have been revealed.
References	Acknowledges information obtained from other sources. Clearly states any information obtained somewhere other than yourself.
Appendices	Shows raw data in tables, graphs, etc.

It is useful to provide a qualitative assessment of the confidence of each finding. **Table 4.3** provides a means of describing confidence for evaluation findings. The degree of confidence in each finding is a combination of the quality and agreement of the evidence that supports it. Multiple, high quality strands of evidence that are mutually supportive would give a very high confidence rating while little evidence with low agreement would result in a very low confidence evaluation finding. An important role of evaluation is to inform improved practice. It is important that any findings close the "management loop". Where an evaluation has found a need for additional action to improve a rehabilitation project, or where lessons are learnt that can improve rehabilitation practice in the future, it should be clearly written up in the report and included in the summary section of the report. Janks et al. (in Deliverable 13) demonstrate the utility of an adaptive management in their Riverhorse Valley case study. From a quality assurance perspective, the report should be reviewed by an impartial party, which can add value and can ask difficult questions that lead to improvements in the clarity and logic of the evaluation report.

Table 4.4: Confidence for evaluation findings taking into consideration the amount and quality of evidence available and agreement in the findings of the evidence based on expert opinion

		Amount and quality of evidence		
		Limited	**Moderate**	**Large/High**
Agreement of findings provided to the evidence	**Low**	**Very low confidence**	**Low confidence**	**Medium confidence**
	Medium	**Low confidence**	**Medium confidence**	**High confidence**
	High	**Medium confidence**	**High confidence**	**Very high confidence**

5 DETAILED MODULES FOR MONITORING WETLAND REHABILITATION

As noted, the purpose of the evaluation will prescribe which particular aspects need to be monitored and evaluated, and in what level of detail. This section lists and describes a number of modules for the monitoring of wetland rehabilitation plans. It should be noted that these modules are by no means exhaustive, but they do provide common and/or useful approaches for monitoring different aspects of wetland rehabilitation outputs and outcomes. Various case studies demonstrate the use the methods contained in the following modules. **Table 5.1** provides a summary of which case studies (Deliverable 13; Kotze et al., 2018) have used which framework modules.

Table 5.1: Overview of the 11 sites included in the evaluation (Deliverable 13; Deliverable 9)

Wetland Name	Province	Method of evaluation used	Land use Context
Manalana	Mpumalanga	Wetland ecosystem service valuation Wetland ecological integrity and functioning	Communally-owned land bordering the Kruger National Park
Greater Edendale Mall	KwaZulu-Natal (KZN)	Wetland ecological integrity and functioning Water quality Vegetation	Private retail development
Baynespruit	KZN	Review of site selection criteria	Municipal land within an urban setting
Dartmoor	KZN	Rehabilitation intervention integrity, maintenance and adaptation Land owner engagement	Privately-owned conservation area
Hlatikulu	KZN	Rehabilitation intervention integrity, maintenance and adaptation	Privately-owned commercial agriculture
Kromme River	Eastern Cape	Water levels	Privately-owned commercial agriculture
Kruisfontein	KZN	Landowner engagement	Privately-owned commercial agriculture
Monontsha	Free State	Rehabilitation intervention integrity, maintenance and adaptation	Municipal land within a peri-urban setting
Xharas wetland	Northern Cape	Wetland ecological integrity Wetland functioning. Wetland ecosystem service valuation	Community land utilised for livestock grazing
Riverhorse Valley	KZN	Rehabilitation intervention integrity, maintenance and adaptation Wetland ecological integrity and functioning Vegetation	Commercially-owned private open-space within an urban setting

5.1 Assessing the maintenance and adaptation requirements of a rehabilitation project

While many rehabilitation projects have finite lifespans, usually reaching completion after a few years, wetland rehabilitation is generally a longer-term process. Therefore, the wetland's period of recovery usually extends for many years beyond the so-called completion of the project. During this recovery period, maintenance and aftercare activities may be required to support the completed project interventions, informed by monitoring of the interventions. Maintenance activities are generally much less costly than the original interventions. However, if issues requiring maintenance are not attended to timeously, they may develop into major issues which in turn may markedly hinder the recovery of the wetland and become potentially very costly to address. Thus, an important part of wetland rehabilitation M&E is monitoring the integrity of the interventions after the project is complete in order to timeously identify any maintenance requirements which may arise. This applies particularly to wetlands where the risks to the interventions are high.

Within a South African context, two aspects are considered critical to monitor, namely 1) integrity and functioning of structural interventions, and 2) land user engagement and aftercare. The importance of structural interventions towards achieving wetland rehabilitation success suggests that these 'building blocks' be carefully considered and monitored using a reliable tool. An updated version of the check sheet developed as a component of WET-RehabEvaluate (Cowden and Kotze, 2009) was developed in collaboration with the WfWetlands programme, to assess the functioning and integrity of wetland interventions post-implementation of the plan (Appendix 4). The development of the updated check sheet was an adaptive and reflective approach, in which a workshop with the WfWetlands programme was held to initially refine the check sheet, following which the check sheet was applied to multiple sites. Furthermore, the check sheet has been extensively used by the expanded project team and WfWetlands, allowing for the further testing and refinement of the check sheet. This collaborative approach has allowed an array of persons with varying qualifications and from different academic disciplines to apply the tool and provide feedback for incorporation into the framework.

Assessing the integrity and maintenance needs of rehabilitation projects can potentially be undertaken at two levels: (1) at the site level, and (2) at the level of the overall project.

5.1.1 Assessing the maintenance requirements at the site level

Identifying maintenance needs at the site level involves four inter-linked sub-components (**Figure 5.1**).

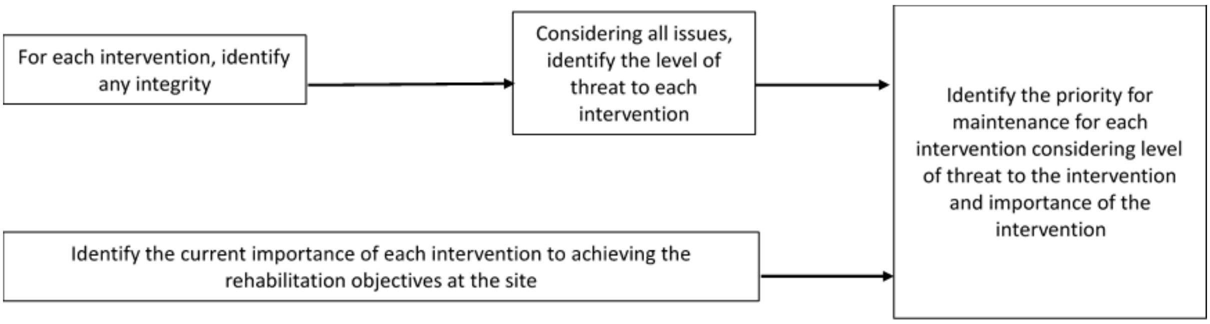


Figure 5.1: Sub-components included in the assessment of maintenance requirements at a wetland rehabilitation site

From **Figure 5.1** it can be appreciated how two interventions, both of the same type and with similar issues, may differ greatly in terms of their importance. Therefore, they may also differ in their priority for maintenance, depending on their respective roles in relation to all of the other interventions at the site (i.e. context is key). For example, concrete drop-inlet weirs along a drainage canal with damaged spillways may be considered to have similar maintenance priorities, but should one of the interventions serve to re-distribute flows across the wetland, it would then be considered critically important and prioritised for maintenance.

Identifying intervention integrity issues: Appendix 4 provides a comprehensive checklist of specific integrity issues for a variety of different intervention types. For example, for gabion structures this includes, but is not limited to, incorrectly packed rock, incorrectly sized rock, rusting through of wire in the gabion baskets. For each of the interventions in the site, this checklist should be used to assist in identifying the presence of any integrity issues.

In addition to the issues described in Appendix 4, note should also be taken of any other issues associated with the interventions, in particular any negative environmental impacts of the interventions not adequately accounted for in the project. For example, an intervention may have diverted water flows out of an artificial drainage channel in order to re-wet an area of wetland but inadequate measures were taken to control the re-entry of this water into the channel. The result of the uncontrolled re-entry may have been development of erosion at the re-entry point, which, if not addressed, could ultimately result in the eventual outflanking of the diversion. A list of potential negative environmental impacts associated with different interventions is given in Table 2 of Armstrong (2008). It may also be that negative environmental impacts associated with implementing the interventions persist, e.g. a persisting compacted access track which was not loosened at the end of implementation (see Table 3 of Armstrong, 2008).

Level of threat to the interventions: Once the structural integrity issues (e.g. rusting of gabion basket wire) at each site have been identified, the level of threat to each intervention needs to be assessed. The level of threat to the intervention should be scored based on the following categories:

- No observable threat (no issues identified);
- Low threat of failure;
- Moderate threat and/or time frame (3-8 years) for failure;
- Imminent failure (high potential for substantial rapid degradation of the intervention within the next two years);
- High risk of failure within the next year; or
- The structure has already failed severely.

Importance of the intervention: Some interventions play a key role while other interventions play a secondary role. A high threat to a key structure would have a higher priority in terms of outcomes and maintenance than a high threat to a secondary intervention. Assessing the relative importance of different structures to the overall ecological outcomes of a rehabilitation project in a wetland is a difficult task. The relative importance of different structures is generally indicated within the plan,[2] but very often the assessor will also need to make an informed judgement based on observations in the field and on any recorded qualitative descriptions of the purpose of each specific structure.

The following general guidelines are given to assist in assessing the relative contribution of different interventions.

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[2] The rehabilitation plan also specifies the order in which structures should be built, but this usually does not correspond with the relative importance of the structures, but relates more to the logical sequence in which they should be built (e.g. if a lower structure is designed to flood the base of the upper structure then the upper should generally be built before the lower structure so that the intended flooding will not interfere with construction).

- Consider the multiple contributions which a structure may potentially make in terms of how the intervention affects: (a) the distribution and retention of water in the wetland, (b) retention of sediment in the wetland, and (c) encouragement of wetland vegetation growth.
- Consider both the direct and indirect contributions made by a structure. While most structures are designed to contribute directly, some structures contribute indirectly through the support which they provide to other key structures, which in turn make the primary contribution.
- Related to the above, it is recognised that interventions are generally designed to work together as a group to achieve ecological outcomes at the site. Therefore, it is recognised that it is somewhat problematic to see each intervention in isolation. Nonetheless, there is value in systematically asking the question for each structure, "If this structure were to fail, what would the implications be for achieving the overall ecological outcomes of the site?"
- The contribution of individual interventions needs to be seen in the context of an evolving system, e.g. in terms of shifting water flow paths and changing vegetation structure and composition. A structure may play an initially important role and then its role becomes superseded and its importance declines greatly over time (see Example 3 discussed below). Conversely, a structure's importance may increase over time, e.g. where headcut erosion advances into a new portion of the wetland.

Thus, whether a structural integrity issue poses a threat to the specific structure and the rehabilitation outcomes will depend strongly on the context, as illustrated further by three examples below. Each of the examples incorporates a gabion structure with severe rusting through of the wire baskets.

Example 1: The wetland has responded to rehabilitation through the development of extensive cover of robust vegetation, taking over the role of the wire in holding the gabion structure together. Thus, even severe rusting would not pose a threat to the integrity of the structure and to the sustained outcomes of the rehabilitation project.

Example 2: The wire is still needed to hold the structure together (with vegetation not having assumed this role) and in addition the structure is needed to play a key role in sustaining the rehabilitation outcomes (e.g. halting an advancing erosion headcut). Thus, a high level of rusting of the wire is likely to pose a severe threat to the structure and to the overall rehabilitation outcomes.

Example 3: This resembles the previous example in that the wire is needed to hold the structure together, but the structure itself makes a very minor contribution towards the overall ecological outcomes at the site, even if the structure's integrity were to be maintained. Thus, the structure is largely redundant – other structures play a more important role – and therefore even if the structure breaks apart severely as a result of its rusted wire, the outcomes of the rehabilitation project would not be significantly threatened.

5.1.2 Assessing maintenance needs at the project level

The previous section dealt with identifying the need for maintenance of individual interventions within a wetland rehabilitation site. In addition, there is a need for guidance in taking a step back to review the overall project in order to decide what maintenance actions to take. **Table 5.2** provides possible maintenance actions, including the option of 'walking away' from the site, although it should be noted that some actions may require additional authorisation from the relevant authorities.

Table 5.2: Possible actions to take at a site based on the results of the structural integrity and ecological outcomes assessments

Structural integrity and ecological outcomes results	Likely actions required
The site was well justified in terms of ecological outcomes achieved (it was a good idea to intervene in the first place), the interventions were generally well implemented, structural integrity is generally good but minor maintenance is required.	In identifying required actions, it is useful to prioritise between (1) those maintenance requirements which, over time, if not addressed are likely to become progressively worse and which could potentially significantly compromise the effectiveness of the interventions in the long term, and (2) those which are less significant and are unlikely to pose a major long-term threat to the interventions.
Major maintenance and/or additional interventions are required at the site, but the risks to the structures do not appear to be beyond that which can be dealt with in the designs of the new/repaired structures and the costs of this major maintenance are likely to be justified in terms of the outcomes of the interventions.	In some cases, major repairs to existing interventions will be required, while in other cases where interventions have failed completely and/or were inadequate, a totally new set of interventions will need to be designed and implemented, sometimes requiring a totally different approach to that which failed, particularly where failure resulted from primarily from problems in strategy/design rather than implementation. In some cases, continued intervention would be described as "fighting the site" in some senses but would be justified based on the outcomes which can be sustained, e.g. at the Craigieburn site.
Rehabilitation should not have been undertaken in the first place because the risks of failure are too high and the ongoing maintenance costs required to prop up/re-instate the interventions are not justified in the light of the benefits which accrue from these interventions.	In most cases the best course of action would be to "walk away" from these sites. However, at some sites before walking away it may be necessary for some of the interventions to be removed and/or additional work done on the interventions to prevent them from further aggravating the overall situation.
Rehabilitation should not have been undertaken in the first place because natural feature/s of the wetland were misdiagnosed as degradation. It may be, for example, that a site was naturally characterised by a very well-defined stream channel flowing through it, and that this was taken as a degraded feature which needed to be "plugged" to increase water retention in the wetland.	The impacts which have been caused by the misdiagnosis need to be assessed and a decision taken as to whether to simply walk away from the site or to plan another series of interventions designed to try and remove/cancel out the effects of the initial interventions. It is anticipated that only a very small proportion of sites will fall into this category. Nonetheless, when assessing all sites, it is important to be open to the possibility that some sites may be found to fall into this category.

From **Table 5.2** it can be seen that for sites with major intervention problems, i.e. requiring major maintenance; it is important to try to isolate what caused the problems. It may have been a case of a good idea that was poorly implemented. Alternatively, it may have been a bad idea to intervene in the first place, and even though it was implemented well under the circumstances, its failure was inevitable.

When deciding on a possible course of action at a site, the results of the landholder perception assessment should also be considered (see following section). This is particularly relevant to situations where there is a failure on the part of the landholders to take responsibility for aftercare and the risks to intervention integrity are high.

5.2 Assessing engagement of stakeholders and landholders in wetland rehabilitation planning, monitoring and evaluation and aftercare

A key social aspect of how wetland rehabilitation is undertaken relates to engagement of stakeholders and landholders in rehabilitation planning, monitoring and evaluation and aftercare, which has potentially profound implications for the long-term sustainability of the wetland rehabilitation outcomes. Land holders refer to whoever is directly responsible for management of the land, including private owners, lessees or communal users. The stakeholders refer to all parties potentially affected by the rehabilitation, including additional land users (e.g. people who visit the wetland to watch birds) and other parties (e.g. downstream water users).

It is recognised that sustaining the outcomes of wetland rehabilitation may be strongly dependent on the management of the wetland and the interventions, and those individuals responsible for that management, usually the landholders. Therefore, as part of monitoring and evaluation of wetland rehabilitation outcomes, it is considered especially important to collect a narrative of how the land holder perceives: (1) the wetland and the wetland rehabilitation project; (2) their engagement in the rehabilitation; and (3) their responsibilities in relation to monitoring, aftercare and maintenance of the interventions and the wetland.

Below are some suggested prompts to help guide a discussion with the land holder around the long-term sustainability of the rehabilitation outcomes. The questions are framed in such a way as to reflect back on a project which has already been implemented. However, ideally the questions should also be posed during the planning phase of the project.

5.2.1 Some prompts to help guide the discussion with the landholder:

- How does he/she perceive the wetland and the benefits supplied by the wetland?
- What contribution, if any, have the rehabilitation activities made to the benefits supplied by the wetland, and were there any other benefits (or disadvantages) derived from the rehabilitation project? The respondent may require prompting to respond beyond "small" or "large" and to elaborate on why.
- How does he/she feel about the manner in which the rehabilitation was undertaken? Again, some prompts may be required, e.g. stakeholder engagements, availability of information relating to the rehabilitation. Here it may be useful to ask "what do you think could have been done differently to improve the way in which the wetland was rehabilitated" or "could the process have been handled better, and how so?"
- Did he/she understand the specific intended outcomes of the rehabilitation plan and how these outcomes were to be achieved? The details of this should preferably have been described with

all stakeholders involved in the rehabilitation during the initial stages of the project. If it was undertaken, were the processes and outcomes clearly defined, providing additional explanations where necessary?

- If there were any risks associated with the rehabilitation with regards to current land uses, were they clearly explained, with possible suggestions for dealing with the negative impacts?
- What does he/she see as needing to be done in terms of (a) monitoring and evaluation of the rehabilitated wetland; (b) maintenance of the rehabilitation interventions; and (c) aftercare of the rehabilitated wetland?
- Who does he/she see as being responsible for carrying out the respective maintenance and aftercare tasks?

It is important to emphasise that the above prompts are not in order of importance, but instead start with more general background questions then move on to questions that relate more directly to the long-term sustainability of the rehabilitation outcomes.

5.2.2 Some suggested methods and guidance for conducting the discussions:

Different methods can be used to solicit the perceptions of the stakeholders and land users. If it is a single person then a one-on-one interview is likely to be most appropriate, but if it is a group of people (e.g. a group of small-scale farmers who communally use a wetland) then a focus group interview is likely to be more appropriate.

When setting up an interview, it is important to appreciate that the wetland and its rehabilitation may have a low priority in relation to the landholder's other demands/interests. Therefore, the interviewer is urged to be prepared for the fact that commitment of the landholder to make him/herself available for the interview may vary greatly amongst different landholders. In some cases, it may be necessary to re-schedule the interview more than once and to be accommodating in terms of venue and time of the interview.

When starting the interview, it is very important to be clear and upfront about the purpose of the interview and to give the interview some context. This context may be provided in various ways. Ideally, the wetland should be visited with the landholder/s, as this provides the interviewer and interviewee with a direct encounter with the wetland and facilitates a potentially rich discussion. If this is not possible then the interviewer could give context to the discussion with photographs and maps of the wetland. Another way to provide context is for the interviewer to briefly share some of the experiences of landholders in other wetland rehabilitation projects and to ask the interviewee/s how these compare with their own experiences.

The interviewer should preferably not be a member of the team or the responsible organisation (e.g. WfWetlands) undertaking the rehabilitation, but if this was not possible, it should not preclude them from carrying out an interview. However, this would need to be openly stated at the beginning of the interview and the potential influence this may have over the landholder's responses acknowledged. In addition, it is important also to always acknowledge that interviewers have their own viewpoints, which are likely to influence the discussion, and in the case of multiple landholders, the different landholders are likely to hold different, sometimes strongly contrasting, viewpoints. However, as explained in the section on social learning, contrasting viewpoints provide potentially valuable opportunities for learning provided that the discussions are carried out in a "safe space" where all involved individuals are encouraged to openly share their views without feeling judged. At the same time, individuals should also be encouraged to be open to hearing the viewpoints of others and learning from these. Therefore, the interviews provide good opportunities for learning by all involved parties.

As an interviewer, try as far as possible, to cross check the landholder's expressed involvement in monitoring and maintenance of the interventions by asking about specific details of the interventions, which will aid in providing an indication of the landholder's knowledge of the interventions.[3] The landholder is more likely to give a better considered and truthful response if the interviewer has shown an interest in the supporting evidence than if this is left out of the interview. However, at the same time as probing for supporting evidence, it is important to be mindful not to make the interviewee feel threatened if they do not know the answers to some of the questions, or if they have not demonstrated the level of commitment to monitoring and maintenance they think the rehabilitation project, or you as the interviewer, might expect from them. Therefore, the interviewer needs to be reminded to be careful about how the questions relating to supporting evidence are phrased.

5.2.3 Responding to sustainability issues revealed in the interview

If the answers reveal any key missing elements in the process of the rehabilitation project (including the engagement with the landholder) then these should be flagged and preferably corrected, thereby helping to "close the loop" in the rehabilitation project cycle. For example, if it was revealed that the landholder had not been engaged fully prior to implementation in terms of understanding how the rehabilitation outcomes were to be achieved, then it could be flagged as a priority to visit the rehabilitated wetland with the landholder and "walk through" the rehabilitation plan with them.

5.3 Economic evaluation of the outcomes of wetland rehabilitation

The economic evaluation of the outcomes of wetland rehabilitation is about assigning economic values to the benefits and costs of the rehabilitation and comparing them. However, many of the benefits of wetlands are not amenable to economic valuation, for example, the contribution a healthy wetland makes to household food security (social value), the role of wetlands in a stabilising the broader socio-ecological system (ecological value) and the cultural significance of wetlands.

An economic evaluation is not always the most appropriate or feasible approach for assessing wetland rehabilitation outcomes and this should be borne in mind before committing to undertake an economic evaluation. In evaluating the outcomes of wetland rehabilitation, an economic assessment should be considered alongside social assessments (e.g. as described in Section 5.2 for assessing land holder perceptions) and ecological assessments (e.g. given in Section 5.4). In choosing whether to conduct an economic evaluation of the wetland rehabilitation, the types of benefits provided by the

[3] This process of cross checking using multiple sources of information is often referred to as triangulation.

wetland, the objectives of the rehabilitation and stakeholders and the resources available for the assessment must be considered.

This module of the Monitoring and Evaluation Framework outlines key concepts of economic valuation and steps to guide an economic evaluation. Application of the steps is illustrated using examples from the project case studies.

5.3.1 Concepts

The economic evaluation of wetland rehabilitation is concerned with well-defined changes in the wetland as a result of the rehabilitation and the benefits of these changes to people. The approach considers the value of wetland ecosystems from the perspective of their contribution to human well-being (e.g., wetland ecosystem services and benefits).4 Certain concepts and conditions apply to economic evaluation; the key concepts and their implications for undertaking an economic evaluation of wetland rehabilitation are outlined in **Box 1**.

[4] Other theories of value are recognised (non-anthropocentric, non-utilitarian value theories), but assessing these values is beyond the scope of this framework.

Box 1 | Economic evaluation of wetland rehabilitation: Concepts and conditions[5]

Evaluating wetland rehabilitation from an economic value perspective requires that the specific contribution of the rehabilitation to human well-being be established.

- This means that the "with" and "without" rehabilitation scenarios must be formulated and compared.

The biophysical outcomes of the rehabilitation provide the basis for evaluating the human well-being benefits specific to the wetland rehabilitation.

The biophysical outcomes of wetland restoration can be linked to human well-being through the ecosystem services approach.

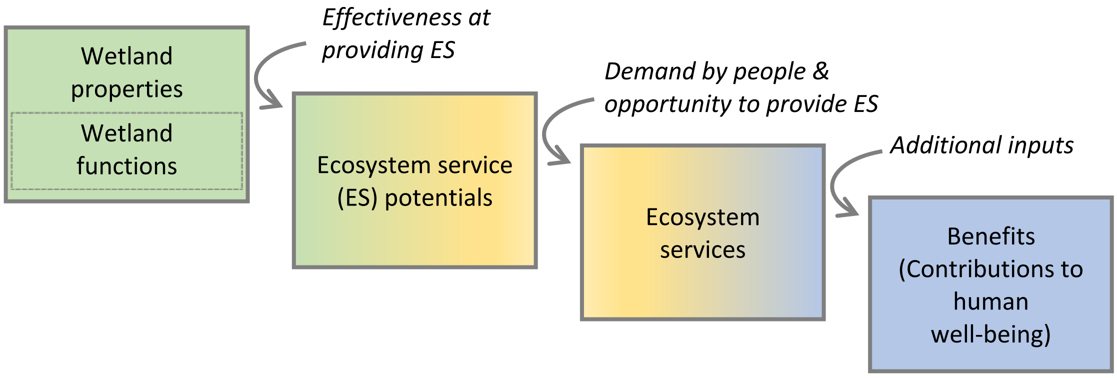

Illustration of the conceptual link between wetland ecosystems, ecosystem services and benefits.[6]

- Determine the biophysical outcomes of the rehabilitation, to provide a solid ecological underpinning to the economic valuation.
- Undertake an ecosystem services assessment of the wetland.
- Clearly define the boundaries of the wetland as a service production area.
- Clearly separate upstream river services from the onsite wetland services.

Wetlands have the potential to supply **a range of ecosystem services** depending on their biophysical characteristics and integrity.

- This means that the potential to provide ecosystem services differs across individual wetlands.

Wetlands **benefit people in different ways**. The importance (values) of wetland benefits are not the same to everyone.

- Identify 'who' benefits from the outcomes of the rehabilitation (e.g. resource poor, vulnerable communities; recreationists).
- Examine the social and political/governance context of the resource users, such as poverty levels, land ownership, vulnerability (e.g. age and gender of household head).
- Examine the economic context of resources users, such as income levels of households, number of dependents, numbers of users, income earning strategies, household discount rate (perspective of risk and time), access to alternatives (e.g. livelihood alternatives).

[5] See Bockstael et al., 2000; Turner et al., 2003; Fisher et al., 2008 for further information.
[6] Modified after Spangenberg et al. (2014), based on Haines-Young and Potschin (2010).

Box 1│ Economic evaluation of wetland rehabilitation: Concepts and conditions[5]
Economic value is a specific theory of value and is not the only possible concept of value, nor is it always the most relevant. **Many of the contributions of wetlands are not amenable to economic valuation.** • Identify other values such as social values (e.g. household food security) and ecological values (system resilience). Clearly state which benefits are included in the valuation and which are not. • If the objective is to measure economic value, then the concepts, principles and criteria associated with economic valuation (and valuation methods) must be adequately addressed for the results to have the properties attributable to this type of valuation.
Wetlands provide ecosystem services that benefit people in the immediate vicinity and away from the wetland. • Consider both 'on-site' and 'off-site' wetland services and resulting benefits. • Consider the downstream benefits and beneficiaries (e.g. flood reduction). • Clearly define the downstream, on-site and remote service users. Wetland rehabilitation is a **long-term process** and an appropriate timeframe that takes into account benefits provided in the long-term (e.g. greater than 10 years) must be selected. • Clearly define the temporal scale of the assessment. • Undertake baseline and long-term monitoring of rehabilitation projects where possible. • Make sure you have current and future timeframes in economic modelling. The process of wetland rehabilitation entails planning and authorisation, implementation, monitoring and evaluation, and post-implementation maintenance. **There are costs associated with each of these activities**. • Record/predict the costs associated with all of these activities. Evaluating the outcomes of wetland rehabilitation from an economic value perspective entails close **collaboration** between wetland ecologists, hydrologists, economists and stakeholders. • Make allowance in the evaluation process (team, budget and time) for collaboration.

5.3.2 Evaluation steps

An economic evaluation of the outcomes of wetland rehabilitation entails assessing the capacity of the wetland to **supply (provide) ecosystem services with and without the rehabilitation,** identifying the benefits to people from these services, assessing the **demand for the services and their benefits** and assigning economic values to the benefits and costs of the rehabilitation and comparing them. Both the "with" and "without" rehabilitation alternatives must be formulated and compared.

A four-stage process[7] to guide the evaluation is outlined below. Practical experience[8] suggests that **attention to Stage 1, particularly a preliminary ecosystem service assessment** which considers both the biophysical and social context, **to prioritise ecosystem services for detailed analysis** is a key first step. Following the initial stage, the process may be iterative as new information is obtained.

5.3.2.1 Stage 1: Define and contextualise the economic evaluation

The purpose of this stage is to identify priority ecosystem services associated with the rehabilitation and determine whether economic valuation is appropriate and feasible (affordable, data available, workable time frame) for valuing the identified ecosystem services and benefits. Many of the contributions of wetlands, for example, the contribution of a healthy wetland to reducing the vulnerability of a single female-headed household, are not amenable to economic valuation. Priority ecosystem services are those services affected by the rehabilitation – either services that would decline or be lost without rehabilitation, or those services likely to increase with rehabilitation – and considered particularly relevant to the rehabilitation objectives or local context.

The ecosystem services affected by the rehabilitation are identified through a comparison of the potential supply of ecosystem services under three scenarios:

1. The **baseline** (or current/pre-rehabilitation) state;
2. The future **'without' rehabilitation** alternative; and
3. The future **'with' rehabilitation** alternative.

Once the ecosystem services likely to be affected by the rehabilitation are identified, it is then possible to identify the likely associated benefits and consider their social and economic values. It may be possible to derive an economic value for a few of the services, but this should in no way make one value more important than another.

This stage entails:

- A preliminary assessment of the wetland ecosystem services and the anticipated effects of the rehabilitation on the provision of these services.
- Consideration of the social, ecological, economic and political context of the area (surrounding and downstream of the wetland).
- Defining and planning the evaluation assessment (e.g. spatial and temporal scope; quantitative/qualitative; is economic valuation appropriate and feasible?).

Steps to guide a preliminary ecosystem services assessment are suggested below. The assessment should be conducted at a preliminary (conceptual) level as it is unlikely to be practical and/or feasible to invest in a thorough quantification of all services at this stage.

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[7] In conceptualising an approach to the economic valuation of the outcomes of wetland rehabilitation, a review of the literature and particularly an analysis of 18 valuation frameworks or guidelines was undertaken. The proposed approach was strengthened by a review and input from Myles Mander (2019).

[8] Mander (personal communication, June 2019).

1. Identify the ecosystems services provided (or potentially provided) by the wetland – range and volume of services – at a preliminary (conceptual) level (as it is unlikely to be practical and/or feasible to invest in a thorough quantification of all services).
2. Identify who uses the services – numbers or people, their vulnerability and dependence (access to alternatives). Consider the social, ecological, economic and political context of the area (surrounding and downstream of the wetland). Visit the wetland area and engage stakeholders. Review existing information (e.g. household census/survey data, wetland and hydrological studies; water quality and flow data).
3. Identify the expected changes in the wetland with and without rehabilitation. Define the time horizon. Define the spatial boundary.
4. Identify which ecosystem services are likely to change with the rehabilitation.
5. Prioritise ecosystem services for detailed analysis – select services which are feasible (affordable, have data, workable time frame) to quantify (baseline and then two futures – with and without rehabilitation) and to measure the demand for the service. Consider the objectives of the rehabilitation in prioritising services for further analysis. Review the wetland rehabilitation plan.

From this stage of the evaluation, the following should be identified:

- The ecosystem services and benefits most likely to be affected, or that were affected, by the rehabilitation intervention – ecosystem service supply for the 'with' and 'without' rehabilitation alternatives;
- The data/evidence available on which to base the evaluation (e.g. water quality and flow data; surveys of household use of wetland resources such as grazing and reeds); and
- The scope of the assessment and an appropriate assessment approach and methods – based on the stakeholder and management objectives, priority ecosystem services and benefits, and available resources (data, funds, time, skills).

5.3.2.2 Stage 2: Assess the capacity of the wetland to provide ecosystem services with and without the rehabilitation

The biophysical outcomes of the wetland rehabilitation provide the basis for evaluating the ecosystem services provided by the wetland and the associated human well-being benefits as a result of the rehabilitation. To identify the benefits of the wetland rehabilitation, **the physical flow of ecosystem services must be determined for both the 'with' and 'without' rehabilitation alternatives.** It is important to consider that the rehabilitation may improve the capacity of the wetland to provide ecosystem services and/or prevent or reduce a decline in its capacity to provide ecosystem services. The purpose of this stage is to determine the provision of ecosystem services by the wetland without rehabilitation and then with rehabilitation.

This stage entails:

- Biophysical assessments, or interrogating existing assessments/information, to determine the response of the wetland to the rehabilitation and identify the biophysical outcomes of the rehabilitation. Biophysical outcomes could be, for example, halting active erosion or preventing future erosion, raising the water table, creating habitat for a specific species), and creating conditions to enhance the provision of specific ecosystem services.

- Assessing the capacity of the wetland to provide priority ecosystem services with and without the rehabilitation through measuring, modelling, making use of indicators, drawing on expert judgement, or through a combination of approaches. This is done by determining the provision of ecosystem services by the wetland without rehabilitation and then with rehabilitation.

5.3.2.3 Stage 3: Assess the current and future demand for the ecosystem services and associated benefits

The purpose of this stage is to establish the demand for the additional ecosystem services and benefits associated with the wetland rehabilitation. An ecosystem service (e.g. water quality enhancement) is only a (human) benefit if there is a demand (desire) by people for the service. There must be a current or future 'beneficiary' of the service.

To assess the demand for ecosystem services, information on their use (current and future desired use), or indicators of their likely use, is needed. Ecosystem service demand assessments are generally based on population numbers and population dependency and ecosystem services use patterns. This information can be obtained from census data, social and economic assessments and interviews. Dependency can be gauged by considering whether the 'beneficiaries' have access to other options or ways of attaining the same benefit (e.g. alternative sources of irrigation water) at a similar cost. The socio-economic status and vulnerability of the beneficiaries and information on the context identified in stage 1 are important in this regard.

This stage entails:
- Identifying who uses the services – numbers or people, their vulnerability and dependence (access to alternatives). Consider the social, ecological, economic and political context of the area (surrounding and downstream of the wetland).
- Reviewing existing information (e.g. household census/survey data, wetland and hydrological studies; water quality and flow data).
- Visiting the wetland area and engaging stakeholders.

5.3.2.4 Stage 4: Compare the supply and demand for priority ecosystem services and benefits for the 'with' and 'without' rehabilitation alternatives

The purpose of this stage is to gauge the benefits of the wetland rehabilitation by comparing the supply and demand for priority ecosystem services and benefits for the 'with' and 'without' rehabilitation alternatives. This can be done as an **index-based comparison of ecosystem supply and demand** as measured on a relative scale or through applying **economic valuation methods** to assign an economic value to the wetland benefits. This is done for both the 'with' and 'without' rehabilitation cases to establish the specific contribution of the rehabilitation.

For an index-based comparison,[9] this stage entails:

[9] Burkhard et al. (2012) present a detailed description and application of a relative supply-demand scale approach to ecosystem service evaluation.

- Assigning a score for supply and demand (separately) for each of the priority ecosystems services on a scale, for example 0 (no relevant supply or demand) to 5 (maximum relevant supply or demand).
- Comparing the supply assessment and the demand assessment (e.g. by subtracting 'demand' from 'supply') to calculate a relative supply/demand index. This is done for both the 'with' rehabilitation and 'without' rehabilitation alternatives.
- Comparing the relative supply/demand index (scores) for the 'with' and 'without' rehabilitation alternatives. In this type of comparison, the relative supply/demand index reflects 'risk' in terms of demand exceeding supply. A reduction in this 'risk' as a result of the rehabilitation is an indication of the contribution of the rehabilitation.

For an economic evaluation, this stage entails:

- Applying economic valuation methods to assign an economic value to the wetland benefits. Again, this must be done for both the 'with' and 'without' rehabilitation cases to establish the specific contribution of the rehabilitation. See **Table 5.3** for an overview of wetland ecosystem services, benefits, value indicators and economic valuation methods. A brief description of economic valuation methods is provided in **Box 16**; see the summary table in Appendix 3 for additional detail.
- Clearly indicating which benefits have been included in the economic valuation and which have not.
- Estimating the economic value of the rehabilitation benefits by comparing the 'with' and 'without' rehabilitation alternatives.
- The economic value of the rehabilitation benefits can then be compared to the cost of the rehabilitation in a cost-benefit analysis as an *indication* of the net benefit of the rehabilitation.
- Reporting the confidence in the estimated economic values, and cost-benefit comparison. The confidence in the estimates depends on the availability of reliable data/evidence (e.g., values based on secondary data, or derived from the literature, should be reported with moderate to low confidence).

Table 5.3 Wetland ecosystem services, benefits, value indicators and economic valuation methods

Ecosystem service	**Benefit outcomes**	**Examples of rehabilitation value indicators**	**Economic valuation methods and example data requirements**
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Flood attenuation	Improved flood protection for downstream infrastructure (e.g. roads, fences, houses) and land use (e.g. agriculture, livelihood/subsistence activities) Downstream property improvements – safety, aesthetic and recreation benefits Reduction in downstream flood danger (risk)	Difference in water levels/flood damage with and without rehabilitation Trends in flooding events (e.g. number and severity of floods over time) Extent of infrastructure and land-use downstream at risk of flood damage with and without rehabilitation Cost of mitigation measures with and without rehabilitation – costs of alternative ways (e.g. built infrastructure) to achieve the reduced level of flooding with rehabilitation compared to without rehabilitation Value of damages to downstream infrastructure, property and livelihood activities in the case of no rehabilitation Difference in property values with and without rehabilitation due to reduced risk of flood damage and/or property improvements Difference in insurance premiums associated with flood risk with and without rehabilitation	Methods: AC, RC, H Reduction in risk and/or area protected as a result of rehabilitation: • Change in flood lines • Flood discharges and associated floodwater levels, flow data, probabilities of flooding Downstream infrastructure and land-uses Previous flood damages, frequency and costs Mitigation actions and costs (including maintenance) Property prices over time and expert inputs from property valuers

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Streamflow regulation	Improved streamflow during low flow periods – improved/extended water supply Water available during low flow/rainfall periods (that would otherwise not be available) for domestic, agriculture or other purposes, in situ and downstream (e.g. fishery production) Improved/extended habitat maintenance (into dry season) including fodder and crop productivity *[Links to provisioning services]*	Difference in low flows with and without rehabilitation Costs of built infrastructure to store the volume difference of low flows with and without rehabilitation Type and extent of surrounding and downstream water and land-uses (links to provisioning services – see below) *[Links to provisioning services]*	Methods: M, AC, RC, H, SP Alternative water storage options (to store the volume difference) and associated costs Alternative sources of water during low flow periods and associated costs Information on onsite (surrounding) and offsite (downstream) water use and land-use activities, productivity data (e.g. agricultural production) *[Links to provisioning services]*

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Water quality enhancement	Improved water quality for surrounding households and downstream uses Health benefits – water use (e.g. recreation and irrigation) Reduced damages associated with use of poor-quality water (e.g. damage to pipes, soil fertility impacts) Increased recreation and cultural opportunities Reduced animal health impacts (or risk) and associated economic impacts (e.g. commercially important species) Reduced sedimentation of downstream streams and dams	Difference in the sink capacity of the wetland with rehabilitation compared to the wetland without rehabilitation Cost of alternatives to achieve the above difference (e.g. cost of water treatment to achieve the equivalent improvement in water quality) Costs of alternative water sources/supplies Costs due to damages from using poor quality water (damages to pipes, soil fertility losses, health effects, dredging costs) which could be avoided through improved water quality enhancement as a result of the rehabilitation. • Change in human health or health risks • Change in animal health or health risks • Change in economic output or production costs Costs associated with accessing alternative recreation and cultural options; willingness to pay for recreation and/or cultural benefits Potential property value effects – difference in values of residences located near the wetland, and downstream, with and without rehabilitation due to improved water quality (aesthetics and odour)	Methods: RC, AC, SP, H Nutrient/pollutant loads entering and exiting the wetland, which, based on the difference between the loads, is used to determine the "sink" capacity of the wetland. This is firstly determined for the wetland without rehabilitation and then with rehabilitation – pollutant concentrations and water flow data. Alternative (realistic) water treatment options and associated costs to achieve the same level of water quality enhancement Damages and associated costs from poor water quality (health surveys, dam storage capacity with and without reduced sediment loads) Mitigation measures and costs to avoid damage from poor quality water (e.g. sediment filters in irrigation systems, dredging of dams) Wetland abundance in the region and the size and uniqueness of the wetland in comparison with other nearby wetlands. Property prices over time and expert inputs from property valuers

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Carbon storage	Increased retention of carbon Mitigation of carbon released through wetland degradation Increased contribution to global climate regulation	Difference in Total Carbon in the wetland with and without rehabilitation The above difference in Total Carbon converted into Equivalent Total CO_2, using the global social cost of carbon (Nordhaus, 2017) and South Africa's share of this cost based on proportional GDP contribution and vulnerability index as estimated by Turpie et al. (2017)	Methods: AC, RC, SP Total amount of carbon sequestered/stored in the wetland (above and below ground) with and without rehabilitation • Significance in terms of global carbon emissions Soil sample analysis data Carbon trade prices

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Biodiversity maintenance (habitat provision)	Improved maintenance of the web of interactive relationships that support regulatory services Improved habitat and nursery provision Biomass production and food web support On-site biodiversity may be associated with non-consumptive use values (such as recreation) or non-use values (such as a bequest for future generations). Direct harvesting of the biota can provide consumptive use benefits (e.g. building materials, foodstuffs, medicinals) *[Links to provisioning services]*	Difference in key biodiversity attributes of the wetland (e.g. extent of habitat suitable for specific wetland-dependent Red-listed species) with rehabilitation compared to without rehabilitation Recreation activities (e.g. bird watching) and opportunities with and without rehabilitation • Existing use of the wetland for recreation Willingness to pay for the above differences Official designation of the site (e.g. as a nature reserve)	Methods: SP, M Wetland abundance in the region and the size and uniqueness of the wetland in comparison with other nearby wetlands Key biodiversity attributes (e.g. provision of habitat for specific wetland-dependent Red-listed species) determined for the wetland without rehabilitation and then with rehabilitation Production function relationships (e.g. between fishery production and refugia or nursery functions or water fowl) *[Links to provisioning services]* Entrance fees to similar wetland-based nature reserves Estimates of willingness to pay for improvements as a result of the rehabilitation

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Provision of water for human use	Increased water supply and/or improved assurance of supply • Improved sanitation and health • Increased irrigation options and related nutritional and livelihood benefits	Difference in annual water store with and without rehabilitation Costs of built infrastructure to store the volume difference with and without rehabilitation Costs associated with securing alternative sources of the equivalent volume of water (e.g. time and costs to collect water from another source) Value of increased productive activities (e.g. increased number of crops grown, greater diversity of crops) Reduced health costs associated with improved sanitation	Methods: M, RC, SP Annual store of water in the wetland which is available for abstraction. This is firstly determined for the wetland without rehabilitation and then with rehabilitation. Sanitation and health information (e.g. frequency of illness, costs associated with illness) Uses of water and related productivity data (e.g. food production and diversity) Access to alternative sources of water, costs associated with alternative sources of water Socio-economic information of water users

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Provision of harvestable resources		Difference between the quantities harvested from the wetland with and without rehabilitation Cost of replacing the resource in order to make up for the above difference	Methods: M Volume of resources available for harvest from the wetland with and without rehabilitation and/or additional length of time resources are available for harvest with the rehabilitation (e.g. grazing available for a longer period into the dry season) Availability and/or access to alternatives or substitutes Price of harvested resources and/or prices of alternatives or substitutes (e.g. cattle feed) Socio-economic information of wetland users
Provision of cultivated foods	Improved food security – quantity and diversity of foods Increased livelihood opportunities (sale of cultivated foods)	Difference between the quantity of food produced from the wetland with and without rehabilitation Cost of replacing the food needed to make up for the above difference Value of increased livelihood opportunities (income from sale of additional quantities of foods)	Methods: M Quantities of foods produced from the wetland with and without rehabilitation and the timing of production (e.g. extended growing season with rehabilitation) Availability and/or access to alternatives or substitutes Price of cultivated foods and/or prices of alternatives or substitutes and costs associated with accessing alternatives (e.g. transport costs to purchase foods from shops) Socio-economic information of wetland users

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Cultural heritage	Enhanced cultural and spiritual experiences Enhanced sense of cultural heritage (non-use values)	Differences in attributes relevant to cultural heritage in the wetland with and without rehabilitation Willingness to pay for the above differences Costs associated with undertaking cultural and spiritual rituals at alternative wetlands	Methods: SP, TC Identification of differences with and without rehabilitation in attributes relevant to cultural heritage Surveys of people's preferences and willingness to pay for, or accept compensation for, cultural heritage benefits (on-site use) Preferences for and willingness to pay, by non-users for improved/maintained wetland condition (non-use values) Time and travel costs in visiting sites of cultural heritage Wetland abundance in the region and (cultural) uniqueness of the wetland in comparison with other nearby wetlands

Ecosystem service	Benefit outcomes	Examples of rehabilitation value indicators	Economic valuation methods and example data requirements
Economic valuation methods: AC – avoided costs; H – hedonic pricing; M – market based; RC – replacement cost; SP – stated preference; TC – travel cost			
Tourism and recreation	Enhanced tourism and recreation experiences Increased economic opportunities associated with tourism and recreation	Differences in attributes relevant to tourism and recreation in the wetland with and without rehabilitation Willingness to pay for the above differences Differences in number of tourists and their expenditure when visiting the wetland with and without rehabilitation Additional costs associated with accessing alternatives/substitutes Potential property value effects – difference in values of residences located near the wetland with and without rehabilitation due to improved tourism and recreation opportunities	Methods: TC, SP, M, H Identification of differences with and without rehabilitation in attributes relevant to tourism and recreation Tourism statistics, visitors spending and travel costs Socio-economic information of wetland users (tourists) Wetland abundance in the region and the size and uniqueness of the wetland (in terms of tourism attractions and recreation options) in comparison with other nearby wetlands – availability of similar alternatives Property prices over time and expert inputs from property valuers
Education and research	Knowledge, learning as a means of strengthening practice Awareness raising Capacity/skills development, eco-literacy	Differences in attributes relevant to education and research in the wetland with and without rehabilitation Willingness to pay for the above differences Value of spending on research and/or educational activities	Methods: SP, M Identification of differences with and without rehabilitation in attributes relevant to education and research Data on educational use and expenditure – records from visitor centres or schools and tertiary institutions, research expenditure, number of publications/research outputs

5.3.3 *Worked examples*

Building on the steps outlined in Chapter 5.3.2, additional information and suggestions to support the evaluation are outlined below and case study examples are provided in the boxes to illustrate the various steps.[10]

5.3.3.1 *Stage 1: Define and contextualize the economic evaluation*

The purpose of this stage is to identify priority ecosystem services associated with the rehabilitation and determine whether economic valuation is appropriate and feasible (affordable, data available, workable time frame) for valuing the identified ecosystem services and benefits.

A conceptual model or diagram is a useful way to describe the relationship between the wetland and people (human well-being) and how the relationship is expected to change with the rehabilitation intervention. This involves conceptualising the outcome (or benefit) pathway of the rehabilitation, the general relationship is illustrated in **Figure 5.2**. See **Box 4** for a case study example.

Wetland rehabilitation	Impacts on wetland condition and function	Changes in ecosystem services	Impacts on human welfare	Economic value of benefits
Physical and management interventions	*Recovery in wetland health/halting a decline in health*	*Measured as service supply with and without rehabilitation*	*Benefits associated with ecosystem services*	*Based on demand for the additional wetland services/benefits with the rehabilitation*

Figure 5.2: Benefit pathway of wetland rehabilitation[11]

The goal of the evaluation is to generate information relevant to decision-makers and stakeholders and those affected by the rehabilitation. Engage with stakeholders to establish:

- The purpose of the evaluation – what are the stakeholder/management objectives, how will the information be used, who is the target audience?
- Identify the intended rehabilitation goals and strategy.
- Define the study parameters (geographical and temporal).
- Ascertain the resources available for the assessment and the required level of detail and rigour.
- Establish what data/evidence/studies are available on which to base the evaluation.
- Identify and consult key stakeholders.
- Identify any alternatives – are there other options for addressing the threats to the wetland or alternatives for achieving the same goal?

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[10] The case studies used as examples are wetland rehabilitation evaluations undertaken as part of this WRC project. For more detail on the case studies, readers are referred to the case study reports by Walters et al. (2016) and Kotze and Cowden, (2018).

[11] Adapted from DEFRA (2011:22)

The extent to which ecosystems and their services benefit people depends on the physical, social and cultural, economic and political and institutional[12] context within which the wetland rehabilitation takes place.[13] **The context of the wetland rehabilitation must be considered.** This will assist in identifying ecosystem service potentials and dependencies and provide insight into the potential beneficiaries of the rehabilitation. Depending on the resources available, this could include a review of existing information (e.g. household census/survey data, wetland and hydrological studies; water quality and flow data) and stakeholder engagement (e.g. key informant interviews and focus group discussions).

Suggested questions and considerations to guide the evaluator in examining the socio-ecological context, catchment level contextual factors and biophysical context of the wetland rehabilitation are outlined below. The VSTEEP process (see Pollard et al., 2014) is an additional resource useful for undertaking an assessment of the context and draws attention to the social, technical, ecological, economic and political aspects of the wetland rehabilitation setting.

Suggested questions for considering the socio-ecological context of the wetland

- What is the current land use, around, upstream and downstream of the wetland?
- Who 'owns' (e.g. private, public, state) the wetland and who is responsible for its management?
- Do people live around and downstream of the wetland, how do they earn/make a living, what is their socio-economic status?
- How do people interact with and relate to the wetland and the associated aquatic system?
- What municipal services are provided in the area (e.g. piped water, waste collection, sanitation) and how reliable are they?
- What are the vulnerabilities of people, infrastructure, ecosystems and biodiversity in the area?
- What are the institutional and governance arrangements in the area; what social structures are in place?

How these factors are anticipated to change in future must also be considered (e.g. improved service delivery, urbanisation, out-migration). See **Box 2** for an example of a description of the socio-ecological context of a wetland rehabilitation project.

[12] "[Institutions are the] rules and conventions of society that facilitate coordination among people regarding their behaviour" (Bromley, 1989 cited by Vatn, 2005:10).
[13] Turner et al., 2008; Barbier et al., 2009; Keeler et al., 2012

Box 2 | Case study example: Socio-ecological context of wetland rehabilitation[14]

Manalana Wetland rehabilitation

The Manalana wetland is situated on the Manalana River, a minor tributary of the Sand River, in the upper Sand River Catchment. Craigieburn Village, which surrounds the wetland, falls within the Bushbuckridge Municipal Area (Ward 16) and is characterised as peri-residential.

Municipal and census information indicated that residents of the Bushbuckridge Municipal Area were vulnerable: employment rates were low, poverty rates were high, household incomes were lower than the province average and social grants (old age, child support and disability grants) were a primary source of income for many households. The Municipality was characterised by political instability and a backlog in service delivery. While 79% of households could access piped water, either from their own property or a communal stand (StatsSA, 2012), the quantity and quality of water was not always sufficient. As a result, residents of Bushbuckridge often had limited access to sufficient good-quality water (Mayher and Raab, 2008) which placed additional pressure on women, as caretakers of the family, and affected the "social fabric of the community in general" (Mayher and Raab, 2008:115).

The natural environment of the Bushbuckridge Local Municipality played an important role in providing services to the residents (Bushbuckridge Municipality, 2014). For example, when water was not available, community members utilised alternative means of gathering and storing water, such as boreholes and rivers (Mayher and Raab, 2008).

Tourism and agriculture had been noted as key sectors for growth and employment opportunities (Bushbuckridge Municipality, 2014).

The Craigieburn Village is a communal area comprising residences, subsistence agriculture and grazing land (Ngetar, 2011). The slopes surrounding the Manalana wetland contain grazing land and agricultural fields, with homes accompanied by household gardens situated on the flatter areas and ridges. The wetland is accessible to the residents of Craigieburn; households are located within 400 metres of the wetland.

A household survey found that approximately 70% of Craigieburn residents used the wetland in some way to meet their livelihood needs, with the predominant group of wetland users being women (Pollard et al., 2008). The women were predominantly between 35 and 70 years of age, and used the wetland to grow food. Hunger was cited as a primary driver of wetland crop cultivation. The wetland provided a safety-net for the residents of Craigieburn Village, particularly for the poor, and was estimated to have contributed to 40% of the food grown locally (Pollard et al., 2008).

[14] See Case Study Report (Walters et al., 2016) for additional detail and references.

Attention should be given to catchment level contextual factors[15] *including:*

- The proximity of the wetland to human settlement and accessibility of the wetland to humans;
- Land use and local industries (farming, mining, tourism) in the vicinity of and downstream from the wetland;
- The size and uniqueness of the wetland in comparison with other nearby wetlands;
- Anticipated changes in human factors in the catchment in the foreseeable future (urban expansion, change in farming practices, increasing nature conservation, road building, river management and so on);
- Conservation schemes within or near the wetland;
- Effluent discharge or nutrient seepage into a river upstream or downstream of the wetland;
- Known or historical problems with the water environment (pollution of the river, flooding episodes).

Suggestions for considering the biophysical context of the wetland

Attention must be given to the type, size, location and health of the wetland and the impacts and threats to the wetland. The conservation status of the region/biome, the extent of intact wetland areas in the region and the uniqueness of the wetland in relation to nearby wetlands must also be considered.

The rehabilitation objective/s and strategy must be identified, including:

- The time frame of the implementation;
- The anticipated life of the rehabilitation; and
- The likely maintenance and management requirements.

See **Box 3** for an example of a description of the biophysical context of the wetland rehabilitation.

[15] Turner et al. (2008)

Box 3 │ Case study example: Biophysical context of wetland rehabilitation

Xharas Wetland Rehabilitation

Xharas wetland, a hillslope seepage transitioning into a valley bottom, is 8 ha in size and located in a valley head position in the Kamiesberg Uplands in the Northern Cape. The Kamiesberg Uplands is a global biodiversity hotspot and a centre for plant endemism within the Succulent Karoo biome. It is also an important high water-yield area, with an annual rainfall of 300-400 mm, in contrast to 100 mm or less in the semi-arid lower-lying areas. Wetlands within the Kamiesberg Uplands have been identified as special habitats in need of particular conservation attention, in view of their very high levels of cumulative transformation/impact, importance in terms of biodiversity conservation and as water sources (Helme and Desmet, 2006; Marsh et al., 2009). Therefore, any wetlands with intact areas remaining are considered particularly important for conservation and rehabilitation.

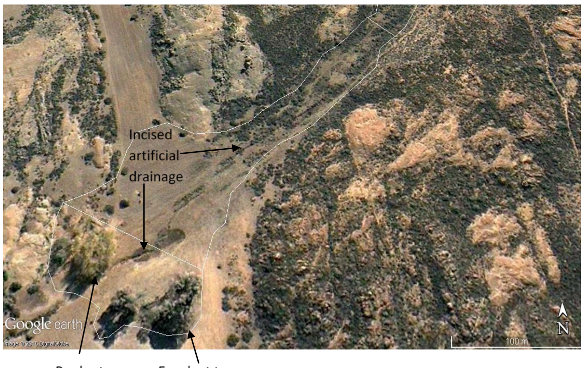
Xharas wetland was identified as still containing a reasonable extent of intact area of wetland compared with many other more transformed wetlands in the Kamiesberg Uplands. Furthermore, it is also in close proximity to other intact wetland areas, notably the Ramkamp wetland, which is one of the most intact and floristically diverse wetlands in the Kamiesberg Uplands (Malan, 2010a and b). Even so, extensive areas of the Xharas wetland had been degraded, and when assessed in 2010 prior to rehabilitation, the wetland had been subject to several impacts, including the following:

- Flow had become more concentrated and the level of wetness reduced by incised artificial drainage channels that extended through two large proportions of the wetland;
- In the upper portion of the wetland, eucalypt and poplar trees had outcompeted the indigenous vegetation, significantly reducing the level of wetness of the area, and localised trampling by livestock had further added to impacts upon the vegetation; and
- Historical cultivation appeared to have disturbed the whole wetland in the past, with some of the wetland continuing to be cultivated up until 2010.

In response to the above issues, a **wetland rehabilitation objective** was set to re-instate near-natural hydrological conditions and enhance the integrity of the wetland area in order to have generally improved its value for biodiversity conservation, the provision of natural resources and ecosystem services. In order to achieve the above rehabilitation objective, the following **rehabilitation strategies** were devised:

- Halt the continued erosion within the incised channel and reduce the extent to which flow is artificially constrained in the channel, by means of a series of structures in the channel;
- Remove the invasive alien trees within the wetland; and
- Shift the track currently located inside the wetland to outside the wetland.

Box 3 | Case study example: Biophysical context of wetland rehabilitation



The upper portion of Xharas wetland shown in 2010 prior to the rehabilitation (image on left) and in 2014 after the rehabilitation (image on right).

A conceptual model is useful for conceptualising the ecological consequences of the proposed rehabilitation intervention and translating the ecological changes into human well-being impacts. It assists in identifying the key ecosystem service impacts of the rehabilitation and modelling/monitoring and data collection requirements to provide evidence on which to base the evaluation. The conceptual model should be developed at the outset of assessment, but allow for refinement throughout the process as more information becomes available and the context of the rehabilitation is better understood. Several activities can be used to develop a conceptual model of the rehabilitation benefit pathway such as expert and/or stakeholder workshops, scoring or ranking approaches using participatory-based methods, observation, key informant interviews and focus groups.[16] Diagrams or mapping exercises are a useful way to capture and illustrate the various relationships. A case study example of this stage of the evaluation is provided in **Box 4**.

[16] Ginsberg et al. (2010) and DEFRA (2011) provide guidance on developing a conceptual 'system' model.

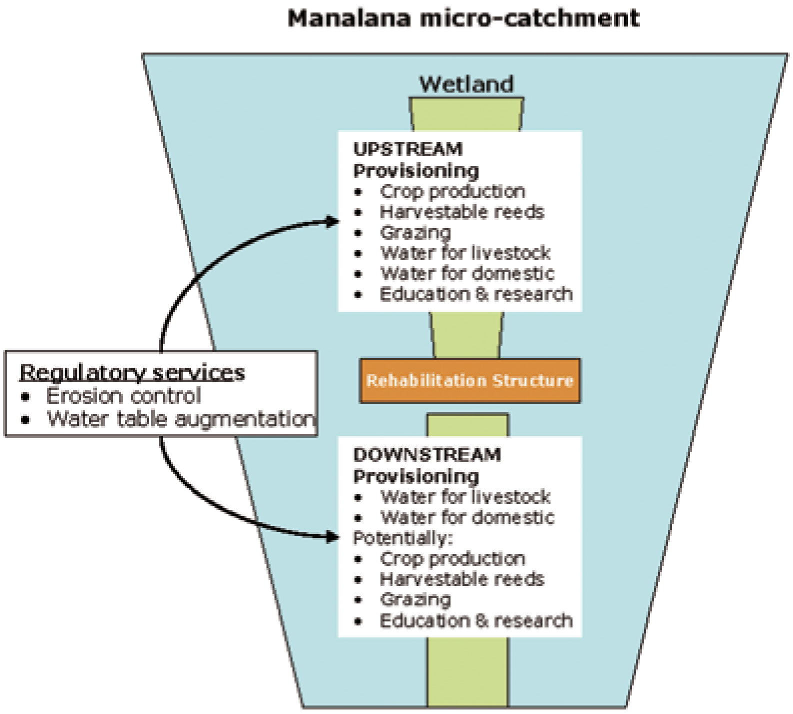
Box 4 | Case study example: Conceptualising the anticipated wetland response and benefits

Manalana Wetland Rehabilitation

Pre-rehabilitation surveys highlighted crop production (especially madumbe, *Colocasia esculenta*, which is particularly reliant on abundant soil moisture), reed harvesting and livestock watering and grazing as key livlihood strategies asscociated with the wetland.

A conceptual analysis, illustrated in a diagram, showed how wetland (field) area could be lost through continued erosion as a result of the advancing headcut and identified a threat of desiccation of the wetland and wetland fields and the resulting impact on crop production and natural resource yields from erosion.

It was projected that the rehabilitation of the wetland would halt the erosion and reduce the threat to wetland-based livelihood activities. The rehabilitation was expected to improve two key regulatory ecosystem services which in turn would improve a number of provisioning services both upstream and downstream. Given the local context of resource-poor households who rely on the wetland as part of their livelihood strategies, an increase in the level of provisioning services is likely to be valued by the households.



Schematic representation of the livelihood benefits of physical rehabilitation of the Manalana Wetland (Pollard et al., 2008)

Together, the conceptualisation of the rehabilitation outcomes and the understanding of the socio-ecological context of the rehabilitation supported the identification and prioritisation of key wetland services and benefits for assessment. Given the vulnerability of the community, the importance of the wetland as a livelihood strategy and the role of the rehabilitation in securing the wetland and the associated livelihood benefits were clear.

From this stage of the evaluation, the following should be identified:

- The ecosystem services and benefits most likely to be affected, or that were affected, by the rehabilitation intervention;
- The data/evidence available on which to base the evaluation (e.g. water quality and flow data; surveys of household use of wetland resources such as grazing and reeds);
- Any benefits foregone and dis-services introduced as a result of the wetland rehabilitation; for example, re-wetting of a wetland might result in the loss of grazing and cropland, increased difficulty of crossing a wetland and greater incidence of mosquitoes; and
- Key stakeholders (e.g. beneficiaries and 'losers', landowners, those responsible for the management of the wetland, role players – see Chapter 4.1).

From this information, the evaluation team must decide on the most suitable approach for assessing the benefits of the rehabilitation, based on the stakeholder and management objectives, context of the wetland rehabilitation and available resources. The approach can range from a rapid qualitative or expert judgment-based assessment on ecosystem service supply and demand, to a detailed evidence-based (e.g. supported by long-term monitoring) assessment and economic valuation of multiple ecosystem services.

Certain ecosystem services and their benefits are more amenable to economic valuation than others (e.g. provisioning service benefits such as grazing and reeds versus cultural or spiritual benefits). It is **essential at this point to consider whether undertaking an economic valuation analysis is appropriate and feasible** based on the types of ecosystem services affected by the rehabilitation and the data and resources available. See **Box 5** and **Box 6** for case study examples.

If proceeding with an economic valuation, an approach appropriate for capturing the effects of the rehabilitation intervention on the priority ecosystem services should be developed (e.g. data collection activities, stakeholder consultation). Valuation methods suitable for valuing the changes in the priority services and benefits must be selected, and data requirements for each method must be ascertained to inform data collection and monitoring. **Table 5.3** outlines wetland ecosystem services, benefits, value indicators and economic valuation methods; a note on data requirements and considerations is also included. A brief overview of economic valuation methods is provided in **Box 16** and additional detail is given in Appendix 3.

Box 5 | Case study example: Is economic valuation feasible, appropriate and relevant?

The **Manalana Wetland** rehabilitation illustrates many of the conditions for a feasible economic valuation study.

- **Clear rehabilitation objectives related to a human benefit outcome:**
    - Objective: Stop sediment from entering the wetland system and halt the actively advancing erosion headcut.
    - Rationale for prioritising the wetland: The wetland is important for direct water supply to the community; flow regulation to downstream water users; erosion control and sediment retention within the wetland; and in the supply of several provisioning services on which local livelihoods depend.
- **Wetland dependence/benefits:** evidence of reliance on the wetland by resource poor households; an assessment of the livelihood benefits of the wetland was conducted prior to rehabilitation.
- **Threats to the wetland and clear human well-being impacts of further wetland degradation:** evidence of existing erosion, other wetlands in the catchment that have experienced severe erosion, threat to livelihoods in the case of further wetland degradation.
- **Feasible:** existing research and data on the wetland including pre-rehabilitation social surveys, and assessments of wetland health and ecosystem service supply and on-going hydrology, geomorphology and vegetation studies, together with resources available for the evaluation team to do a post-rehabilitation rapid assessment of wetland health and wetland use (focus groups, crop field and reed harvesting measurements, fodder condition), facilitated a comparison of the **"with" and "without" rehabilitation cases allowing the added value of the rehabilitation to be isolated.**
- **Appropriate:** wetland resources and crops are traded locally and market prices exist for use in an economic valuation.

The evaluation also highlighted other wetland benefits, not easily assigned a monetary value, for example the wetland provides an 'insurance' strategy – the opportunity to use the wetland in future even if not used now – for future household shocks (e.g. job loss, death of household member).

Box 6 | Case study example: Is economic valuation feasible, appropriate and relevant?

The **Greater Edendale Mall Wetland** rehabilitation illustrates a case where it was considered not feasible to proceed with economic valuation.

The primary aim of the wetland rehabilitation project was to address the impacts of the development of a shopping mall on the (existing) wetland habitat. The primary objective of the project was to improve the conditions within the onsite wetland, so as to improve the integrity of the system. The principal benefit associated with this objective was the contribution of the rehabilitation to critical habitat maintenance (no nett loss). This is a broad benefit to which it is difficult to assign a specific economic value.

The water quality enhancement contribution of the wetland was explored as an additional benefit. The results of the water quality monitoring programme (pre-, during and post- rehabilitation) and the wetland health and ecosystem services assessments (pre- and post-rehabilitation) were interrogated.

> Estimating the value of the water quality enhancement service of a wetland relies on a well-planned, water quality monitoring programme that extends both upstream and downstream of the wetland, identification of upstream water pollution sources and consideration of the downstream environment and use of water. Both water pollutant concentration and water flow data are required to estimate the pollutant loads and the amelioration capacity of the wetland. This must be determined for both the 'without' rehabilitation' and the 'with' rehabilitation scenarios.

In order to have accurately assessed the improved water quality enhancement service with the rehabilitation of the Greater Edendale Mall wetland, flow data was required to calculate pollution loads. Flow data was not collected at the time of water quality sampling. Therefore, pollution loads could not be determined and economic valuation of this service was considered too uncertain without some measured evidence of changes in pollution loading as a result of the rehabilitation.
The evaluation of the rehabilitation demonstrated that the objectives of the wetland rehabilitation had been achieved, and the benefits of the rehabilitation were still being derived approximately six years after implementation. The evaluation also highlighted that the habitat diversity and integrity of the wetland was at risk if the appropriate management and maintenance activities were not implemented at the appropriate times. Appropriate recommendations were made to the Mall management.

In this case, assigning a low confidence economic value to the potential water quality enhancement service would not have provided meaningful additional information to inform the evaluation outcomes and recommendations.

5.3.3.2 Stage 2: Assess the capacity of the wetland to provide ecosystem services with and without the rehabilitation

The purpose of this stage is to determine the provision of ecosystem services by the wetland without rehabilitation and then with rehabilitation. Both the 'with rehabilitation' and 'without rehabilitation' alternatives must be assessed.

This step may make use of qualitative, semi-quantitative, quantitative assessments or a combination thereof. The supply of ecosystem services can be measured quantitatively (e.g. a reduction in the load (kg) of nitrogen between the wetland inflow and outflow) or a 'scoring' approach can be taken (e.g. 0 to 5 reflecting low to high ecosystem service supply). For example, a WET-EcoServices (Kotze et al., 2007) assessment can be undertaken for both the 'with' and 'without' rehabilitation scenarios to assess the relative changes in the level of functioning of the wetland system. See Chapter 5.4.1 for additional detail on the WET-EcoServices tool. Case study examples illustrating different approaches to assessing the change in the capacity of the wetland to provide ecosystem services with the rehabilitation are provided in **Box 7**, **Box 8** and **Box 9**.

Depending on whether the evaluation is undertaken before the rehabilitation intervention (based on predicted changes) or after the rehabilitation intervention and whether and to what extent changes in the wetland are measured and monitored (e.g. pollutant load monitoring over time), this phase may continue over several years and include multiple data collection stages and/or routine monitoring**.** A baseline from which to assess change is critical and the baseline situation and data collection in terms of the pre-rehabilitation situation is an important consideration. **However, the economic valuation analysis must be based on the 'with' rehabilitation and 'without' rehabilitation alternatives, rather than the 'with' rehabilitation and 'pre-rehabilitation' cases to account for the likely continued degradation of the wetland without rehabilitation.**

Box 7 | Case study example: Manalana Wetland Rehabilitation evaluation – Assessing the supply of provisioning services for the 'with' and 'wetland' rehabilitation alternatives

Madumbes (*Colocasia esculenta*), internationally known as taro, are the principal crop grown in the wetland fields. Two factors were considered in evaluating the supply of the crop cultivation service: the extent (number and area) of wetland fields, and the yield of madumbes (kg/m^2) with and without the rehabilitation. Rather than increasing the capacity of the wetland to supply this service, the rehabilitation aimed to prevent a future decline in capacity as a result of further erosion.

An assessment of the post-rehabilitation (2015) madumbe crop production was undertaken and compared to the pre-rehabilitation assessment (2008), to give an indication of whether crop production had declined, improved or been maintained since the pre-rehabilitation case.

Mapping and in-field verification indicated that there had been no significant change in the wetland area available for cropping since the pre-rehabilitation assessment suggesting that no fields had been lost to erosion. Farmer interviews confirmed that the number of wetland fields remained the same as that recorded pre-rehabilitation. Madumbe yields were calculated and compared to the pre-rehabilitation estimates and to similar studies. The results indicated that there had been no change in madumbe yield from the pre-rehabilitation levels, suggesting that the wetland rehabilitation activities had succeeded in securing the crop production potential of the wetland.

Average Madumbe yield (kg/m^2)		Method
Post-rehabilitation (2015)	2,5	Calculated from in-field observation and farmer interviews
Pre-rehabilitation (2008)	2,5	Calculated from household survey (Pollard et al., 2008)
Similar study (Kotze et al., 2002)	2,5 to 3,5	Literature

A similar comparison was done for the supply of wetlands reeds (for making into reed mats) and grazing potential (source of livestock fodder during the dry season) which showed no significant change in the supply of these services suggesting that the rehabilitation efforts had secured the potential supply of reeds and livestock fodder for use by the local residents.

Note: This ecosystem service 'supply' assessment compared the pre-rehabilitation and post-rehabilitation cases to provide 'evidence' that the rehabilitation had prevented a decline in the potential supply of services by the wetland. In the valuation assessment the 'with' (the post-) rehabilitation case was compared to the 'without' rehabilitation alternative which projected a decline in the potential supply of ecosystem services in the case of continued degradation which would occur without the rehabilitation.

Box 8│ Case study example: Edendale Mall Wetland Rehabilitation evaluation, ecosystem services scores for the 'with' and 'without' rehabilitation cases			
Ecosystem services	**Without rehabilitation**	**With rehabilitation**	**Notes**
Flood attenuation	2.3	2.4	The effectiveness of the wetland to attenuate floods was improved by an increase in surface roughness and the promotion of diffuse flows that spread across the wetland.
Stream flow regulation	3.0	3.0	The provision of stream flow regulation services remained unchanged as the extent of different hydrological zones was not altered by the rehabilitation.
Sediment trapping	2.0	2.6	The effectiveness of the wetland to trap sediment was increased by the improved ability of the wetland to attenuate floods and the direct evidence of sediment trapping within the post-rehabilitation landscape.
Phosphate trapping	2.6	2.9	The effectiveness of the wetland to trap phosphates was increased by the improved ability to trap sediments and the promotion of diffuse low flow patterns.
Nitrate removal	3.1	3.3	The effectiveness of the wetland to remove nitrates was improved by the promotion of diffuse low flow patterns.
Toxicant removal	2.7	3.2	The effectiveness of the wetland to remove toxicants was increased by the improved ability to trap sediments and the promotion of diffuse low flow patterns.
Erosion control	2.3	2.6	The effectiveness of erosion control was improved by the increase in surface roughness. In addition, direct evidence of erosion and the level of soil disturbance in the wetland were lower in the post-rehabilitation landscape.
Carbon storage	2.3	2.7	Carbon storage in the wetland was improved by decreasing the level of soil disturbance within the wetland.
Biodiversity maintenance	1.1	1.4	Biodiversity integrity was improved through the removal of alien invasive plant species and the establishment of indigenous species.
Water supply	1.3	1.2	The use of water supplied by the wetland decreased due to the area becoming private land that is no longer accessible to the public within the post-rehabilitation landscape.
Harvestable goods	1.0	0.6	The provision of harvestable goods decreased due to the area becoming private land that is no longer accessible to the public within the post-rehabilitation landscape.
Cultivated goods	0.0	0.0	No change.
Socio-cultural significance	0.0	0.0	No change.
Tourism and recreation	0.0	0.7	The provision of tourism and recreation services was increased by the improvement in the aesthetics of the wetlands and the increased extent of open water.
Education and research	1.0	2.0	The opportunity for research was improved by the research project to develop a wetland rehabilitation monitoring and evaluation framework.

Box 9 │ Case study example: Xharas Wetland Rehabilitation evaluation – Summary of the effect of the rehabilitation on the supply of ecosystem services[17]					
Ecosystem services	**Spatial extent of wetland[18]**	**Effect of the rehabilitation interventions on the supply of the service**	**Level of functional enhancement within affected area**	**How widely the benefits supplied by the wetland might be experienced**	**Level of confidence in the assessment**
Streamflow regulation	2.9ha	The removal of the eucalypt trees around the spring in Unit 1, in particular, as well as plugging the artificial drain running through the area has contributed significantly to improving the downstream supply of water.	Moderate	8 km downstream given the small size of the wetland and small volume supplied by the spring, although sustained	Moderately low
Groundwater recharge	2.9ha[19]	The particular geological and geomorphological setting appears to favour groundwater recharge. See accompanying text.	Moderately high	Local area rather than the regional water table. Based on a very coarse approximation this local area is taken as a 300 m radius around the wetland.	Moderately low
Phosphate assimilation	2.9ha	Through more diffuse water flow and the greater sediment deposition, the effectiveness of the wetland for assimilating phosphates was increased.	Moderate	8 km downstream	Moderate
Direct water supply for livestock	0.2 ha	Prior to rehabilitation interventions the spring had not dried up, but the removal of the eucalypt trees around the spring in Unit 1 is likely to contribute positively to assurance of supply from this spring.	Moderate	2 km radius around the wetland	Moderately high
Grazing for livestock	2.9 ha	As explained in the accompanying text, the increased plant growth in the wetland resulting from greater water storage in the wetland has contributed positively to the provision of livestock grazing.	Moderate	1 km radius around the wetland	Moderate
Maintenance of biodiversity	2.9ha	The importance of wetlands generally in the Kamiesberg Uplands for maintaining biodiversity is particularly high, and the improved integrity of the rehabilitated areas within the Xharas wetland are therefore assumed to have a significant contribution to biodiversity.	High	10 km radius around the wetland	Moderately high

[17] Note, no disservices were noted resulting from the rehabilitation.

[18] This refers to the spatial extent of wetland supplying the service which has been affected by the rehabilitation interventions.

[19] This service is likely to be supplied from an area somewhat larger than the 2.9 ha wetland, and would include the surrounding non-wetland foot-slope areas.

5.3.3.3 Stage 3: Assess the current and future demand for the ecosystem services and associated benefits

An evaluation of the benefits of the wetland rehabilitation must consider the demand for the priority ecosystem services and their benefits; see **Box 10** for an explanation of ecosystem service demand.

Box 10│ Ecosystem service demand[20]
An ecosystem service (e.g. water quality enhancement) is only a (human) benefit if there is a demand (desire) by people for the service. There must be a current or future 'beneficiary' of the service. Ecosystem services are not necessarily 'used' or demanded in the same location as they are produced (e.g. ecosystem services provided by wetlands might only be used downstream from the wetland). Understanding the demand for ecosystem services can be complicated by the fact that people are not always aware that they are 'using' or benefitting from ecosystem services. Demand can change over time and space, independent from actual ecosystem service supply. Key factors affecting the demand for wetland ecosystem services and benefits include: • The socio-economic status of the local or regional population; population vulnerability and distribution • Personal preferences (e.g. a preference for madumbe vegetables grown in wet areas rather than those grown under irrigation) • Access to alternatives (other options or ways of attaining the same benefit at a similar cost) • Future infrastructure development (e.g. housing, roads, water and sanitation) • Uncertainty – climate change, political and economic setting. Potential demand for ecosystem services and benefits in future should be considered. For example, the provisioning services of wetlands (e.g. grazing, reeds, crop cultivation) may only be used during times of stress such as when a household member becomes sick or unemployed. The regulatory services of wetlands (e.g. water quality enhancement and flood attenuation) become increasingly important as infrastructure development and population pressures increase.

To assess the demand for ecosystem services, information on their use (current and future desired use), or indicators of their likely use, is needed. Ecosystem service demand assessments are generally based on population numbers and population dependency and ecosystem services use patterns. This information can be obtained from census data, social and economic assessments and interviews. Dependency can be gauged by considering whether the 'beneficiaries' have access to other options or ways of attaining the same benefit (e.g. alternative sources of irrigation water) at a similar cost. The socio-economic status and vulnerability of the beneficiaries and information on the context identified in stage 1 are important in this regard.

[20] Adapted from Burkhard et al. (2012)

Indicator and scoring approaches are useful ways of summarising information on ecosystem services and benefit demand, particularly when it is not possible or feasible to quantify demand through primary data collection, see **Box 11** for a case study example.

Box 11│ Case study example: Assessing the demand for ecosystem services
The evaluation of the **Xharas Wetland** rehabilitation illustrates a rapid ecosystem services demand assessment. The demand assessment involved referring back to the information gathered in Stage 1, in particular: (1) the proximity of the wetland to human settlement and accessibility of the wetland to humans, and (2) the land-use and property rights/land tenure upstream, within and downstream of the wetland. The approximate number of individuals benefiting from the enhanced provision of the service was given very coarsely in terms of orders of magnitude (i.e. 1, 10, 100, 1000, >1000 individuals). Some indication of the **level (low, medium, high) of vulnerability/dependency** of the above individuals was also provided by considering the following: • Uniqueness of the wetland with respect to the supply of services; • Availability of other sites to supply the services provided by the wetland in question. For provisioning services this would generally depend on the availability of other/another similar wetland/s nearby which are accessible and are as secure in terms of tenure; • Availability of alternatives provided by built infrastructure/municipal services. Such alternatives would generally be less available in rural areas than urban areas; • The socio-economic status of the individuals – generally speaking, poor people have fewer alternatives available to them than people who are materially better off. **Desktop sources of data** included the following: • Stats SA (census data, level of municipal service supply); • Municipal reports – development plans, zoning; • Tourism statistics from relevant governmental departments – for recreation/tourism related use/demand which would have been adjusted to the specific study area; • Rainfall data and trends – useful in gauging opportunity for flood attenuation and flow regulation services.

Based on this information, the demand for individual ecosystem services was 'scored' (low to high) and summarised in a table.

Ecosystem service	**The number of individuals benefiting[1]**	**Vulnerability/ dependency of these individuals**	**Current overall demand for the service[2]**	**Projected future demand for the service**	**Level of confidence in the assessment**
Streamflow regulation	100	Moderate	Moderately high	Moderately high[3]	Moderately low
Groundwater recharge	100	Moderate	Moderately high	Moderately high[3]	Low
Phosphate assimilation	10	Moderate	Moderate	Moderate	Moderate
Direct water supply for livestock	100	High	High	High[3]	Moderately high
Grazing for livestock	10-100	Moderate	Moderately high	Moderate[3]	Moderate
Biodiversity maintenance	>1000	Low	High	High	Moderately high

[1]The approximate number of individuals benefiting from the enhanced service provision (i.e. 1, 10, 100, 1000, >1000)
[2]Based on the approximate number of individuals benefiting and vulnerability/dependency of these individuals
[3]Potentially increasing from current levels as a result of greater extremes of predicted climate change

In the case of an economic valuation, assessing the demand for ecosystem services and benefits will depend on the types of ecosystem services and benefits being considered and the valuation methods selected. Information on beneficiary numbers and dependency and ecosystem service/benefit use patterns are essential. In this case, actual or desired 'use' is measured quantitatively for example the amount of wetland resources harvested, the amount (kg) of sediment retained by the wetland, the amount spent on alternatives to improve water quality or prevent downstream flooding. Again, this is done for both the 'with' and 'without' rehabilitation cases.

Box 12 summarises the types of data collected for a cost-benefit analysis of a wetland rehabilitation based on the livelihood benefits of the wetland, including the collection of information on wetland use (crop cultivation, reeds harvested, livestock grazed) and dependency (e.g. access to alternatives).

Box 12│ Case study example: Cost-benefit analysis – Data collection
During the evaluation of the **Manalana Wetland** rehabilitation both ecological and socio-economic data were collected and compared to baseline data from before the wetland was rehabilitated. This data was used to inform a cost-benefit assessment of the livelihood benefits (crop cultivation, reed harvesting, livestock grazing) of the wetland rehabilitation. **Data collection activities included:** • Desktop review of existing information for the site and municipal area; • Application of the VSTEEP tool to generate an understanding of the Social, Technical, Economic, Environment and Political context; • Spatial mapping of the wetland and livelihood activities; • Wetland level data collection for the application of the WET-Health, WET-EcoServices and WET-SustainableUse techniques; • Field level measurements and farmer interviews to collect data on the number and size of the cultivated plots within the wetland, areas, extent and timing of reed harvesting, livestock numbers and areas and timing of livestock grazing, types of crops cultivated and yields and cultivation practices; and • Focus group sessions to explore wetland service use and dependency, local perspectives on the rehabilitation and the local context (including service delivery and household vulnerability) and obtain data on crop production and reed harvesting details, crop and reed sales, household consumption/use and input costs. **Baseline (pre-rehabilitation) socio-economic data:** In this case study, research conducted prior to the rehabilitation (in Pollard et al., 2005) provided a socio-economic baseline for the evaluation and included information on (a) household characteristics of wetland users; (b) use of the wetland; (c) length of time in use; (d) field and plot information; (e) well-being status of users; (f) means of access; (g) livelihood contributions; and (h) questions relating to perceived wetland health. An assessment of cultivation practices, the characteristics of crop fields and estimates of cropped area, yields and sale prices were also undertaken prior to rehabilitation (Pollard et al., 2008).

5.3.3.4 Stage 4: Compare the supply and demand for priority ecosystem services and benefits for the ‘with’ and ‘without’ rehabilitation alternatives

The purpose of this stage is to gauge the benefits of the wetland rehabilitation by comparing the supply and demand for priority ecosystem services and benefits for the <u>‘with’ and ‘without’ rehabilitation alternatives</u>. This can be done as an **index-based comparison of ecosystem supply and demand** as measured on a relative scale or through applying **economic valuation methods** to assign an economic value to the wetland benefits. This is done for both the ‘with’ and ‘without’ rehabilitation cases to establish the specific contribution of the rehabilitation.

Note: In practice, ecosystem service ‘supply’ assessments are often undertaken for the pre-rehabilitation (baseline) and post-rehabilitation case, particularly in the case of a post-rehabilitation evaluation. However, for the economic assessment the ‘with’ (the post-) rehabilitation case must be *compared to the 'without' rehabilitation alternative to account for a likely decline in the potential supply of ecosystem services by the wetland in the case of continued degradation which would occur without the rehabilitation.*

For an index-based comparison:[21]

- The relative supply and demand for each of the priority ecosystems services are assigned a score (separately) on a scale, for example 0 (no relevant supply or demand) to 5 (maximum relevant supply or demand).
- The supply assessment and the demand assessment are compared (e.g. by subtracting 'demand' from 'supply') to calculate a relative supply/demand index. This is done for both the 'with' rehabilitation and 'without' rehabilitation alternatives.
- The relative supply/demand index (scores) for the 'with' and 'without' rehabilitation alternatives are compared.

In this type of assessment, the relative supply/demand index reflects 'risk' in terms of demand exceeding supply. A reduction in this 'risk' as a result of the rehabilitation (i.e. a higher score for the relative supply/demand index for the 'with' rehabilitation alternative) indicates the contribution of the rehabilitation. A simplified example is provided in **Box 13** to illustrate the approach.

[21] Burkhard et al. (2012) present a detailed description and application of a relative supply-demand scale approach to ecosystem service evaluation.

Box 13 | Illustrative example: Index-based ecosystem service supply – demand comparison

The tables below illustrate the outcomes of an index-based ecosystem service supply – demand assessment. To establish the contribution of the rehabilitation the 'without' rehabilitation and the 'with' rehabilitation cases were compared. In this example, it has been assumed that the demand for ecosystem services has not changed between the 'with' and 'without' rehabilitation cases. In the 'with' rehabilitation alternative, the supply scores are higher compared to the 'without' rehabilitation alternative and consequently the relative supply/demand scores have increased. This suggests that the risk of ecosystem demand exceeding supply (for the specific ecosystem services) has been reduced through the rehabilitation efforts. In the 'without' rehabilitation alternative, ecosystem service supply was lower than demand for six ecosystem services, whereas, 'with' rehabilitation supply now equals demand for three of these services.

WITHOUT WETLAND REHABILITATION			
Ecosystem service	**Relative supply index**	**Relative demand index**	**Relative supply/demand index**
Streamflow regulation	2	4	-2
Groundwater recharge	3	4	-1
Phosphate assimilation	2	3	-1
Direct water supply for livestock	2	5	-3
Grazing for livestock	2	4	-2
Biodiversity maintenance	4	5	-1

WITH WETLAND REHABILITATION			
Ecosystem service	**Relative supply index**	**Relative demand index**	**Relative supply/demand index**
Streamflow regulation	3	4	-1
Groundwater recharge	4	4	0
Phosphate assimilation	3	3	0
Direct water supply for livestock	3	5	-2
Grazing for livestock	3	4	-1
Biodiversity maintenance	5	5	0

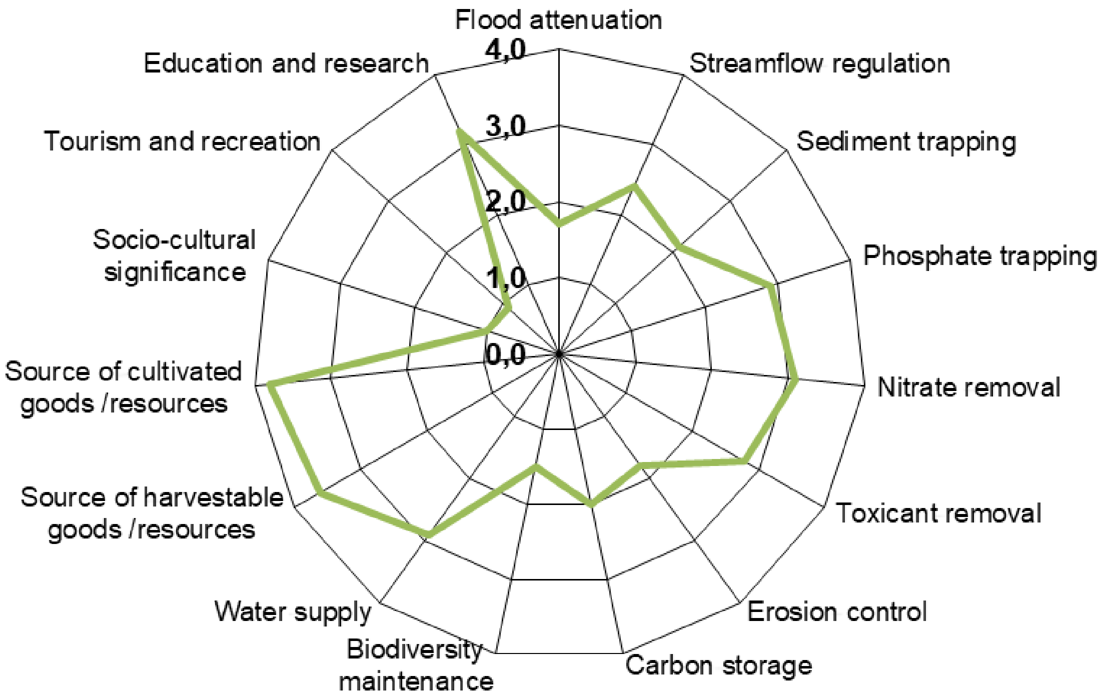
Burkhard et al. (2012) present a detailed description and application of a relative supply-demand scale approach to ecosystem service evaluation.

A second option for evaluating the benefits of wetland rehabilitation is to apply **economic valuation methods** to assign economic values to the benefits of the wetland. Again, this must be done for both the 'with' and 'without' rehabilitation alternatives to establish the specific contribution of the rehabilitation. Certain ecosystem services and their benefits are more amenable to economic valuation than others and an economic valuation analysis is unlikely to capture all the values associated with the wetland. It is important to identify as many benefits (and non-benefits) as possible and then clearly indicate which have been included in the economic valuation. See **Box 14** for a case study example.

Box 14 | Case study example: Identifying a range of potential wetland services and benefits

Manalana Wetland rehabilitation

A WET-EcoServices assessment of the Manalana Wetland identified that the wetland had the capacity to supply a range of ecosystem services as illustrated in the diagram below.



Given the importance of the wetland as a livelihood strategy for the surrounding community and the objectives of the rehabilitation, the economic evaluation focused on the benefits associated with the wetland as a source of cultivated goods (crops) and harvestable resources (reeds and livestock grazing). Only these benefits were compared in a cost-benefit analysis, however the evaluation clearly identified other potential benefits and emphasised that the cost-benefit analysis findings were based only on a sub-set of benefits which underestimated the total value of the rehabilitation.

Approaches to economic valuation can be separated into *primary economic valuation*, which involves the collection of data specific to the wetland, services and beneficiaries under consideration, or *secondary valuation* which involves using values estimated in other studies of similar wetlands and in a similar biophysical and social context (generally referred to as a benefit or value transfer approach).

There are several economic valuation methods; some are more suited to specific ecosystem service benefits than others and the rationale behind the selection of valuation methods must be given. There is much literature on ecosystem service and benefit valuation methods; **the protocol developed by**

Turpie and Kleynhans (2010) for the quantification and valuation of wetland ecosystem services is a valuable resource.[22] While the focus of the protocol is not specifically on assessing the changes in ecosystem services with a rehabilitation intervention, the principles and methods for assessing, measuring and valuing wetland related ecosystem services and benefits are relevant. The protocol provides guidelines on the valuation of the provision of natural resources; flow regulation; water quality amelioration; recreation and tourism; scientific and educational value; and cultural, spiritual and existence value.

Each of the wetland ecosystem services outlined in the WET-EcoServices assessment technique (Kotze et al., 2007, see Chapter 5.4.1) is linked with potential benefits, economic value indicators and suitable economic valuation methods in **Table 5.3**; a note on data requirements and considerations is included. A brief overview of economic valuation methods is provided in **Box 15**; see Appendix 3 for additional detail.

Box 15 | Overview of economic valuation methods for ecosystem services

Primary economic valuation methods are generally described under three broad categories:

Market-based methods:

Market-based methods are used to estimate economic values for ecosystem services and benefits that are bought and sold (traded), or for ecosystem services or goods that are 'inputs' in the production of products or services that are bought and sold. Market-based valuation methods make use of existing market behaviour and market transactions to derive the value of ecosystem services and benefits. The market price approach makes use of existing prices for goods and services traded in the market, for example cultivated foods from wetlands. The production function approach treats an ecosystem good or service as an 'input' into the production of a marketed 'output'. The value of the ecosystem service is derived from the value of the marketed good, for example the value of reeds harvested from a wetland could be derived from the value (price) of reed mats.

Non-market-based methods:

Non-market valuation methods are used to estimate economic values for ecosystem services and benefits that are not 'bought and sold' (traded in a market). Non-market valuation methods include revealed preference and stated preference methods. Revealed preference methods are based on observed behaviour (e.g. how people spend their money, the environmental attributes they are willing to pay for such as aesthetically pleasing views) from which the value (and demand) for ecosystem services is inferred. Stated preference methods are based on asking people to value ecosystem services or benefits either directly, or by asking questions designed to elicit the importance of ecosystems to people.

Cost-based methods:

Cost-based methods use various costs as a proxy for benefits and include methods based on the costs of avoiding damages due to lost services (e.g. flood damage) or the costs of replacing services (e.g. buying feed for livestock as a replacement for wetland grazing in dry periods). Strictly, replacement costs are not a measure of economic value as the method is not based on people's actual willingness to pay to avoid damage or pay for the replacement. The method is based on the

[22] The book *Valuing Ecosystem Services: The Case of Multi-functional Wetlands* by Turner et al. (2008) is also a very useful resource.

Box 15 │ Overview of economic valuation methods for ecosystem services
assumption that if people incur costs to avoid damages caused by lost ecosystem services, or pay to replace the service, then those services must be worth at least what people paid.

Once ecosystem service benefits have been valued, they can be compared to the costs of the rehabilitation in a **cost-benefit analysis** using a **Net Present Value (NPV) approach**. This type of assessment provides an *indication* of the net benefit of the rehabilitation, as it is not possible to assign an economic value or monetary measure to all the benefits of wetlands. The confidence in the estimated economic values, and cost-benefit comparison, will depend on the availability of reliable data/evidence (e.g. values based on secondary data, or derived from the literature, should be reported with moderate to low confidence).

In a NPV analysis, the *annual added value* of the wetland rehabilitation benefits (i.e. the difference in the value of wetland benefits between the 'with' and 'without' rehabilitation case) is compared to the rehabilitation costs (and any other costs, e.g. maintenance) over a suitable timeframe (e.g. 25 years). A positive NPV indicates that the benefits exceed the costs over the timeframe. See **Box 16** for a case study example.

The costs and benefits of wetland rehabilitation accrue at different points in time; generally, the costs to undertake wetland rehabilitation are incurred immediately, while the benefits accrue over time. To compare costs and benefits at different points in time, a present value approach is used where all future benefits and costs (e.g. maintenance) are reduced to a common time dimension (the base year) for comparison. 'Discounting' (an economic technique) is applied to do this and is an important consideration, along with an appropriate time frame (e.g. life of the wetland rehabilitation/structures), in the analysis as it can significantly influence the cost-benefit analysis results. Guidelines (e.g. Mullins et al., 2014) and current best practice must be consulted in selecting appropriate discounting procedures and rates.

Box 16 | Case study example: Cost-benefit analysis of the Manalana Wetland rehabilitation

An economic valuation approach and cost-benefit analysis of the livelihood benefits of the wetland rehabilitation was undertaken.

Ecosystem services valued:

- Source of cultivated goods/resources – madumbe crop
- Source of harvestable goods/resources – reeds (for reed mats), livestock grazing during the dry season

Ecosystem services likely affected by the rehabilitation, but not valued:

- Streamflow regulation and water supply – particularly for human and livestock use
- Education and research
- Water quality enhancement

Valuation methods:

- Combination primary and secondary data
- Market prices – crops (madumbes R/kg) and reeds (R/bundle), primary data
- Replacement cost – livestock grazing during the dry season, values from literature

Costs:

- Costs of the rehabilitation interventions *(no monitoring or maintenance costs)*

Cost-benefit analysis:

- Net present value analysis (NPV) – a positive NPV indicates that the benefits exceed the costs over the time frame
- Timeframe – 25-year (based on life of structures), 50-year period also considered
- Discount rate – 3, 6 and 8%; 8% recommended for SA, but considered too high for ecosystem-based services and benefits.

Results:

Cost-benefit analysis – Manalana Wetland rehabilitation	**'With' Rehab**	**'Without' Rehab**
Value of benefits (R/yr)	120 071	34 388
Madumbe cultivation (R/yr)	86 632	21 658
Reed harvesting (R/yr)	15 993	7 497
Grazing for livestock (R/yr)	17 446	5 233
Value added of the wetland rehabilitation (R/yr)	**85 683**	
Cost of rehabilitation (R – total)	**1 103 490**	
Net present value (discount rate, life of structures)		
NPV (3%, 50 years)	+	
NPV (6%, 50 years)	+	
NPV (8%, 50 years)	-	
NPV (3%, 25 years)	+	
NPV (6%, 25 years)	-	
NPV (8%, 25 years)	-	

Box 16│ Case study example: Cost-benefit analysis of the Manalana Wetland rehabilitation

Conclusion:

The results of the cost-benefit analysis indicate that at a 3% discount rate the benefits of the rehabilitation (based on crop cultivation, reed harvesting and livestock grazing) exceed the rehabilitation costs over both the 25 year and 50 year life of rehabilitation scenarios (positive NPV). A 25 year life of rehabilitation is considered realistic given the "cut and fill" nature of the site and that limited maintenance and monitoring of the rehabilitation structures is undertaken. At higher discount rates (6 and 8%), the crop cultivation, reed harvesting and grazing benefits do not exceed the rehabilitation costs over a 25 year period.

Confidence:

- Crop production and reed harvesting – moderate-high
- Livestock grazing – moderate.

Limitations:

- Partial valuation of the direct use value added by the rehabilitation to selected provisioning services and therefore an under-representation of the economic value of the wetland rehabilitation.
- Limited to the benefits to the immediate community surrounding the wetland and upstream of the rehabilitation structures (the Craigieburn Village), downstream benefits were not considered.

Potential additional benefits not assessed in the study included:

- Additional wetland crops (such as pumpkins and winter vegetables)
- The contribution to health and satisfaction of wetland crops
- Access to surface water for domestic use (washing, irrigating gardens) and livestock watering
- Downstream benefits (such as flow regulation, water quality enhancement)
- Regulatory services (e.g. streamflow regulation, sediment trapping, erosion control, carbon storage)
- Value of the wetland as a livelihood strategy in times of need
- Values associated with sense of identity of wetland farmers (predominantly woman with access to few alternatives)
- Secondary benefits associated with improved household income, particularly ability to pay school fees.

The results and conclusion reported here are for the economic valuation and cost-benefit analysis component of the wetland rehabilitation evaluation. The case study also explored other benefits associated with the wetland and the opinions of the Craigieburn Village residents on the rehabilitation. For example, residents expressed the value of "farming as a way of life", and identified several benefits to farming, including food diversity, exercise and as a way of dealing with stress. Job provision was also identified – wetland farmers employ young men to prepare fields and fences. During the focus groups and interviews residents also raised several challenges including that younger members of the community showed less interest in farming compared to the past, crop pests, and little government support for farming.

5.4 Assessment of wetland functioning and condition

Evaluating the level of ecosystem functioning and ecological integrity/condition of the identified wetland habitat is necessary during the site contextualisation and the monitoring of the wetland rehabilitation outcomes. Changes in functioning and condition may be useful indicators for identifying where the possible changes may be occurring within the system and its catchment over time. Two wetland tools have been developed to assess such changes, namely WET-Health (Macfarlane et al., 2007) and WET-EcoServices (Kotze et al., 2007). The adoption of these tools allows for a rapid assessment of the outcomes of rehabilitation, focussing on the improvements in the functioning and integrity of the wetlands.

It should be noted that when subjective scoring methods such as the methods described above are used in the context of monitoring, it is particularly important that measures be taken to promote consistency of application. This is in order to allow for reliable comparisons to be made between different wetlands and within the same wetland across different instances in time, e.g. immediately prior to rehabilitation interventions and three years after completion of the interventions. The following measures (adapted from Kotze et al., 2018) are recommended:

- Assessments should be undertaken by ecologists who are trained and experienced in the application of the tools.
- Owing to the subjective element of the scoring process, the assessments should preferably be undertaken by two assessors, and each of the assessments should be subject to review by a “third party” reviewer.
- In an attempt to control for bias, the ecologist who was involved in the planning and implementation of the interventions at the site should preferably not conduct the evaluation. This takes into account Zedler (2007)’s caution that evaluating a project in which one was involved can potentially result in biased findings.

5.4.1 Assessment of wetland functioning

At the outset of the assessment, the wetland system identified during the delineation study would be classified as a specific HGM unit. To quantify the level of functioning of the wetland system, and to highlight its relative importance in providing ecosystem benefits and services at a landscape level, a WET-EcoServices (Kotze et al., 2007) assessment may be performed. The WET-EcoServices assessment technique focuses on assessing the extent to which a benefit is being supplied by the wetland habitat, based on both:

- The opportunity for the wetland to provide the benefits; and
- The effectiveness of the particular wetland in providing the benefit.

Ecosystem services, which include direct and indirect benefits to society and the surrounding landscape, are assessed by rating various characteristics of the wetland and its surrounding catchment, based on the following scale:

- Low (0);
- Moderately Low (1);
- Intermediate (2);
- Moderately High (3); or

- High (4).

The scores obtained from these ratings for the wetland HGM unit are then incorporated into WET-EcoServices scores for each of the fifteen ecosystem services (**Table 5.4**).

Table 5.3: Ecosystem services supplied by wetlands
(Kotze et al., 2007:14)

<table>
<tr><td rowspan="15">Ecosystem services supplied by wetlands</td><td rowspan="8">Indirect benefits</td><td rowspan="8">Regulating and supporting benefits</td><td colspan="2">Flood attenuation</td><td>The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream</td></tr>
<tr><td colspan="2">Stream flow regulation</td><td>Sustaining stream flow during low flow periods</td></tr>
<tr><td rowspan="5">Water quality enhancement benefits</td><td>Sediment trapping</td><td>The trapping and retention in the wetland of sediment carried by runoff waters</td></tr>
<tr><td>Phosphate assimilation</td><td>Removal by the wetland of phosphates carried by runoff waters</td></tr>
<tr><td>Nitrate assimilation</td><td>Removal by the wetland of nitrates carried by runoff waters</td></tr>
<tr><td>Toxicant assimilation</td><td>Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters</td></tr>
<tr><td>Erosion control</td><td>Controlling of erosion at the wetland site, principally through the protection provided by vegetation</td></tr>
<tr><td colspan="2">Carbon storage</td><td>The trapping of carbon by the wetland, principally as soil organic matter</td></tr>
<tr><td rowspan="7">Direct benefits</td><td colspan="3">Biodiversity maintenance</td><td>Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity</td></tr>
<tr><td rowspan="3">Provisioning benefits</td><td colspan="2">Provision of water for human use</td><td>The provision of water extracted directly from the wetland for domestic, agricultural or other purposes</td></tr>
<tr><td colspan="2">Provision of harvestable resources</td><td>The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.</td></tr>
<tr><td colspan="2">Provision of cultivated foods</td><td>The provision of areas in the wetland favourable for the cultivation of foods</td></tr>
<tr><td rowspan="3">Cultural benefits</td><td colspan="2">Cultural heritage</td><td>Places of special cultural significance in the wetland, e.g. for baptism or gathering of culturally significant plants</td></tr>
<tr><td colspan="2">Tourism and recreation</td><td>Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife</td></tr>
<tr><td colspan="2">Education and research</td><td>Sites of value in the wetland for education or research</td></tr>
</table>

5.4.2 Assessment of wetland condition/integrity

To determine the level of ecological integrity, a WET-Health (MacFarlane et al., 2007) assessment can be undertaken for the HGM units within the site. The WET-Health assessment technique gives an indication of the deviation of the system from the wetland's natural reference condition for the following biophysical drivers:

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

The impacts on the wetland, determined by features of the wetland and its catchment, are scored based on the impact scores and then represented as Present State Categories as outlined in WET-Health (**Table 5.5**).

Table 5.4: Impact scores and present state categories for describing the present state of wetlands (MacFarlane et al., 2007:30)

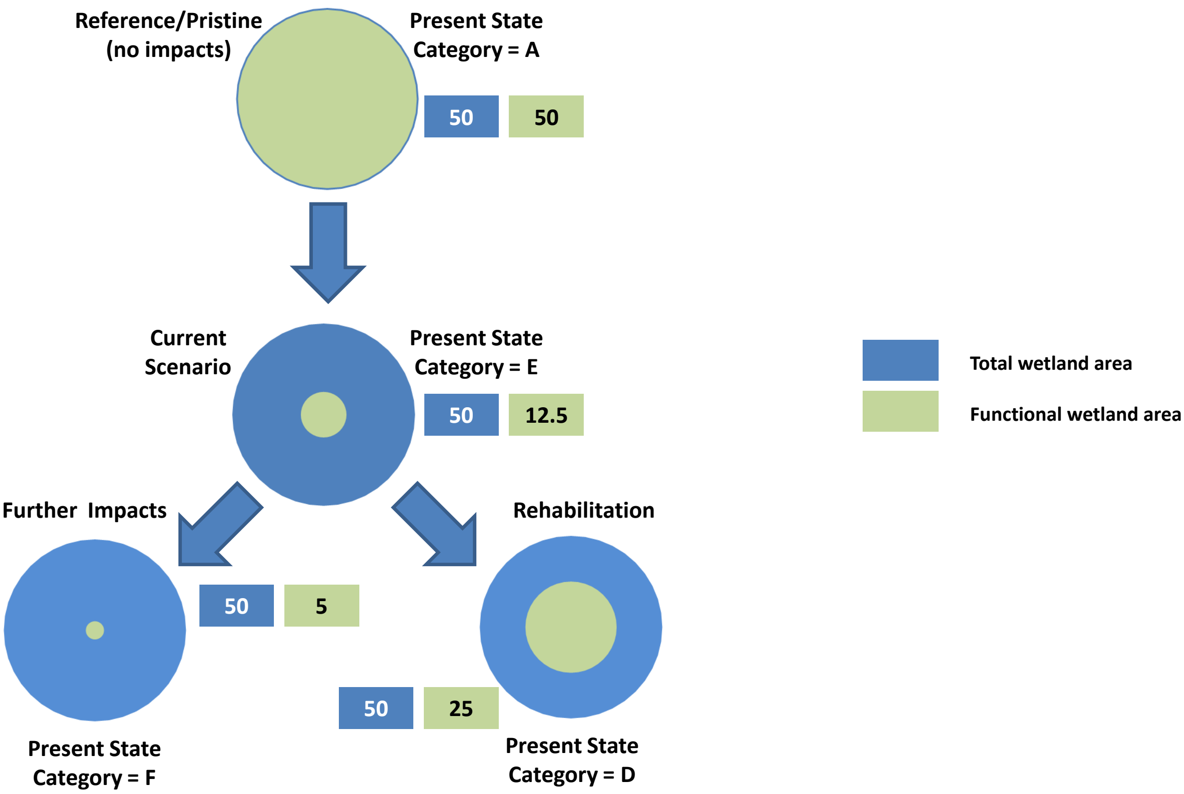
Impact Category	Description	Impact Score Range (0-10)	Present State Category
None	Unmodified, natural	0-0.9	A
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately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

The scores for hydrology, geomorphology and vegetation are simplified into a composite impact score, using the predetermined ratio of 3:2:2 (MacFarlane et al., 2007), respectively for the three components. The composite impact score is used to derive a health score that then provides the basis for the calculation of hectare equivalents (also referred to as functional area), which can be described as the health of the wetland expressed as an area. Cowden and Kotze (2009) make use of a simple example to explain the concept of hectare equivalents conceptually illustrated in **Box 17** (Cowden et al., 2013:14).

Box 17. Example of the use of hectare equivalents to represent changes in wetland health (taken from Cowden et al., 2013)

The assessment of wetland health is based on comparisons to a reference state, i.e. where the wetland's health is unmodified and the functional area of wetland is equivalent to the full extent of the system. For example, if the health of a 50ha wetland is 100% (*Present State Category = A*) this equates to 50 hectare equivalents. In many instances the current scenario for a particular system reflects some form of historical degradation. If the abovementioned wetland was *seriously* degraded, the health would be reduced from the reference state to 25% (*reflecting a wetland health score of 2.5*); a drop in hectare equivalents from 50 to 12.5 (50ha x 0.25) hectare equivalents would be recorded. The following would therefore be expected if the wetland in the above scenario was subject to the following two future options:

a) Further degradation of the wetland linked to development, with the system's health being further reduced to 10% would result in a drop in hectare equivalents to 5 hectare equivalents; and
b) Rehabilitation of the wetland habitat, with the system's health being increased to 50% would result in a gain in hectare equivalents to 25 hectare equivalents.



NOTE:
The sizes of the circles are directly related to the extent of wetland habitat and functional wetland area in the landscape

5.5 Water levels

Since hydrology is one of the three driving factors influencing the functioning and integrity of a wetland system, it is notably beneficial to measure and monitor the hydrological changes occurring within a wetland. The hydrology of wetlands is often highly modified as a result of farming and other anthropogenic impacts on the landscape, and therefore improving the hydrological condition of a wetland is often a primary objective of wetland rehabilitation (Cowden and Kotze, 2009).

An important aspect of the hydrology of a wetland is the hydroperiod. "The hydroperiod defines the changes of a wetland's surface and sub-surface water level giving rise to a particular seasonal pattern, very much like a hydrological signature" (Mitsch and Gosselink, 1986). Understanding the hydroperiod is important as it has a direct impact on the physical, chemical and biological composition and function of a wetland system (Mitsch and Gosselink, 1986; MacFarlane et al., 2007).

To determine the water levels within a wetland, a water level tape measure and permanent gauge boards will be the main equipment requirements for surface water monitoring. Sub-surface measurements are usually taken using dip wells, which can be made from 50 mm PVC pipe with 3 cm incisions at 5 cm intervals across the length of the pipe to allow water penetration. The pipe is covered with a permeable geofabric and tied down with cable ties to avoid sediment from entering the dip well. The dip wells can be installed by drilling wells into the soil, using a handheld auger. Once installed, water levels should preferably be measured at least every two weeks. Should the monitoring budget allow, water level data loggers can be easily installed into the described wells, providing long-term continuous water level data. It may however, only be possible to visit the wetland once or a few times during the year. While this will not allow the hydroperiod to be described, it may potentially provide a snapshot comparison between different areas in a wetland (e.g. between a rehabilitated area and a reference area). It is preferable to include at least one wet season snapshot and one dry season snapshot. When augering holes at various locations onsite, in order to make such 'snapshot' comparisons, it is important to leave these for a period of time after augering the hole before the measurement is taken. The time lapse will depend on the soil types; the water will take longer to seep through in clay soils compared to sandy soils (Cowden and Kotze, 2009).

As noted in WET-RehabEvaluate, a change in hydrology can be inferred by a change in vegetation. Vegetation is relatively sensitive to changes in soil moisture, influencing the species composition. Therefore, changes in the hydrological regime of a wetland could be determined through a vegetation assessment and fixed-point photographs. However, there is often a time lapse between the changes in the hydrological conditions onsite and the vegetation response, which should be factored into observations (Cowden and Kotze, 2009).

5.6 Water quality monitoring

Aquatic ecosystems are particularly susceptible to water quality impacts, and in most instances, they are the receivers of water of variable quantity and quality given their positions in the landscape. However, it is the type of aquatic ecosystem that determines the flow-accumulation response of water in the system. For example, rivers act as 'drains' in the landscape, whereas wetlands are usually 'sinks' (Dallas and Day, 2004). As a result, any alterations or disturbances taking place within a catchment will either extend longitudinally in a downstream direction as water quality impacts within a catchment when entering a lotic (or flowing) system (e.g. rivers, streams and drainage lines), or they tend to build up/accumulate pollutants when entering lentic (non-flowing) systems (e.g. lakes and wetlands). As a result, the ability to monitor water quality within a wetland context becomes problematic on the basis that water quality variables tend to be spatially and temporally uneven within a wetland. In addition, this inherent variation in water quality becomes even greater between different wetlands types, and little is known about the range of concentrations from naturally occurring/unimpacted wetlands (Malan and Day, 2012; Malan et al., 2012). There is some indication of the degree of impairment from a study carried out by Malan and Day (2005) who analysed the water quality data from several hundred wetlands ranging from impacted to pristine. However, it should be noted that since wetland water quality is highly variable, one has to be very cautious of the interpretations drawn from once-off sampling (Malan et al., 2012).

Depending on the landscape context, the position of wetland habitat in relation to river ecosystems may present other opportunities for monitoring water quality. Wetlands that are connected to rivers (downstream and/or upstream) can be assessed using typical river monitoring tools that provide an indication of changes to the instream water quality impacts due to flows moving through the rehabilitated wetland. The water quality within a river affects the composition of both micro- and macro-organisms, and numerous scientific studies have established that certain organisms have specific water quality thresholds and tolerances. This has led to the development of various sampling techniques to establish the diversity and abundance of aquatic taxonomic groups, each of which are usefully arranged within the aquatic food chain comprising several trophic levels. Thus, the influence of water quality on one trophic level can affect other levels both down and up the food chain. At the base of the aquatic food chain are unicellular algae known as benthic diatoms. Benthic diatoms are present in all rivers, and they are generally not limited by habitat availability because of their microscopic nature. South Africa has a good record of diatom species and their individual water quality tolerances. This makes them useful for inferring integrated water quality conditions, and they are particularly useful for determining historical water quality conditions as their silica frustules (shells) remain behind once they die, leaving a record of past conditions. Sampling of benthic diatoms is relatively simple (Taylor et al., 2005), and samples are typically interpreted according to two indices: 1) the Specific Pollution sensitivity Index (SPI), and 2) the percentage of pollution tolerant valves (percentage PTV), both of which give an indication of water quality conditions at a sample site. Benthic diatoms, however, do need to be analysed in a laboratory by a diatom specialist.

Aquatic macro-invertebrates offer another means for monitoring water quality by providing an indication of water quality based on pollution tolerances established for macro-invertebrate families. In addition, macro-invertebrates react quickly to pollution events, and they are able to colonise previously disturbed/polluted habitats if conditions improve. Additionally, they integrate water quality conditions over time and account for synergistic and additive effects of different water quality parameters. The South African Scoring System version 5 (SASS5) was developed by Dickens and Graham (2002) as a rapid technique for determining river ecosystem health using aquatic macro-invertebrates as bio-indicators. The SASS5 technique has been accredited to ISO 17025 standards, and forms part of one of the DWS river eco classification models for EcoStatus determination. The only limitation is that macro-invertebrate families tend to be influenced by availability of sampling habitats (or biotopes) at a site, and certain instream habitat types, namely stones (in current and out of current), gravel, sand and mud (GSM) and vegetation (aquatic and marginal, must ideally be present for the method to accurately measure river 'health' or state – reliability of results is reduced if one or more biotopes are absent. In addition, inference need to be made in order to separate out habitat drivers from water quality drivers. This said, its application in evaluating wetland rehabilitation can be effective when SASS5 is implemented upstream and downstream of the wetland to determine the changes in water quality once the water flows have been through the wetland. Another limitation in implementing SASS5 is that the method needs to be carried out by a DWS accredited SASS5 practitioner, however, this does add to the rigour and defensibility of the method in terms of obtaining an accurate result, as well as with the interpretation of water quality influences. A simplified alternate to SASS5 is the MiniSASS method, which was recently developed as more user-friendly approach/citizen science tool for monitoring river 'health'.

Water quality monitoring could also include conventional water chemical analyses by collecting water samples at strategically-placed locations. Depending on the nature of the project and the parameters needing to be analysed, water chemical monitoring can become expensive due to the laboratory costs required to test and analyse the water samples. However, this form of water quality monitoring is strongly influenced by the timing of water sampling relative to the timing of pollution events. Nevertheless, water chemical sampling can sometimes be more appropriate in certain situations, for example sites where the water is highly polluted or where biological sampling cannot to undertaken due to the lack or limitation of sampling material/habitat.

5.7 Erosion and sedimentation

The most common erosional features within degraded wetland systems are headcuts and gully erosion, which are often at the forefront of wetland rehabilitation plans. Erosion within a system occurs as a result of over-steepening within a section of the system, which begins to erode to equalise the system to a stable state, i.e. where the amount of erosion occurring is equal to the amount of deposition within a system. Erosion can be a natural in-system process or can be largely as a result of anthropogenic interruptions to the natural functioning of the system. Before any rehabilitation planning is undertaken to stabilise the erosion, it is very important to understand the origin of the erosion and to determine whether it is natural process. Once this is better understood, planning to stabilise or ignore the erosion can be planned accordingly. Prior to the planning and implementation of the rehabilitation plan, these erosion features should be measured to provide a baseline to which rehabilitation outcomes can be compared.

In terms of gully erosion, the depth, width, length, steepness and vegetation cover should be assessed (Cowden and Kotze, 2009). Headcut erosion should be measured in terms of the vertical drop, slope and vegetation cover. In addition to these observations, detailed topographical surveys can be undertaken across various portions of the system to determine the changes in the length, width and depth of the erosion features, whilst possibly gaining an understanding as to whether the sediment has been exported or deposited within the system. Variations in the cross sections essentially can be used to infer the rate of sediment deposition in the channel and within the system over time, and should, therefore, be considered for inclusion into the baseline and ongoing monitoring of the system. When assessing the outcomes of the rehabilitation in terms of erosion, the monitoring results should be placed in context of the rehabilitation activities, paying particular attention to the anticipated versus the actual outcomes of the rehabilitation.

In terms of sediment accumulation, wetlands are known as extremely efficient sediment traps, polishing the water before it enters the downstream reaches. In high sediment yielding catchments, the enhancement of these sediment trapping services should be considered. To better understand the sediment-trapping services provided by a system, a baseline assessment should be undertaken to quantify the possible sediment activities within the wetland and catchment, and the movement of sediment through the system. As mentioned above, detailed topographical surveys can be undertaken, specifically where sediment is expected to be exported or deposited, providing evidence of sediment accumulation based on increases in elevation within and adjacent to the channel. An alternative method would be to install sediment discs. These discs are secured on the surface of an area likely to receive sediment, then at predetermined intervals (often annually following the rainfall season) the amount of sediment that has settled on the discs is measured and quantified (Cowden and Kotze, 2009).

5.8 Vegetation

Vegetation composition within a landscape often provides an informative overview of the hydrological condition within the site and the integrity of the system. Two indices have recently emerged as a means to measure the changes in vegetation cover and composition, namely Wetland Index Value (WIV) and Floristic Quality Assessment Index (FQAI). The Wetland Index Value may be used to determine whether wetland habitat is present onsite prior to and after wetland rehabilitation has been completed. Such information may be used to provide an indication of whether wetland rehabilitation has resulted in a system moving towards functional wetland habitat. Floristic Quality Assessment Index provides an estimate of habitat quality by assessing the extent to which an ecosystem is similar to the benchmark/desired condition. The application of these two indicators is presented in Appendices 4a and 4b. It should be noted that in some instances, changes in vegetation patterns and structure can be useful for recording changes and this is often achieved through photographic records (refer to Appendix 6 for guidance on fixed-point photography).

In terms of sampling protocol there are numerous approaches that have been tried and tested, one of which is explained in detail below. The following vegetation sampling protocol is based on the US EPA approach (Kentula et al., 2011) as adapted by Kotze and Macfarlane (2014). The intention is to use vegetation sample plots to refine the vegetation impact ratings allocated to disturbance units targeted for rehabilitation as part of the WET-Health condition assessment and to act as a reference for future monitoring.

- Based on a rapid visual observation, identify the main vegetation zones in the wetland area to be rehabilitated and in nearby area/s of wetland. The zones are likely to vary according to both their natural level of wetness and degree of human impact.
- Purposefully locate at least three transects (with permanent markers at each end) in the wetland to encompass the observed vegetation zones, and to include the area anticipated to be affected by the rehabilitation interventions and a 'control area' nearby which preferably represents wetland zone/s which have been subject to similar human impacts as the area to be rehabilitated but which will not be affected by the rehabilitation interventions. It is recognised that it may be

difficult or impossible to locate a 'control area', and not more than 20% of field time should be dedicated to locating and sampling in control plots.

- Each end of the transects should be permanently marked with a suitable marker (e.g. upright metal stake, appropriately painted) and the location of start and end points should also be accurately recorded using a suitable GPS (preferably accurate to less than 2 m).
- Fixed point photos should be taken from each end stake, looking along the transect line (see Appendix 6 for further guidance on fixed point photography). It may be useful to include additional photo points at quadrat sites as a visual record of vegetation structural characteristics.
- Vegetation should be sampled using a 2 m by 2 m quadrat, which is generally large enough to capture the sort of structural heterogeneity typically found in herbaceous wetlands. However, in the fynbos larger quadrats are likely to be required, depending on the vegetation structure of the particular wetland.
- Purposefully locate quadrats along each transect on the downslope/downstream side of the transect (**Figure 5.3**). Facing in a downslope/downstream direction, measure the distance from the left end of the transect to the quadrat and record its location using a GPS (**Figure 5.3**). A minimum of three quadrats per zone should be sampled, and the more heterogeneous the zone, the greater the number of quadrats. It may be necessary to locate a few quadrats away from the transects, depending on the spatial pattern of the zones.
- For each quadrat sampled, the following should be recorded:
    - Plant species present, and the aerial cover class (**Table 5.5**) of each;
    - Total aerial cover;
    - Height of vegetation strata present in the quadrat (sometimes only a single stratum will be present);
    - The wetland hydrological zone for each plot should be established using the DWS delineation guidelines; and
    - Water depth if flooded.

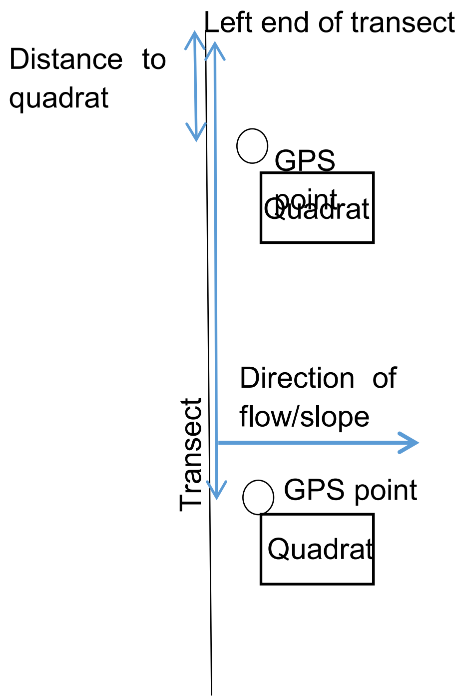


Figure 5.3: Orientation of quadrats in relation to transects

Table 5.5: Vegetation cover classes, based on the classes of Londo (1984), to be used for vegetation sampling

CLASS NAME	CLASS INTERVAL
<1	<1%
1	1%
2	2%
4	3-5%
8	5-10%
13	10-15%
20	15-25%
30	25-35%
40	35-45%
50a	45-50%
50b	51-55%
60	55-65%
70	65-75%
80	75-85%
90	85-95%
>95	>95%

When back in the office, data is captured onto a standard spreadsheet template and species are classified into appropriate classes in terms of:

- Disturbance status allocated to each species (alien invasive plants; ruderal or weedy plants; occasionally ruderal or weedy plants; non-ruderal but pioneer species; plant species intolerant of disturbance); and
- Hydric status according to the classes given in **Table 5.6**Table 5.6.

These data are then used to calculate WIV and FQAI indices for each sampling point. Thereafter, these indices are used to refine WET-Health scores as required.

Table 5.6: Description of hydric status applied to wetland plants

SYMBOL	HYDRIC STATUS	DESCRIPTION/OCCURRENCE
OW	Obligate	Almost always grow in wetlands (>99% occurrence)
F+	Facultative positive	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas
F	Facultative	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas
F-	Facultative negative	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)
D	Terrestrial	Almost always grow in drylands

6 CONCLUSION

The user is encouraged to develop M&E as an integral part of the life cycle of the wetland rehabilitation project rather than only after implementation. The wetland rehabilitation M&E should therefore look to follow the general process described in Chapter 4, beginning with the evaluation of the initial conceptualisation of the rehabilitation project, followed by an evaluation of the context, rehabilitation strategy, objectives and plan. Next, the implementation of the plan is evaluated and finally, the outcomes of this implementation are evaluated, firstly in relation to the strategy and objectives of the rehabilitation and secondly, the initial conceptualisation and selection of sites is evaluated in the light of the outcomes. Irrespective of the approach adopted, a critical component of M&E is reporting, and guidance is provided in Chapter 4.10.1 in this regard. An integrated evaluation report serves to provide the reader with the evaluation's findings which are supported by evidence collected during monitoring or during the evaluation itself. The structure and content of the report should be congruent with the evaluation principles described in Chapter 3 to ensure transparency and availability of the information used to inform the evaluation.

The framework, developed as a set of principles and criteria (refer to Chapter 3), a step-by-step guide (refer to Chapter 4), and a series of modules for monitoring specific components relevant to wetland rehabilitation (refer to Chapter 5), was designed to plan and implement M&E of wetland rehabilitation projects with a focus on an adaptive management approach. As mentioned, the step-by-step guide should not be implemented as a 'recipe'. As such, deviations from the prescribed steps are likely to be needed to accommodate the requirements of specific project sites and varying objectives. Furthermore, the details of the modules for monitoring of wetland rehabilitation are also likely to change over time, especially if one considers that the WRC is currently funding amendments to WET-Health and WET-Ecoservices assessment tools (Chapter 5.4)

As such Chapter 5.4 may need to be amended in future to account for the revised tools. Furthermore, the development of the framework highlighted the need to develop further understanding of the regional variation in the indicator status and coefficients of conservatism recorded for each wetland plant species for use in the recommended vegetation indices. This could be achieved either through a focussed research project or through collation of expert opinion on a per project basis by the team responsible for the M&E of the specific wetland rehabilitation project. With the continued interrogation of the Wetland Management Series, it is evident that WET-RehabPlan and WET-RehabMethods would both need to be updated in the short to medium-term to account for changes in understanding and to accommodate the adaptive management approach prescribed by the M&E framework.

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8 APPENDICES

APPENDIX 1: CASE STUDY SYNTHESIS REPORT

Full reports available on the Water Research Commission website.

A1 INTRODUCTION

This synthesis report has been developed to provide the reader with a quick and accessible overview of the study sites visited throughout the development of the Monitoring and Evaluation (M&E) framework, highlighting how the experiences at each study site assisted in further developing and strengthening the framework as a whole. Each of the study sites included a combination of either social, ecological and/or economic aspects, which influenced the type of assessments that were undertaken and the focus of the study as a whole. It is important to note that not all study sites represented all three components, and it is fairly uncommon that all three components are represented at rehabilitation sites as a whole. Ideally, a rehabilitation plan should be designed in such a way that all three components are integrated into the anticipated outcomes of the rehabilitation plan, but this is not always possible. For example, where rehabilitation has been implemented on private land, the social benefits associated with that rehabilitation are likely to be minimal to none. Therefore, the need to understand the context of the site is imperative before rehabilitation aims and objectives are set, to ensure that the proposed outcomes and overall focus are realistically achievable.

The sections below provide summaries of the study sites that were used to test and improve the M&E framework. The lessons learnt at each site were used to strengthen the final framework, and are documented at the end of each of the study site sections. It should be noted that the case studies pertaining to the Greater Edendale Mall (Section A2.1) and the Manalana Wetland (Section A2.2) provide additional details about the studies. Each of these studies were undertaken at the outset of the framework development and incorporated detailed studies, as such a substantial amount of data was collated per site. In addition, these sites looked at adopting the overall framework, whilst the subsequent case studies generally only adopted the component/s of the framework applicable to evaluating the project against its objective/s.

A2.1 Greater Edendale Mall

The Greater Edendale Mall is located in Pietermaritzburg, KwaZulu-Natal and has encroached into an area of hillslope seepage wetland habitat. To obtain environmental authorisation for the mall development, 2.4 ha of wetland habitat had to be retained and rehabilitated within the property boundary. The primary aim of the rehabilitation was to address the impacts of the development on the wetland habitat, in order to encourage an adequate improvement in the integrity of the wetland onsite to ensure a 'no-nett-loss' of wetland habitat integrity. Wetland monitoring requirements were specified as conditions of authorisation by the relevant authorities and were undertaken prior to and after the completion of rehabilitation activities. In addition, quarterly monitoring of water quality was required to determine whether the construction and operation of the mall had negatively impacted downstream water quality. During the rehabilitation activities, a specialist was present on site weekly in order to have managed the implementation and identify unforeseen outcomes of the rehabilitation activities.

The methods employed to collect monitoring data before and after rehabilitation activities included:

- Fixed point photographs;
- Assessment of wetland functioning using the WET-EcoServices framework;
- Assessment of wetland integrity using the WET-Health framework;
- Assessment of the change from vegetation indicative of terrestrial conditions to vegetation indicative of hydric conditions, utilising the Wetland Index Value;
- Assessment of the change from vegetation dominated by alien and pioneer species to natural species utilising the Floristic Quality Assessment Index;
- Assessment of the change of plant communities utilising hierarchical clustering, analysis of similarities and similarity percentage analysis;
- Assessment of the change in water quality from the point at which water enters to the point at which water exits the wetland;
- Interviews with the Greater Edendale Mall manager to establish economic benefits of the wetland rehabilitation; and
- Interviews with patrons of the Greater Edendale Mall to establish social-economic benefits of the wetland rehabilitation.

The results derived from the collected monitoring data indicated that the wetland rehabilitation had succeeded in retaining 2.4 ha of wetland habitat on site. The results of the WET-EcoServices and WET-Health assessment tools indicated that the ecosystem services provided by the wetland habitat had improved and that the integrity of the wetland had improved from 1.89 ha equivalents to 2.12 ha equivalents. Water quality monitoring results indicated that the concentration of certain pollutants, namely nitrates and ammonia, showed a significant decrease in concentration from the point at which the water entered the wetland to the point at which the water exited the wetland. Other pollutants, including soluble reactive phosphorus and nitrite, did not show a decrease in concentration between the two points.

The vegetation survey indicated that the rehabilitation activities had resulted in an improvement to the vegetation. However, a significant change in hydric conditions and floristic quality was not achieved. It is likely that a significant change in hydric conditions was not observed because a large area of the pre-rehabilitation wetland habitat housed vegetation indicative of hydric conditions. The Floristic Quality Assessment took only species presence into account and did not account for species abundance; therefore, it is important to also consider the change in plant communities as a result of the rehabilitation activities, which indicated that a significant change in plant community composition had been achieved. The significant difference may be attributed to the increased abundance of plant species such as *Cyperus dives, Cyperus latifolius*, *Cyperus articulatus*, *Pycreus macranthus* and *Typha capensis*. This result suggests that the impact of the rehabilitation activities on the flora was more positive than initially suggested by the assessment of floristic quality.

The interview process with the Greater Edendale Mall manager was unsuccessful in providing insights into the socio-economic impacts of the wetland rehabilitation. It did, however provide useful insight into management aspects of the wetland. The mall manager, although admittedly recently appointed, was unaware of the management and maintenance requirements of the wetland within the post-rehabilitation landscape, which were stipulated conditions of the environmental authorisation for the development.

The outcome of the interviews conducted with the Greater Edendale Mall patrons suggested that while the patrons were aware of the aesthetic improvement created by the rehabilitation activities, they felt that the wetland was an area of disease, wild predators and a hiding place for criminals, and would rather the area be used for something else, such as grazing land or a sports field. It is however, important to note that the wetland is within the private boundary of the mall and therefore would not be available to the surrounding community for private use, regardless of the type of land use proposed.

The results of the study were applied to the origin and evolution framework, which assisted in identifying the following aspects of the rehabilitation project:

- The wetland that existed before the rehabilitation implementation was a hillslope seep impacted upon by catchment land use change, drains and infill within portions of the wetland.
- The rehabilitation activities successfully rectified the impacts and reinstated areas of intact wetland habitat. The base level of the wetland was reset and the wetland was transformed into an alternate stable state, with reinstated portions of the wetland now functioning as an unchannelled valley-bottom wetland rather than a hillslope seepage wetland.
- The rehabilitation activities were successful in enhancing the provision of ecosystem services, particularly the ecosystem services related to enhanced water quality. The water quality monitoring data served to quantify the improvement in water quality, especially in reducing the nitrate and ammonia concentrations.
- It is expected that the wetland will remain 'locked' in an alternate stable state, depending on whether the structural integrity of the rehabilitation interventions remain intact. The integrity of the wetland habitat is however, under threat from alien invasive plants, which continues to require careful management.

The application of the evaluation criteria identified the following key aspects of the Greater Edendale Mall wetland rehabilitation project:

- **Relevance** – The rehabilitation activities have successfully retained 2.4 ha of wetland habitat within the Greater Edendale Mall site and therefore the conditions of the authorisation were satisfied;
- **Effectiveness** – The objective of the rehabilitation was achieved and therefore the rehabilitation activities have been effective;
- **Impact** – The rehabilitation activities ensured that the requirements of the environmental authorisation were satisfied as wetland area was retained on site, areas of wetland habitat were reinstated, diffuse flows promoted, the base level was raised and alien invasive plants cleared;
- **Adaptability** – Weekly implementation monitoring was undertaken during construction activities which allowed for unforeseen outcomes to be accounted for in the rehabilitation plan. For

example, an area of pooling water was identified during the construction phase, which was incorporated into the rehabilitation plan as an open water pond to increase habitat diversity.

- **Resilience** – The wetland has been transformed into an alternate stable state by rehabilitation activities. Given that the wetland is located on private property, the threats from the surrounding area that would potentially change the state of the wetland are limited (e.g. grazing, cultivation, etc.). The only envisaged threat to the state of the wetland is damage and/or lack of management of the intervention structures and encroachment of alien invasive vegetation; and
- **Sustainability** – The structures have been in place for approximately six years and all appeared to be intact and functioning as planned.

The overall evaluation of the rehabilitation interventions suggested that the wetland rehabilitation activities were successful in achieving the aims and objectives of the rehabilitation plan. The rehabilitation activities successfully satisfied the requirements of the environmental authorisation for the mall and if continuous management and maintenance is undertaken, the wetland will remain 'locked' within its alternate stable state.

A2.2 Manalana Wetland

The Manalana wetland is situated on the Manalana River, a minor tributary of the Sand River, in the upper Sand River Catchment. Craigieburn Village, which surrounds the wetland, falls within the Bushbuckridge Municipal Area, Mpumalanga. In a survey in 2004, the wetland was noted for its importance to local peoples' livelihoods in an area with high levels of poverty. During the same survey it was found that headcut (gully) erosion threatened portions of the wetland that were used for food crop cultivation and consequently the wetland was prioritised for rehabilitation. It was, at the time, predicted that the headcut erosion would propagate rapidly into the intact cultivated portion of the wetland, creating a gully which would have resulted in a loss of fields and productive capacity, if no intervention were put in place. The Manalana Wetland was rehabilitated in 2009, by means of two concrete weirs and a gabion weir, with the aim of halting the advance of erosion which threatened the wetland. As part of a summative evaluation of the Manalana Wetland rehabilitation project, the value of the ecological benefits and the livelihood benefits of the wetland were assessed, six years after the wetland was rehabilitated, and compared against a projected state of the wetland, had the degradation not been arrested through the implemented rehabilitation structures.

The methods employed to collect the monitoring data for the Manalana wetland included:

- Site contextualisation;
- Assessment of wetland functioning using the WET-EcoServices framework;
- Assessment of wetland integrity using the WET-Health framework;
- Assessment of the sustainability of agricultural activities using the WET-Sustainable framework;
- Assessment of the integrity of the rehabilitation structures using the WET-RehabEvaluate framework;
- Interviewed and facilitated focus groups with the wetland farmers to identify and assess the benefits of the rehabilitation outcomes to the Craigieburn Community, which included:
    - Crop cultivation;
    - Reed harvesting;
    - Grazing for livestock; and
    - Cost-benefit comparison.

The results from the collected monitoring data were divided into three sections; site contextualisation, ecological data, and social-economic data. The site contextualisation was undertaken using the VSTEEP tool and utilised previous reports and the data collected during the interview process to gain an understanding of the historical and then current drivers within the landscape. The results of the ecological assessment identified that the wetland was currently in a seriously modified state as a result of impacts including, but not limited to, high intensity stormflow within the catchment, cultivation, vegetation removal and alien invasive plants. The predicted trajectory of change, which considered the existing rehabilitation structures, suggested the following:

- The catchment would undergo development leading to hardening over the next five to ten years which would increase surface flows entering the wetland;
- The absence of alien invasive plant control would lead to an increase in abundance of undesired species within the catchment and the wetland; and
- Increased geomorphic instability.

The assessment of ecosystem services identified that the wetland was supplying a moderately high level of services relating to cultivated foods, harvestable natural resource provision and nitrate removal. According to the assessment of sustainability of the land use within the Manalana wetland, elements including the retention of sediment, accumulation of organic matter, retention and recycling of nutrients and the natural composition of vegetation within the wetland, were ranked as low sustainability due to the land uses and impacts within the catchment.

The assessment of the integrity of the rehabilitation structures indicated that rehabilitation structures were intact with no indication of damage or failure, and appeared to have been functioning as planned. It was considered unlikely that natural processes would take over the functioning of the structures, therefore in order to halt erosion within the wetland over a long period of time, it was determined that the structures would need to maintain their functionality.

The livelihood benefits of the wetland were assessed. Baseline information on field extent and crop yields were available from the pre-rehabilitation assessment. A comparison between the pre-rehabilitation and post-rehabilitation findings on crop production was made to ascertain whether there had been any significant change in wetland crop cultivation. Madumbe (taro) production was selected as an indicator crop (being the main wetland crop cultivated in the area). The average madumbe yield per unit area estimated during the post-rehabilitation assessment, 2.5 kg/m^2, was found to be the same as that of the pre-rehabilitation assessment. Mapping and in-field verification indicated that there had been no significant change in the wetland area available for cropping since the pre-rehabilitation assessment. The results indicate that there has been no significant change in madumbe production (yield and extent) since the pre-rehabilitation assessment, suggesting that the wetland rehabilitation activities have succeeded in securing the crop production potential of the wetland. The secured monetary value[23] of the rehabilitation to madumbe production was estimated to be R64 974 per year.

Focus group discussions indicated that, while the volume of crop production had remained the same, there were fewer wetland farmers. An emerging trend in crop cultivation appeared to be an increase

[23] All monetary values are reported in 2015 Rands unless otherwise indicated.

in the sale of locally grown crops to the rest of the community (non-farmers) and even outside of the community. The findings suggest a change in the culture of cropping in the area, from subsistence agriculture (all households growing their own) to small-scale commercial agriculture, where some households have 'specialised' in crop production to supply both the local community and further afield.

Following a similar process, the additional livelihood benefits of reed harvesting and livestock grazing were assessed. The added monetary value of the rehabilitation to reed harvesting was estimated to be R8 496 per year. The added monetary value of the rehabilitation to livestock grazing (fodder) was estimated to be R12 212 per year. Based on the aggregated benefits, a comparison of the added value of the wetland rehabilitation to the costs of the rehabilitation suggest that, when considered at a three percent discount rate over a 25 year period or a six percent discount rate over a 50 year period, the rehabilitation of the wetland was a worthwhile investment. This result is based on the assessment of three provisioning service benefits; a range of additional potential benefits as well as beneficiaries further afield are yet to be investigated, suggesting that estimates in this study represent a lower bound of the added value of the rehabilitation intervention. It was clear from the results that the choice of discount rate influenced the results of the NPV analysis.

The results of the study were applied to the origin and evolution framework, which assisted in identifying the following aspects of the rehabilitation project:

- The Manalana wetland is a discontinuously channelled valley-bottom wetland located in the headwaters of the Motlamogatsana River, a tributary of the Sand River, and was shaped by repeated erosion and deposition events.
- Human intervention in the catchment and wetland had probably sped up the erosional processes within the wetland.
- The rehabilitation of the wetland appears to have had two clear effects on the dynamics of the wetland. The first, and most obvious effect, was that erosion that was active in the wetland and threatening two unchannelled portions of wetland, had been arrested. The second effect of the rehabilitation on the wetland dynamics was limited to the area of wetland above one of structures, where changes brought about by the rehabilitation to the hydrodynamics of the wetland above the structure may have contributed to improved growing conditions for wetland food crops than what had previously existed in the degraded wetland prior to rehabilitation.
- The rehabilitation of the Manalana wetland has had two important effects on ecosystem services provided by the wetland. Firstly, by halting active erosion that threatened two sections of unchannelled wetland, the food crop provisioning service offered by these two areas of unchannelled wetland was protected. Secondly, the rehabilitation may have contributed to improved growing conditions for wetland food crops compared to what had existed in the degraded wetland prior to rehabilitation.
- Based on predictions of catchment change to hardened surfaces and more frequent intense rainfall events, it could be expected that the wetland will exhibit increased hydrogeomorphic dynamism and increased unpredictability in patterns of erosion and deposition.

The application of the evaluation criteria identified the following key aspects of the Manalana wetland rehabilitation project:

- **Relevance** – The rehabilitation focussed on the need of the local beneficiaries by protecting their livelihoods through halting erosion that threatened the ability of the wetland to supply ecosystem services. The evaluation has identified that the rehabilitation had increased the ability of the wetland to resist change, secured the wetland habitat and safeguarded the provisioning of ecosystem services to the community.
- **Efficiency** – Positive net present values suggest that when considered at either a 3 percent discount rate over a 25 year period or, a 6 percent discount rate over a 50 year period, the rehabilitation of the wetland was a worthwhile investment. However, there was some contention over an appropriate discount rate for evaluating ecosystem related projects, in addition the rehabilitation costs were based on expected costs, whereas actual costs may have been higher.
- **Effectiveness** – The rehabilitation of the Manalana wetland had been effective in achieving the objectives of the rehabilitation.
- **Impact** – Use of the provisioning services of the wetland were still actively being undertaken, supporting the livelihoods of particularly vulnerable members of the Craigieburn Community. There appeared to be a shift in the culture of wetland cropping in the area, from subsistence agriculture towards small-scale commercial agriculture. While a positive socio-economic benefit, this trend raises concerns regarding the long-term health of the wetland if crop cultivation within the wetland were to expand and/or intensify.
- **Adaptability** – The lack of the basic monitoring and lack of engagement between the implementer and the wetland beneficiaries strongly suggested that the adaptive ability associated with the rehabilitation at that point in time was weak.
- **Resilience** – The rehabilitation had contributed positively to the wetland system resilience to change that could be brought about by cultivation and ongoing erosion. The rehabilitation interventions introduced new artificial base levels that resulted in paused erosion in parts of the wetland. The interventions did nothing to change the drivers of the erosion which were still present. The resilience of the site is therefore inextricably linked to the survival of the structures.
- **Sustainability** – The benefits of the rehabilitation are still being derived, approximately six years after the implementation thereof.

A2.3 Lessons learnt from the evaluation of the Greater Edendale Mall and Manalana wetlands

The six general principles of monitoring and evaluation were applied to evaluate the rehabilitation of both wetlands. This process allowed the project team to ensure that the evaluations were aligned with the six principles and provided a platform to document lessons learnt while undertaking the evaluations. The six general principles include:

- Utility;
- Accuracy and credibility;
- Feasibility;
- Participation, access to information and transparency;
- Social learning; and
- Propriety.

The application of the six general principles helped identify lessons/issues that should be considered in future evaluations. These included:

- The social learning between the evaluators and the users of the Manalana wetland could have been strengthened;
- Integrating different disciplines to form agreeable solutions proved difficult;
- Documenting of the rehabilitation process from beginning to end proved to be important to ensure that the evaluator had access to as much data as possible in order to make a confident evaluation;
- The evaluator should report on the confidence of the data that had been collected to inform the evaluation;
- In order to ensure that the evaluation is feasible, the minimum amount of data that is required to undertake the evaluation should have been determined;
- Monitoring data collection should promote an adaptive monitoring approach;
- Data that was not collected, but would have been useful had it been available, should have been documented; and
- The evaluation process should have promoted social learning within the project team and, between wetland practitioners and the users of the evaluated wetland.

A3.1 An evaluation of potential candidate wetlands for rehabilitation to improve water quality in the Baynespruit catchment, Pietermaritzburg, KwaZulu-Natal

The Baynespruit catchment has been subjected to substantial modifications over the years, and the Baynespruit River is one of the most highly polluted rivers in Pietermaritzburg, KwaZulu-Natal. Limited data are available on the freshwater ecosystems within the Baynespruit catchment. Such data are required to make informed management decisions and to inform rehabilitation planning within the catchment.

The evaluation of the Baynespruit catchment is considered to be a clarificatory evaluation, which includes an evaluation of different alternative approaches and/or sites during the planning stages of a project. The aim of this study was to investigate the health, provision of ecosystem services and the potential for rehabilitation of selected wetlands in the Baynespruit catchment. To achieve this aim, the following objectives were addressed:

- Existing wetlands in the Baynespruit catchment were mapped using a variety of spatial coverages, historical and current aerial imagery, and other applicable data e.g. contours;
- The 76 identified wetlands were screened at a desktop level in order to select case study sites as candidates for rehabilitation;
- The nature and extent of human impacts, and the current effectiveness of the selected wetlands with respect to improving water quality were assessed using the WET-Health (Macfarlane et al., 2007) and WET-EcoServices (Kotze et al., 2007) assessment techniques; and
- The potential of the three selected wetlands for enhanced effectiveness in improving water quality were identified based on the above assessments and possible rehabilitation measures were suggested.

A3.1.1 Key lessons

The successive screening process employed in this study provided a useful means of narrowing down a large set of candidate wetlands to a much smaller set of priority candidate wetlands with reference to a specific rehabilitation objective. Such evaluations are often required in the planning phase of many wetland rehabilitation projects, and the approach is likely to have wider applications.

The findings of this study highlighted the importance of field verification for refining the accuracy of the delineation derived primarily from desktop assessment, verifying the HGM type and describing the vegetation. The findings also demonstrated that although the WET-Health and WET-EcoServices results were useful for an initial evaluation, key information on wetland structure (e.g. cross-sectional profiles) and geomorphic dynamics were required to undertake a meaningful evaluation of the potential contribution of rehabilitation to the delivery of specific ecosystem services.

Finally, the case highlighted the importance of considering site limitations, as revealed by the contextual information, when prioritising sites for rehabilitation. For example, the wetland which was identified as having the greatest potential to increase retention of inflows and the size of the wetland area which could be functionally enhanced, also had some of the greatest limitations imposed by existing residential developments into the fringe of the wetland.

A4.1 A formative evaluation of the structural integrity check sheet based on a workshop held with Working for Wetlands representatives at Hlatikulu wetland

The study focussed on the application of the structural integrity check sheet from an earlier version of the Walters et al. (2019) framework by a variety of persons, with varying levels of experience, in the wetland rehabilitation field of practice. The field workshop:

- Provided participants with an opportunity to apply the check sheet to a diversity of interventions in order to gain practical experience and, at the same time, provide feedback in terms of (1) gaps/issues in content, and (2) clarity of the check sheet; and
- Explored how a formative evaluation (an evaluation that informs future actions), 3 to 5 years after the rehabilitation interventions were completed and the site had time to respond to the rehabilitation, may contribute in terms of the long-term sustainability of the rehabilitation outcomes.

In addition to revealing several refinements to the check sheet (incorporated into the check sheet in Walters et al., 2019), this assessment usefully demonstrated the value of a structural integrity assessment 3 to 5 years after completion of the rehabilitation interventions. The implementation cycle for most rehabilitation projects incorporates the assessment of the structural integrity of the interventions shortly after implementation. This allows the most obvious problems associated with the implementation to be identified and suitably addressed. However, subsequent monitoring is rarely undertaken due to a variety of reasons, but monitoring at this interval of 3 to 5 years was shown to be invaluable in terms of identifying adaptive management requirements.

A4.1.1 Key lessons

The Hlatikulu case demonstrated how several maintenance issues had emerged within 3 to 5 years after completion, which have implications for long term sustainability of the rehabilitation outcomes. Such issues may have been difficult to anticipate immediately after completion of the interventions, or may have started to manifest only a few years after completion. Responding to these changes would generally require minor maintenance (e.g. removal of debris that had accumulated in the spillway of one of the interventions) and/or amendments to the interventions (e.g. the slight lowering of a spillway of another intervention in order to prevent low flows from out-flanking the intervention) with limited cost implications. However, if the identified issues are not addressed then at least some of these issues are likely to develop into major structural failure with much greater cost implications.

A5.1 An evaluation of the rehabilitation interventions of the Companjesdrif area of the Kromme River wetland, Eastern Cape

In the Companjesdrif area of the Kromme River wetland in the Eastern Cape, two erosion control interventions had successfully achieved their primary purpose of halting gully erosion which was threatening a large intact area of Palmiet (*Prionium serratum*) wetland. However, questions were raised about other effects of the interventions. The objectives of the evaluation were to:

- Assess the effect of the two erosion control interventions on the water table at a local level by comparing water tables, for both dry and a wet period, in an intact area of Palmiet wetland upstream of the structures and in the eroded channel immediately below the structures; and
- Undertake a preliminary examination of the possible contribution of the interventions to increased erosion in the downstream reach, based on the water table data and other available evidence.

The methods included: (1) Water level measuring at points along seven transects across the site; (2) sediment sampling and analysis; and (3) a topographic cross-section and analysis of aerial images.

The water table elevation patterns showed that the depth to the water table varied between approximately 0 m and 4 m below the surface. From upstream of the structures to downstream there was a 7.8 m drop in surface water elevation. All water tables were lower in winter than in spring. Also, in winter the depth to the water table was significantly lower along the eroded reach in comparison to the non-eroded reach. The results of water table elevations measured in winter along the non-eroded reach showed that, in general, the water table was lightly sloping away from the channel, which resulted in an area of sub-surface water discharge with respect to the channel. The water table elevations measured in winter along the eroded reach showed that the water table was sloping towards the channel, which resulted in an area of sub-surface water recharge with respect to the channel.

Sand made up the greatest depth of the profile but at least one silt and/or loam horizon was also present and varied in depth and thickness. This indicated that the sediment was predominantly non-cohesive but with some cohesive layers. Organic matter (OM) content did not exceed 17% and therefore no peat was present.

The aerial images showed that the eroded reach downstream of the structures had become significantly wider between when the structures were constructed, in 2005, and 2013. However, there appeared to be little change from 2013 to 2016. Various factors potentially causing this widening were considered based on the available evidence. There appeared to be little evidence for onsite disturbance (e.g. from cattle) being the main cause, or for raised water levels in the channel to have caused bank failure (as a result of diminished shear strength). It appeared most likely that channel widening had resulted from the structures promoting upstream sediment retention and therefore decreased sediment supply downstream. The structures had led to the de-stabilisation of the downstream stream bed.

A5.1.1 Key lessons

The approach employed in this assessment, of using basic water level measurements and sediment profile descriptions to assist in wetland rehabilitation evaluations, provided a practical demonstration of the water level assessment module of an earlier version of the wetland rehabilitation M&E framework (Walters et al., 2019).

The case hopefully provides a practical demonstration of the systematic screening of different possible causative factors to ultimately draw conclusions from a diverse body of evidence on the effect of rehabilitation interventions in the absence of a control site.

The results of the assessment highlight the importance of not confining the assessment to whether the rehabilitation objectives have been achieved but also to include unintended consequences of the interventions.

A6.1 Assessing the engagement of the land owners in wetland rehabilitation on Kruisfontein Farm, Mooi River, South Africa

The purpose of this case study was to apply an earlier version of the module of the M&E framework (Walters et al., 2019) that guides the assessment of stakeholder and landholder engagement in wetland rehabilitation and aftercare. Furthermore, this included a critical reflection on the application of the module to identify and document specific inadequacies/gaps in the module which needed to be refined or added to. This information informed the improvement of this module in the latest M&E framework.

The results of the interview suggested that, in this case, the landowner had the willingness and understanding to care for the rehabilitated wetland in the long term. However, this was reduced by uncertainties regarding who was responsible for maintaining the rehabilitation interventions and who to contact should problems within the interventions or wetland have arisen. Although the landowner saw monitoring as their role, it was unclear what, when and how the monitoring should have been undertaken. The lack of clarity in this regard left the type and frequency of monitoring to the discretion of the landowner.

The interview with the WfWetlands Provincial Co-ordinator (PC) supported the findings taken from the interaction with the landowner. The PC's responses in the interview indicated that the Kruisfontein project was considered successful from an implementation output perspective but no consideration had been given to the success of the project from an outcome perspective. While the PC had frequent contact with the landowner during the implementation phase, there was no further contact between WfWetlands and the landowner once implementation was completed. Moreover, there was no agreement, or even a discussion, regarding who might have been responsible for the monitoring and aftercare of the wetland.

A6.1.1 Key lessons

Upon reflection, the following amendments were recommended to improve the module that guides the assessment of stakeholders and land-user engagement in wetland rehabilitation and aftercare:

- The purpose of the module should be made clearer. Stakeholder perceptions in this case served to provide an indication of the landholder/stakeholder's willingness and ability to meaningfully participate in post wetland rehabilitation implementation monitoring and aftercare. Should it be required that a landholder/stakeholder be responsible for the long-term monitoring of the wetland and they are not willing or able to do this, then this presents a clear risk to the long-term success of the rehabilitation.
- Some additional questions were also identified which may, depending on what is required from the landowner, be required to more adequately assess the landholder/stakeholder's willingness and ability to participate. For example, does the landholder/stakeholder understand how the rehabilitation interventions, as individual interventions and as a system, function and how it relates to the rehabilitation objectives?

A7.1 Monontsha wetland: An evaluation of the wetland in terms of the integrity of the structural interventions

The Monontsha wetland is located within the Monontsha community in the Free State province. The catchment of the Monontsha wetland has been substantially altered from its natural conditions to peri-urban settlements, with one of the predominant catchment impacts including hardened surfaces and the consequent increase in flood intensity. Some of the community members are reliant on the wetland as a natural resource, particularly for the grazing of livestock, subsistence cultivation and sand mining. The result of the changes in the catchment and in-system characteristics from natural conditions have led to *inter alia*, the formation of headcut erosion, erosion gullies, desiccation and/or loss of wetland habitat. The rehabilitation of Monontsha wetland commenced in the early 2000s, and since 2007 the rehabilitation activities had been undertaken under WfWetlands. The main objective was to reinstate the hydrological conditions of the wetlands, through *inter alia*, the deactivation of any erosion, the encouragement of diffuse flows across portions of the HGM units, raise the water table, and sediment trapping. Due to the reliance of the community on the natural resources within the wetland, management of livestock grazing and sand mining activities were included in the rehabilitation recommendations.

The purpose of the Monontsha assessment was to apply the structural integrity check sheet from an earlier version of the M&E framework (Walters et al., 2019) to the site in order to assess the intervention maintenance requirements of the site. The assessment was also used as an opportunity to further refine the structural integrity check sheet, which was subsequently amended and updated to incorporate observations made on-site that may not have been considered when the check sheet was initially drafted, thereby updating the check sheet information. The Monontsha site had many interventions with high maintenance requirements and some had failed completely, and it therefore provided a useful contrast to the Hlatikulu site where, for most interventions, the maintenance issues were not far advanced.

It was noted that the Monontsha wetland had been subjected to various levels of adaptive management, whereby modifications to various structures were implemented to account for site conditions and ensure the structural integrity of the structures. Some structures required redesign or modifications to account for outflanking around the structures and the implementation of support structures were required in some instances.

A7.1.1 Key lessons

The assessment provided a fairly strong example of how adaptive management has the potential to support existing rehabilitation plans and encourage positive system responses. However, in instances where structures had been poorly designed, the degree of structural failure was relatively high with outflanking, erosion upstream and downstream of the structures, vandalism and tunneling being some of the major contributors to failure. Since the implementation of many of the structures, much headway has been made regarding rehabilitation strategies and structural designs; thus, the failures that were observed have assisted in contributing towards lessons learnt. It was critical to allow for the consideration of changes in population pressures on the site, including increased hardened surfaces and the possibility of increased cattle pressure on the land, since the implementation of rehabilitation when evaluating the rehabilitation. These changes may have been one of the driving factors leading to structural failures since the changes in the site contextualisation had been fairly significant and the rehabilitation had not accounted for these additional flows or pressures on the system.

A8.1 Using an adaptive management approach to implement wetland rehabilitation activities in the Riverhorse Valley floodplain

The uMhlangane River, located in Durban, has been identified by the Durban Green Corridors (DGC) initiative as a focus area for rehabilitation efforts to improve the management of freshwater ecosystems within the uMgeni River Catchment. The portion of the uMhlangane River floodplain located within the area of private open space of the Riverhorse Valley Business Estate was chosen as a pilot wetland rehabilitation project by the eThekwini Municipality in order to address developmental challenges within the uMhlangane River catchment. The sectors that were involved in this work included: Environmental Planning and Climate Protection Department; Coastal Stormwater and Catchment Management Department; Economic Development Unit; eThekwini Water Services Unit; and Riverhorse Valley Business Park.

In 2010, GroundTruth was appointed by the eThekwini Municipality to compile a wetland rehabilitation plan to address the impacts that existed within the Riverhorse Valley floodplain. Rehabilitation implementation activities began in May 2014 and were still underway at the time of this report. An earlier version of the M&E Framework (Walters et al., 2019) was applied in order to reflect on the progress of the rehabilitation implementation and respond adaptively when mismatches between the intended outcomes and the actual outcomes of the rehabilitation were identified.

The Riverhorse Valley floodplain has been subjected to extensive sugarcane cultivation for many years, and the remnant cultivation drains that were installed to drain the wetland are still present within the floodplain, limiting the diffuse flow of water through the system. It was anticipated, that under natural conditions, the uMhlangane floodplain would have been characterised by large areas of seasonal and permanent wetness. The rehabilitation aimed to deactivate the existing ridge-and-furrow network, plug the furrows with earthen berms, excavate two attenuation ponds to manage the high flood peaks that originate from the industrial areas into the floodplain, excavate a meandering channel and reintroduce diffuse flows through the floodplain, and construct a concrete dual-spillway weir to direct baseflows from the John Dory stream into the Riverhorse Valley wetland area. Overall, this rehabilitation strategy aimed to reinstate near-natural hydrological conditions within the wetland by improving the water retention time within the wetland and spreading the flow of water across the rehabilitation site

During the course of the rehabilitation activities, regular site visits were undertaken by ecological control officer (ECO), which was required by legislation to ensure compliance of the proposed activities with the conditions contained within the record of decision.

A8.1.1 Key lessons

Due to their dynamic nature, wetlands often react very differently to new drivers in a system, such as rehabilitation structures. As such, rehabilitation strategies need to account for such challenges and adapt accordingly along the way. Adaptive management employs learning-by-doing in a scientific way that allows for evidence-based management decisions to be made as new information becomes available.

The Riverhorse Valley rehabilitation is a very useful example of where adaptive management has been implemented to inform adjustments and amendments to the implementation. In order to attain the original objective in the face of implementation problems, it was necessary to adjust and amend the rehabilitation plan to account for unforeseen outcomes, and adjust and amend the rehabilitation plan to account for unforeseen changes to site contextualisation. During the implementation of the initial rehabilitation phase, a number of amendments to the work being undertaken and the rehabilitation plan were made; including the adoption of different methods to level the ridge-and-furrow sections, the material that was initially used to plug the drains failed therefore different material was required, and the establishment of vegetation within the rehabilitated areas required the establishment of a wetland plant nursery to support the revegetation efforts. Although these remedial actions may not have been part of the initial rehabilitation strategy, their implementation allowed for the necessary rehabilitation objectives to be met. In addition to these changes, the location of a concrete structure was amended prior to implementation as the functioning of the system was better understood.

The dynamic nature of ecological systems often requires a flexible approach to assist in achieving the rehabilitation objectives. The importance of implementation support and adaptive management was apparent on three levels in this case: ensuring that the implementation activities were undertaken to specification by the contractors; informing amendments to the original rehabilitation plan based on onsite observations made during the project implementation phase; and, informing amendments to the original rehabilitation plan based on changes to site contextualisation. The regular site visits enabled the wetland engineers and ecologists to identify enhancements to the rehabilitation plan that were not identified during the rehabilitation planning phase of the project.

A9.1 Assessing the change in the physical flow of ecosystem services associated with wetland rehabilitation interventions in the Xharas wetland

The Xharas wetland lies within the Leliefontein communal, Kamiesberg Uplands, Northern Cape, which is characterised by low economic activity and high unemployment. In response to extensive degradation in the wetland, primarily as a result of historical drainage and cultivation, the wetland was rehabilitated in 2011. The primary objective of the rehabilitation activities was to re-instate near-natural hydrological conditions and enhance the integrity of the wetland area in order to have generally improved its value for biodiversity conservation, the provision of natural resources and ecosystem services.

In order to achieve the above rehabilitation objective, the following rehabilitation strategies were devised: halt the continued erosion within the incised channel and reduce the extent to which flow is artificially constrained in the channel, by means of a series of structures in the channel and, remove the invasive alien trees within the wetland.

An assessment of the change in the physical flow of a range of ecosystem services resulting from the rehabilitation interventions was undertaken. The methods applied in the valuation were based on the guidelines given in an earlier version of Walters et al. (2019) for "Valuing the outcomes of wetland rehabilitation" as well as using some of the indicators and methods given in WET-EcoServices (Kotze et al., 2009) and the WET-Health (Macfarlane et al., 2009) assessment undertaken in 2010 prior to rehabilitation and then repeated in 2014/15. Further to this, the valuation draws from the results of water table monitoring undertaken by community monitors as part of a WfWetlands project. The valuation was carried out in a four-stage process:
Stage 1: Define and contextualize the ecosystem service evaluation assessment;
Stage 2: Conceptualise the *system and the responses to the rehabilitation interventions;*
Stage 3: Assess the current and future demand for the services; and
Stage 4: Summarise the results of the supply and demand assessment

The overall results are summarised in **Table II** from which it is clear that the greatest contribution of the rehabilitation was to the maintenance of biodiversity. Demand for biodiversity maintenance was high given the wetland's location in Kamiesberg Uplands for which wetlands have been identified as special habitats in need of particular conservation attention. Within the local landscape rehabilitation of the Xharas wetland made a significant contribution to decreasing cumulative loss of wetland habitat as well as occupying a strategically important location in terms of landscape connectivity.

Table II: The relative contribution of rehabilitation interventions in the Xharas wetland to the physical flow of specific ecosystem services

Ecosystem services	**Supply**		**Demand**
	Level of functional enhancement within the affected area[1]	**How widely the benefits supplied by the wetland might be experienced**	
Streamflow regulation	Moderate	8 km downstream	Moderately high
Groundwater recharge	Moderately high	Local area taken as a 300 m radius around the wetland	Moderately high
Phosphate assimilation	Moderate	8 km downstream	Moderate
Direct water supply for livestock	Moderate	2 km radius around the wetland	High
Grazing for livestock	Moderate	1 km radius around the wetland	Moderately high
Maintenance of biodiversity	High	10 km radius around the wetland	High

[1]This refers to the level of functional enhancement specifically resulting from the rehabilitation interventions.

The enhanced retention of water referred to above, together with the elimination of excessive loss of atmospheric water by eucalyptus and poplar trees, contributed significantly to the potential supply of the following services: groundwater recharge, streamflow regulation, water supply, and livestock grazing, for which demand was moderately high to high. With projected climate change, the demand for all these services is likely to increase.

A9.1.1 Key lessons

For the four-step process described above, each step had considerable latitude in terms of what to assess and how to assess. Thus, the worked example developed in this case, together with its several tables which can serve as templates, has particular value for less experienced assessors and for comparison of results across multiple sites, particularly where these sites are assessed by different assessors.

The valuation revealed several important limitations of WET-EcoServices when applied in a rehabilitation evaluation context (e.g. some ecosystem services, such as groundwater recharge, were not included in WET-EcoServices at all but may be important in certain landscapes).

A10.1 A formative evaluation of the Zaalklapspruit wetland rehabilitation project, Mpumalanga Province

The Zaalklapspruit wetland, Mpumalanga Province, was rehabilitated in order to enhance its capacity to mitigate Acid Mine Drainage (AMD) from its catchment. Drained portions of the wetland and an incised the channel running through the system, resulted in substantially concentrated flows. These drains were deactivated so as to spread flows and reduce the retention time of water within the wetland. Periodic detailed monitoring of water quality of inflows and outflows from the wetland began a year prior to rehabilitation and were still being monitored at the time of writing this report. However, the monitoring of vegetation only received initial attention, thus an opportunity existed for repeating the baseline quadrat-based survey three years after rehabilitation to review the vegetation response. In addition, there had been no systematic assessment of the structural integrity of the rehabilitation interventions and whether the interventions were achieving the purpose/s for which they were designed. Thus, a formative evaluation was undertaken at Zaalklapspruit wetland focussed on two main components:

- An assessment of the vegetation based on a repeat survey of the initial baseline vegetation assessment; and
- An assessment of the structural interventions in terms of integrity and contribution to achieving the rehabilitation objective.

A baseline vegetation survey, undertaken in 2012, focussed on the portion of the Zaalklapspruit wetland which was to be rehabilitated. For each quadrat, an attempt was made to identify all graminoid (grass, sedge and rush) species present and estimate their aerial cover as a percentage of the quadrat. In the follow-up survey undertaken in March 2017, the same sampling methods were applied and an attempt was made to relocate each quadrat as close as possible to its original location.

In order to understand any changes in the vegetation, the application of two vegetation indices, which are comprehensively described by Cowden et al. (2013), were applied:

- ***Wetland Index Value (WIV):*** This index is designed to address the question of whether the vegetation composition has shifted to a more hydric state (in this case, in response to re-wetting of historically drained areas); and
- ***Floristic Quality Assessment Index (FQAI):*** This index is designed to address the question of whether the vegetation composition has shifted away from (or towards) species which are predominantly ruderal/weedy, and/or pioneer, a situation described as having low floristic quality and which is typically associated with high levels of human impact.

The most striking change in vegetation was noted as *Typha capensis*, which was entirely absent in the pre-rehabilitation survey, occurred in 6 of the 20 quadrats in the post-rehabilitation survey. Other species, such *Pycreus nitidus*, also showed a marked increase from the pre- to post-rehabilitation survey, and appear tolerant of AMD. However, there was a reduced frequency and abundance of terrestrial grasses, notably *Eragrostis chloromelas*. The WIV results show that there was a decline in the number of quadrats transitional between wetland and non-wetland, and an increase in the frequency of quadrats falling within the wettest wetland class. The FQAI results show that there was an increase in quadrats in the lowest FQAI class and a decrease in quadrats in highest FQAI class. Important factors contributing to this were the increased incidence of pioneer species, notably *T. capensis,* and in the number of alien species post-rehabilitation compared to pre-rehabilitation.

Concrete weirs and walls, and earthen plugs were used to rehabilitate the wetland. Upon inspection of the concrete weir a number of issues were noted, including that the concrete had not been mixed to specifications, there was inappropriate accumulation of debris and/or vegetation around spillway, and cracks were evident within the structure. The weakened concrete appeared to be the result of the water, sourced from the wetland, used to mix the concrete of the interventions, as the designs had not specified the need to import water for construction purposes. The use of the in situ acidic water resulted in limited curing of the concrete mix, which resulted in concrete that was 'softer' than the specifications.

Through relatively simple adaptive management modifications to the existing interventions, opportunities for further spreading flows were identified. However, before embarking on this more "aggressive" approach to enhancing wetland functioning, it would be necessary to consider the degree to which flows into these additional areas can be sustained through drier periods, as sustained flows assist in maintaining anaerobic conditions and desired processes within the wetland. If areas of the wetland into which AMD had been distributed (and in which anaerobic conditions were to develop) were subsequently to dry out, and therefore be subjected to aerobic conditions, a potentially high risk of pollutants being released back into the water column would exist.

A10.1.1 Key lessons

Water quality monitoring provided little indication of how the AMD was spatially distributed across the wetland. Thus, it was recommended that the existing detailed water quality monitoring be supplemented with much less detailed monitoring of a few parameters, notably pH and electrical conductivity, at several points widely distributed across the wetland.

The above specific lesson highlighted a general lesson that a wetland rehabilitation project's M&E component needs to be reviewed and adjusted in a formative way. That is, "what is monitored and when" is not set in stone but can be adjusted in order that it best serve the ultimate outcomes of the project. During the course of implementation, additional indicators can be added, and in some cases, indicators modified or substituted, but careful consideration needs to be given to the trade-off between comparability with the baseline and improvements in future monitoring.

An important consideration, raised by the potentially different approaches towards rehabilitating the Zaalklapspruit wetland, was the need to explicitly consider the risk posed by different approaches, e.g. the more "aggressive" wetland enhancement approach referred to above.

A12.1 Assessing the structural integrity and the stakeholders' perceptions of the wetland rehabilitation activities within the Dartmoor Vlei, KwaZulu-Natal midlands

The monitoring of the overall functioning and integrity of individual interventions within a wetland system is considered to be the minimum monitoring requirement to establish the success of the rehabilitation strategy. The landholder perceptions and assumed responsibilities towards monitoring and aftercare are also recognised as very important to the sustained rehabilitation outcomes in the long term. The Dartmoor case study represents an evaluation of the structural integrity and stakeholder perceptions for Dartmoor Vlei wetland located within the Mnyamvubu catchment (Karkloof area) of KwaZulu-Natal. In 2004-2005 a series of weirs and spreader canals were constructed with objectives of stabilising the erosional features within the canal, raising the water table, encouraging the spread of diffuse low flows across the wetland and enhancing the wetland as suitable breeding habitat for wattled cranes. An evaluation of the Dartmoor rehabilitation and its outcomes was undertaken in 2007, which was considered too soon to reliably assess the long-term ecological outcomes of the interventions. Therefore, it was recognised that there was value in re-visiting the site approximately 10 years later.

All of the interventions within the Dartmoor Vlei were assessed using an earlier version of the intervention integrity check sheet of Walters et al. (2019). In order to establish the perceptions of the stakeholders towards the rehabilitation activities within the Dartmoor Vlei, semi-structured interviews with the identified key stakeholders were conducted. The stakeholders interviewed included the current landholder and the WfWetlands PC and were based on the landholder interview guidance in a draft version of Walters et al. (2019).

All of the nine weirs within the system showed some issues in terms of their structural integrity, with four under high threat and the remaining weirs under moderate threat. Interestingly, the 2007 survey noted similar types of maintenance issues as in 2017, but much less severe. The degree to which the interventions were achieving their intended purpose was generally low, particularly in the case of the spreader canals. Thus, the objectives of raising the water table and encouraging the spread of diffuse low flows across the wetland were only being achieved to a limited extent. An assessment, using WET-Health, of the degree to which the interventions were obstructing the draining effect of the artificial drains was 30% less in the 2017 assessment than originally assessed in 2007. However, despite this assessment for the overall wetland, a strategically placed intervention had significantly raised the water table in the drain immediately alongside the wattled crane nest site. Therefore, the rehabilitation was still making an important contribution to the fourth objective of contributing towards breeding habitat for wattled crane.

With regards to the monitoring and evaluation of the wetland, the WfWetlands representative highlighted that WfWetlands undertook thorough M&E during the implementation, but following implementation, WfWetlands encouraged the landowners to undertake their own M&E. However, the landownership of Dartmoor changed a few years after completion of the rehabilitation interventions and associated with this change there appeared to have been a loss of knowledge relating to the project and the required M&E. This was evident in landholder's limited knowledge of the rehabilitation interventions. Although the landholder indicated willingness to take the responsibility for monitoring the interventions, she highlighted that, due to her limited technical knowledge, she would require input from an expert. Even though the landholder also indicated a willingness to assume responsibility of the maintenance of the interventions, it was unlikely that she understood what a considerable undertaking it was and the associated financial implications thereof. The WfWetlands representative highlighted that the landowners were encouraged to undertake their own M&E for the site with guidance from an expert, if possible. However, in this instance, a formal M&E program was not in place.

A11.1.1 Key lessons

The following key lessons were taken from this case study:

- The importance of waiting for several years to elapse before being able to reliably assess the outcomes of wetland rehabilitation interventions: In this case study, the contribution to improving ecological condition noted 10 years after completion of the rehabilitation was significantly lower than was originally predicted to occur during the assessment 2 years after completion of the interventions;
- The value of assessing functionality of the interventions based on both a wet season and a dry season visit: The dry season assessment was especially useful in locating water flows moving beneath the structures while the wet season monitoring was especially useful for monitoring the distribution of flows across the wetland linked to each intervention;
- The importance of timeous response to the early detection of structural integrity issues: In this instance minor structural integrity issues were identified two years after the completion of the rehabilitation and at the time were considered to have a minimal effect on intervention functionality. However, these structural integrity issues had escalated in severity eight years later, to the point where the functionality of the interventions was being substantially compromised. Addressing issues as they arise may initially not be considered important but in the long run, early intervention may result in a substantial cost saving, as invariably a minor issue to address is substantially cheaper than a major issue, which in some instances may even require rebuilding an entire structure;
- The value of considering the separate but interrelated aspects of intervention integrity and intervention functionality: In this case, generally the integrity issues were also found to be impacting upon functionality of an intervention, but there were some cases where the integrity of the intervention was considered to be reasonable while functionality was very limited;
- The importance of assessing outcomes in relation to specific objectives set for the rehabilitation: Rehabilitation projects often include multiple objectives, against which outcomes of rehabilitation interventions need to be reviewed. This case study highlighted that two of the three objectives,

namely stabilise erosional features and, increase the water table and encourage diffuse flows across the wetland; were being poorly met. In contrast, the fourth objective, the enhancement of the wetland so as to provide suitable breeding habitat for wattled cranes, was being reasonably well met, although was considered to be under threat; and

- The critical need to address landholder responsibility in relation to wetland rehabilitation monitoring, evaluation and maintenance: In this case study it was seen how, despite the current landholder specifically managing the wetland primarily for biodiversity conservation purposes, they did not know what factors relating to the integrity of the interventions to monitor. Therefore, the landholder was not in a position to contribute to M&E even though ideally placed to do so. A key factor resulting in this situation was that when the current landholder took over land-ownership several years after the rehabilitation interventions had been completed, they were not informed about what needed to be monitored and/or whom to contact.

APPENDIX 2: QUESTIONS AND CONSIDERATIONS TO MAKE WHEN UNDERTAKING VSTEEP

- Values:
  - Identify the goals and objectives of the rehabilitation that supports and secures livelihoods; and
  - Attempt to understand the value systems within the community that may drive the way in which resources are used and/or managed.
- Social:
  - Indigenous knowledge vs. western knowledge;
  - Social structure, distribution of resources (land tenure), distribution of power (authority);
  - Social organisation, gender roles, individual vs. group, family lineage and social groups;
  - Cultural and religious values;
  - Education; and
  - Sources of data: Stats SA, IDP, WRC, AWARD.
- Technical:
  - Aspects related to the problem/intervention; and
  - Associated infrastructure (water supply).
- Economic:
  - Productions systems: industries, mining, manufacturing, agricultural production;
  - Marketing systems: commodity boards, markets, commercial activity;
  - Employment rates (formal and informal); and
  - Economic policy: pricing policy, trade, etc.
- Environmental:
  - Drivers of degradation (at a catchment and wetland scale);
  - Physical environment: soils vegetation, climate, water, disease, atmosphere, topography, etc., in the context of ecological systems;
  - Resources available; and
  - Conservation status and management
- Political (Stakeholder mapping, power and influence):
  - Power: between institutions and levels, between and within countries; linkages not neutral (one person's degradation is another's accumulation or one person's gain is another's loss);
  - Institutions: political parties, farmer community organisations, international organisations, national and local bureaucracies, multi- and bi-lateral organisations, NGOs, multi-national corporations.
  - Customary systems,
  - NGOs involved, and
  - Municipality.

APPENDIX 3: ECONOMIC EVALUATION – SUPPORTING MATERIALS

Additional information

Various discussions, reviews and guides to valuing the benefits of ecosystems are available:

- **For introductions** see Barbier et al., 1997; Pagiola et al., 2004; Heal et al., 2005; Eftec, 2006; Turner et al., 2008; EPA, 2009; TEEB, 2010; DEFRA, 2011.
- For **restoration specific examples** see Rutherford et al., 2000; Lewis III, 2001; Pendleton and Baldera, 2010; Robbins and Daniels, 2012.
- For **locally developed manuals** see Ginsberg et al., 2010, Turpie and Kleynhans, 2010; and Mullins et al., 2014.

An overview of economic valuation methods

Method	Approach	Applications	Strengths	Challenges
Market-based (M)	Observe prices directly in markets	Ecosystem goods and services traded in markets, or ecosystem services or goods that are inputs in the production of market goods or services	Market data are often readily available; estimates based on observed data of actual consumer preferences; robust. Production function approaches may be technically difficult.	Limited to cases where ecosystem services/goods are traded in the market; prices may need to be adjusted to correct for distortions; information is needed on the relationships between improved quality or quantity of the ecosystem service and the output – these relationships may not be well known or understood.
Non-market-based	**Revealed preference – Travel cost (TC)** Takes travel and time costs incurred as a proxy for value	Recreation and cultural heritage related services	Estimated values are revealed from actual behaviour of individuals	High data requirements. Difficulties arise when trips are to more than one destination or for more than one purpose.
	Revealed preference – Hedonic pricing (H) Estimate the influence of environmental characteristics or environmental amenities on price of market goods (usually property)	Water quality, aesthetic views, proximity to recreational sites	Estimated values are revealed from actual behaviour of individuals	Large data requirements and specialist econometric expertise
	Stated preference (SP) Individuals are surveyed to elicit their preferences, in the form of statements, ratings, rankings or choices, for predefined (hypothetical) alternatives regarding changes in ecosystem services/benefits	A broad range of ecosystem services	Currently the only approach for estimating non-use values, can also be used to estimate use values; flexible (many hypothetical scenarios can be constructed); much information can be collected and collated from the sample population through the survey	Assumes individuals understand the service/benefit in question; vulnerable to respondent bias; can be expensive and time-consuming, (survey design and extensive pre-testing); based on asking people questions, as opposed to observing their actual behaviour (which is a source of much controversy)
Cost-based	**Replacement cost (RC)** Costs of replacing the benefits of the ecosystem are used to value the benefit	Ecosystem services that have a human-made equivalent that provides similar benefits to the ecosystem service	Less data and resource intensive – it is often easier to measure the costs of producing benefits rather than the benefits themselves; data or resource limitations may rule out other	Should be used with caution. If conditions (substitutability, demand for substitute, lowest cost alternative) do not hold, the method is likely to over or under-estimate actual value. Few

Method	Approach	Applications	Strengths	Challenges
	Avoided costs (AD) Costs avoided due to the presence of the ecosystem service (e.g. flood damage).	Services that provide protection to infrastructure (e.g. flood attenuation)	valuation methods; improved validity when based on actual expenditure	environmental resources have such direct or indirect substitutes. Not a measure of economic value

APPENDIX 4: INTEGRITY AND FUNCTIONALITY CHECK SHEETS TO ASSESS WETLAND REHABILITATION INTERVENTIONS

The integrity and proper functioning of rehabilitation interventions are critical to the long-term success of wetland rehabilitation, and the assessment thereof should be the foundation of any M&E process. An initial step in this process includes a post-construction check sheet. A post-construction check sheet (to assess for example, that structures are built to specification, are complete and at the correct location, etc.) should be completed for each intervention constructed. In most cases, some form of a post-construction check sheet will be completed by the site agent when authorising the site sign off. However, in instances where this is not the case, one may be required to complete such an assessment. An example of a post-construction check sheet is given below. Some general background information should be given (e.g. GPS coordinates) as well as the approximate percentage completed at the time of sign-off.

In addition to the post-construction check sheet, as a minimum level of M&E, all wetland rehabilitation projects should assess the integrity of the interventions at the end of the implementation cycle (i.e. completion of the rehabilitation strategy which may include multiple interventions) and then again three to five years post implementation. Identifying damaged or failing structures allows for maintenance to be conducted that can save an intervention and in so doing save a great deal of money and ultimately ensure that a rehabilitation project succeeds.

A rehabilitation structure that is damaged or has failed cannot do its intended job (functionality) and will negatively impact the outcomes of the rehabilitation project. In addition, we cannot assume just because a structure is good condition that it is doing the job (function) that it was intended to do. Errors, for example, could be made during planning or structures can "settle" post implementation, both of which can lead to poor functionality and thus poor outcomes.

In addition to an integrity assessment, a functionality assessment should be conducted at the same time. The functionality assessment allows one to assess whether or not the structures are able to perform their intended function. These functions could include lifting a water table in a drain/gully, spreading water out from a drain/gully, flooding a headcut (gullyhead erosion) and trapping sediments. Other interventions could include measures to support the recruitment of wetland vegetation and the retention of sediment not linked to structural intervention. If a structure or a suite of structures (i.e. a group of structures with a common function) are not functioning (spreading water, etc.) as intended then an adaptation process will be required to modify the interventions so that they do what is required. There are also instances where the context of the rehabilitation may have changed which can lead to structural and/or functional challenges. For example, the land use within the wetland may have changed. A wetland that was not grazed by cattle could now be grazed meaning that the interventions such as earthen structures need to be cattle-proofed through hardening. Another example could be rapid urbanisation within a wetland catchment that has led to increased stormwater discharges and the need for larger spillways.

Much of our wetland rehabilitation in South Africa is based on the manipulation of hydraulic conditions at a location that influences the distribution and retention of water, and thus sediments, within a wetland. In order to ascertain whether or not the interventions constructed are having the hydraulic effect we desire, we need to collect data in the field that allows us to assess this. In the absences of flows that we could observe on any given day, we can use our knowledge of the topography within the wetland to build an understanding of how water moves through the wetland and what affect our interventions have on that movement. When we conduct a functionality assessment, we need be able to collect the data (evidence) that the structures are doing as intended.

To conduct a comprehensive integrity and intervention functionality assessment method generally requires the following resources:

1. Two people, at least one should be a wetland ecologist/restoration practitioner who can use a dumpy or abney level;
2. A dumpy level or an abney level and staff;
3. A GPS;
4. A camera;
5. A clear map of the rehabilitation site that shows the location of the rehabilitation interventions. The map should include contour lines (the smaller the interval the better);
6. A copy of the rehabilitation plan (or a summary thereof);
7. Clip board and integrity and functionality data sheet;
8. A pencil for making notes in the field (unlike ink, pencil doesn't 'run' if it gets wet); and
9. Gumboots or waders.

Once the integrity of a structure has been assessed then it is important to assess its functionality. To assess its functionality, one has to understand what the structure (or group of structures) are meant to do from a physical process perspective. *Is the intervention meant to impound water? Is it supposed to direct flows into another area of the wetland? Is it meant to flood back over a headcut to deactivate the erosion? Is it meant to support another intervention by flooding back to the toe of that intervention?* These functionality objectives will (should) be in the rehabilitation strategy and plan. A dumpy or abney level can be used to collect data that can be used to answer the aforementioned questions. For example, taking levels within the area that is meant to be flooded by an intervention relative to the top or spillway provides robust evidence (data) about whether or not that effect is being achieved. In a similar way if the full supply level of an impounding structure intended to flood out a headcut is below the level of the headcut, we can assume that the functionality of the structure is impaired and the objectives of halting the erosion will not be met. Secondary (biotic) indicators can be used to supplement the findings of the functionality assessment but should not take the place thereof.

It is understandable that identifying issues and the associated level of threat for the structures under review can often become confusing and seem complicated if the reviewer has little to no experience in assessing structural integrity. As such, this integrity check sheet has been designed to be as user-friendly as possible, ensuring transparency in the overall approach. **Box A4.1** provides the level of threat and level of functioning ratings to be applied during the application of the check sheets.

Box A4.1
<u>Level of threat:</u> 1 = No observable threat 2 = Low threat of failure 3 = Moderate threat and/or timeframe (3-8 years) for failure 4 = Imminent failure (high potential for substantial rapid degradation of the intervention within the next 2 years) 5 = High risk of failure within the next year 6 = The structure has already failed severely
<u>Level of functioning:</u> 1 = functioning at optimum level (100%) 2 = minor signs of functional failure (100-75%) 3 = Moderate level of functioning (75-50%) 4 = high degree of functional failure (50-25%) 5 = very high degree of functional failure (25-0%) 6 = complete functional failure (0%)

To provide visual illustrations of some of the examples of varying degrees of structural failure, the images below have been provided, describing the issues within each of the illustrations.

Figure A4.1 illustrates a gabion basket structure with numerous notable issues affecting the integrity and functioning of the structure. The sketch is looking in an upstream direction and is depicting following:

- The movement of water underneath the structure as it travels downstream, undercutting the foundation of the structure;
- The gabion's sidewalls have been vandalised and the gabion wire has been cut to access the small stones that are used to fill the baskets. This reduces the strength of the structure, making it vulnerable to further erosion; and
- Flows are not only depicted underneath the structure but flowing around the structure, completely bypasses the structure's spillway.

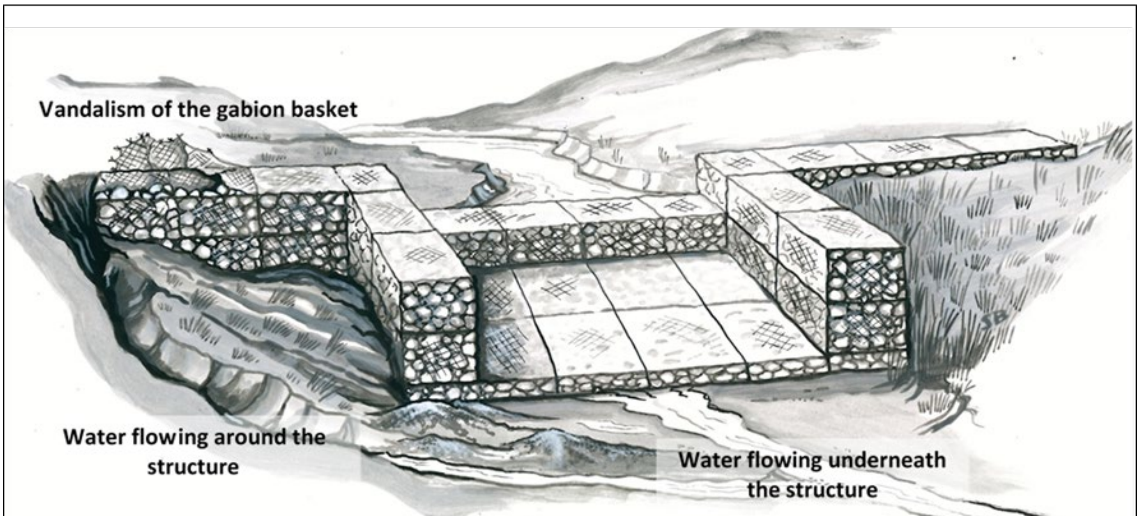

Figure A4.1: Illustration showing the impacts of undercutting and vandalism of a gabion structure, looking upstream

Figure A4.2 is depicted looking downstream and illustrates the following:

- Erosion within the upstream reaches may occur as a result of cattle/livestock trampling the vegetation resulting in the formation of preferential flow paths. The occurrence of cattle would be associated with the intervention retaining water upstream of it and thus, providing a source of water for livestock;
- Cattle/livestock often compact earthen structures such as berms and impact on the integrity and longevity of the structures;
- Materials used during construction of the structure have been left behind, which can often affect the natural flow of water within the stream and can lead to preferential flow paths developing;
- Either as a result of poor design or weak structural foundations, water is flowing around the structure and eroding at the base. As a result, the structure has begun to slump and will eventually fail completely on this weakened side; and
- A tree is lying across a section of the river downstream of the structure, causing an impediment to flows which could lead to flooding of the upstream reaches during a high rainfall/storm event.

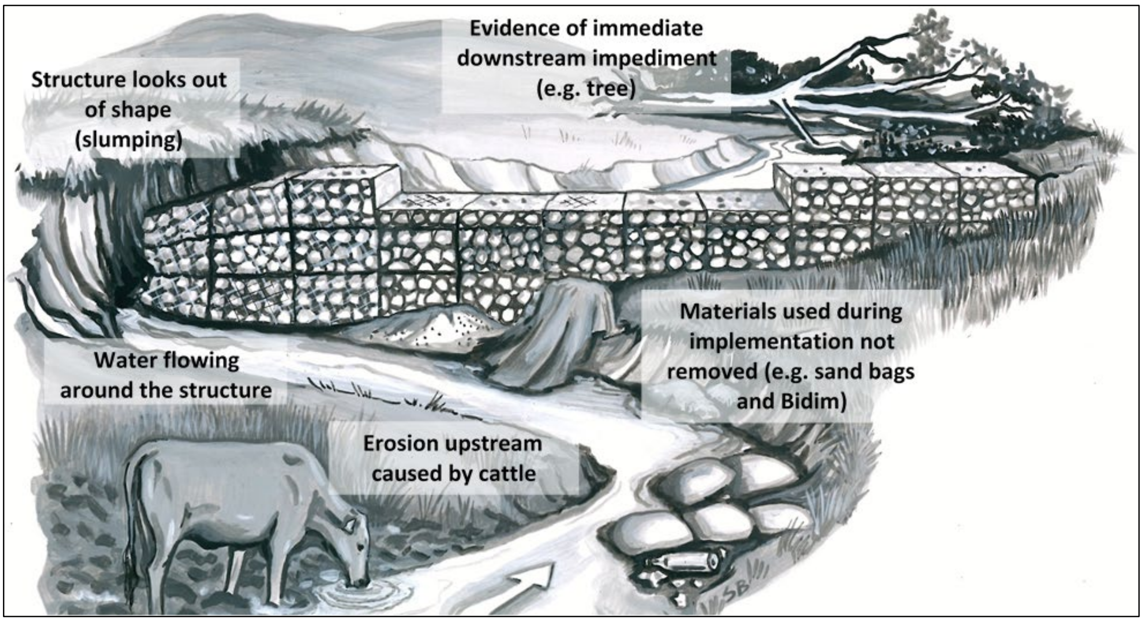

Figure A4.2: Illustration highlighting some of the challenges experienced when materials from construction are left onsite, the issues of a structure beginning to fail and unfavourable impediments within the system

A4.3 illustrates some of the issues that may be identified when reviewing the integrity of structure regarding the flow of water around and over a structure and how the collection of debris can affect this. This illustration is from a downstream perspective, looking upstream and depicts the following:

- Water is flowing around the structure, causing sections of the gabion basket to slump;
- Along the spillway of the structure, a collection of debris or vegetation along the left-hand side has limited the flow of water, reducing the width of flow over the spillway. This debris is collecting at the bottom of the spillway, further confining the flow of water and forming a barrier to flows to the downstream reaches; and
- Gabion baskets may sometimes be capped with concrete to reduce the risks of vandalism to the baskets. If the concrete has been incorrectly mixed or poorly applied, it can often wear down fairly quickly, exposing the gabion wire and reducing the integrity of the structure.

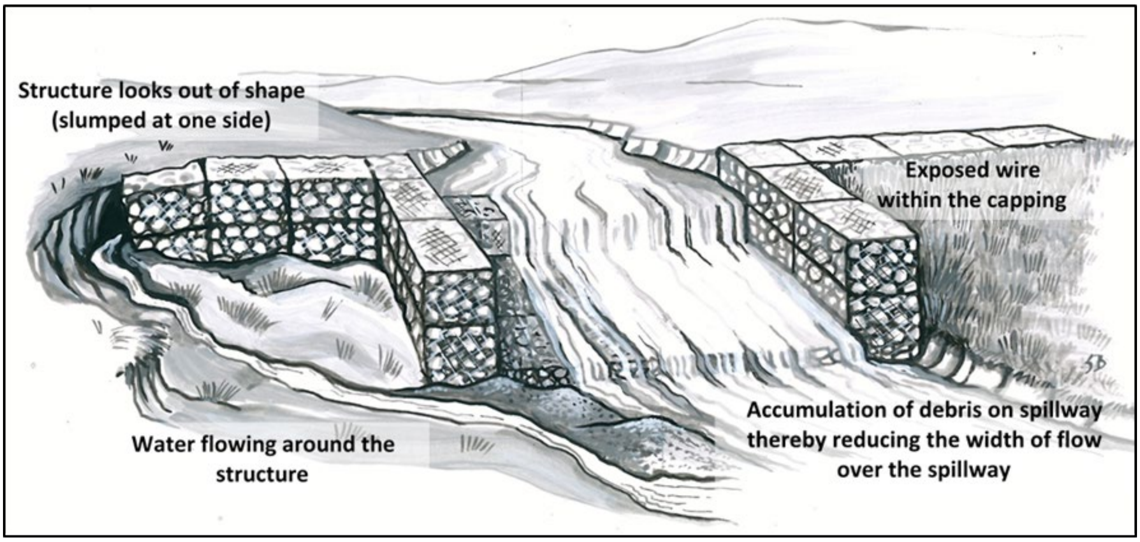

Figure A4.3: Illustration showing a structure beginning to slump, possibly as a result of the water moving around the structure and affecting the stability of the structure. In addition, the wire from the gabion baskets have become exposed from under the concrete capping

Figure A4.4 is illustrated from a downstream perspective looking upstream, and depicts the following:

- Although the slow seepage of water through the gabion baskets is allowed, the strong flow of water through the baskets is not favourable, as the movement of water has the potential to displace some of the baskets. The water flowing through the structure has led to the slumping of the structure near the middle, which may be confining flows to the middle of the structure as a result, which increases the chances of erosion occurring on the structure; and
- The confined flows occurring as a result of the slumping, the collection of debris and construction materials on the structure will assist in confining the flows further and reducing the potential for diffuse flows moving downstream.

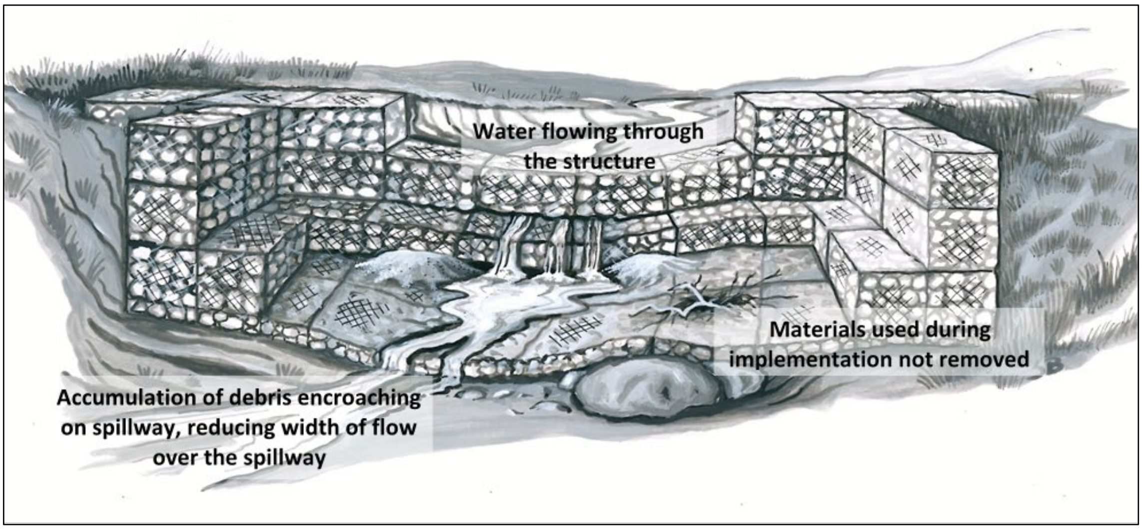

Figure A4.4: Illustration showing the issues associated with water flowing through a structure as it causes slumping on the stilling basin, the impacts of accumulated debris near the structure and construction materials being left onsite

When reviewing a structure's integrity some of the common issues that may be identified have been discussed above. Using the integrity spreadsheet provided below, the risks of structural failure can be analysed and the need to restore, rebuild and/or undergo maintenance will be reviewed. Before the issues associated with a structure can be fully understood, a comprehensive understanding of how the system operates should be attained, since some of the system drivers may be causing the erosion and degradation of the structures themselves.

A description of the rehabilitation objectives and strategy

Name/s of assessor/s:	**Date of assessment:**
Name of wetland:	
Objectives of the Rehabilitation:	
Strategy designed to achieve the objectives	
Sketch of wetland, series of interventions and anticipated outcomes of rehabilitation, e.g. overall wetland, anticipated water flow paths, problems upstream and downstream of each intervention. It is important to reflect the local context within which each intervention occurs in the wetland area, ensuring the relative importance of the different interventions is understood in terms of overall function of the rehabilitation.	

Post-construction check sheet

Name/s of assessor/s:				**Date of assessment:**
Intervention (structure) number:	**GPS coordinates:**		**S ° ‘ “**	**E ° ‘ “**
Gabion structure:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Correctly packed rock				
Correctly sized rock				
Correct compaction of backfill material (visual surface inspection)				
Lacing and bracing correctly implemented				
Correct installation of materials to retain water				
Geofabric adequately in place with all contact surfaces with soil				
Visible erosion damage				
Concrete-capped gabion:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Evidence of 100 mm of concrete				
Chute/trapezoidal drain:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Sloped at the planned angle				
Visible erosion damage				
Concrete work:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Correct compaction of backfill material (visual surface inspection)				
Evidence of good shuttering techniques				

Visible erosion damage				
Earthen Structures (including berms and diversions):	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Visible erosion damage				
Spreader Canals:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Canal set out on contour				
Visible erosion damage				
Fencing:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Dimensions according to specifications				
Authorised deviations from plan				
Sloping of Gully Walls:	**YES**	**NO**	**ACTION**	**Comments (Description & Mitigation)**
Structure is constructed in the correct location and orientation				
Structure is constructed at an acceptable elevation				
Authorised deviations from plan				
Sloped at planned angle				
Topsoil in place				
Evidence of gypsum application				
Visible erosion damage				
SIGN OFF SUMMARY	**YES**	**NO**	**RECOMMENDATION/NOTES**	
Subject to the minor mitigation measures described above, this structure may be signed off as complete				
Name:	**Signed:**			

Integrity Assessment per Intervention

Name/s of assessor/s:		**Date of assessment:**	
Intervention (structure) number:	**GPS coordinates:**	**S ° ‘ “**	**E ° ‘ “**
Purpose (function) of structure:			
Has the purpose of the intervention been achieved?		**YES**	**NO**
Gabion structure issues:	**Tick**	**Possible reasons for issues; other comments**	
Rusting of the wire but wire baskets still intact			
Rusting of wire in the baskets to the point that baskets have broken open			
Damage to PVC coating			
Removal of rocks from the baskets			
Removal of wire from the baskets			
Water flowing under the structure			
Water flowing through the structure			
Water flowing around the structure			
Structure looks out of shape/distorted (e.g. slumped at one side)			
Erosion upstream, e.g. caused by cattle paths			
Backfill material has sagged below the level of the adjacent ground			
Damage to geotextile, e.g. vandalism, fires, etc.			
Evidence of erosion where water enters the channel downstream of the intervention			
Accumulation of debris and/or vegetation encroachment on spillway thereby reducing the width of flow over the spillway			
Evidence of immediate downstream impediment, e.g. tree or remnants of an intervention			
Materials used during implementation not removed, e.g. sand bags			
Diversion canal used in construction of the structure has not been fully deactivated			
Concrete capping <100 mm thick* *Applies only to concrete-capped gabions			
Cracks evident within the capping*		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Exposed wire within the capping*		Level of structural functioning (1 = 100% to 6 = non-functional):	

Level of threat: 1 = No observable threat; 2 = Low threat of failure; 3 = Moderate threat and/or timeframe (3-8 years) for failure; 4 = Imminent failure (high potential for substantial rapid degradation of the intervention within the next 2 years); 5 = High risk of failure within the next year; 6 = The structure has already failed severely
Level of functioning: 1 = Functioning at optimum level (100%); 2 = Minor signs of functional failure (100-75%); 3 = Moderate level of functioning (75-50%); 4 = High degree of functional failure (50-25%); 5 = Very high degree of functional failure (25-0%); 6 = Complete functional failure (0%).
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase height of spillway

Chute/trapezoidal drain/rock masonry:	**Tick**	**Comments**	
Evidence of movement of rock			
Evidence of damage to the sidewalls			
Water flowing under the structure			
Water flowing through the structure			
Water flowing around the structure			
Structure looks out of shape/distorted (e.g. slumped at one side)			
Erosion upstream, e.g. caused by cattle paths			
Evidence of erosion where water enters the channel downstream of the intervention			
Debris around the energy dissipaters			
Inadequate protection of the entrance approach			
Energy dissipaters absent or damaged.			
Accumulation of debris and/or vegetation encroachment on spillway thereby reducing the width of flow over the spillway			
Evidence of immediate downstream impediment, e.g. tree or remnants of an intervention			
Evidence of erosion around or below the structure			
Evidence of a stilling basin at the base of the chute		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Evidence of loosening and/or absent rocks		Level of structural functioning (1 = 100% to 6 = non-functional):	
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase length of chute			

Concrete work/rock masonry:	Tick	Comments	
Cracks evident within the structure, i.e. water leaking through the structure			
Water flowing under the structure			
Water flowing through the structure			
Water flowing around the structure			
Structure looks out of shape/distorted (e.g. slumped at one side)			
Erosion upstream, e.g. caused by cattle paths			
Backfill material has sagged below the level of the adjacent ground.			
Exposed rebar, i.e. steel reinforcing			
Materials used during implementation not removed, e.g. sand bags			
Evidence of erosion where water enters the channel downstream of the intervention			
Accumulation of debris and/or vegetation encroachment on spillway thereby reducing the width of flow over the spillway			
Evidence of downstream impediment, e.g. tree or remnants of an intervention			
Evidence of water movement through the temporary construction diversion canal		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Evidence of loosening and/or absent rocks		Level of structural functioning (1 = 100% to 6 = non-functional):	
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase height of spillway			

Earthen Structures (including berms and diversions):	Tick	Comments
Excessive settling of the soil (>10% of overall height)		
Signs of erosion under the structure		
Signs of erosion through the structure		
Signs of erosion around the structure		

Evidence of erosion where water enters the channel downstream of the intervention			
Inadequate establishment of vegetative cover (refer to revegetation section for assessment details)			
Damage by livestock, e.g. trampling			
Risk of and/or overtopping		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Inappropriate/unplanned re-entry of water downstream of the intervention		Level of structural functioning (1 = 100% to 6 = non-functional):	
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase length/height of berm			

Spreader Canals:	**Tick**	**Comments**	
Erosion of the lip of the canal			
Blocked passage of water flows through the canal			
Scouring within the canal.			
Development of unplanned/undesirable outlet point			
Erosion at the offtake/outlets			
Blockage of decant point due to accumulation of vegetation		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Canal not set out on contour		Level of structural functioning (1 = 100% to 6 = non-functional):	
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase length of canal			

Geocell	**Tick**	**Comments**	
Sinking/collapse of cells			
Tunnelling under structure		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
		Level of structural functioning (1 = 100% to 6 = non-functional):	

<table>
<tr><td colspan="4">Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. increase length of canal</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Fencing:</th><th>Tick</th><th colspan="2">Comments</th></tr>
<tr><td>Signs of sagging</td><td></td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Broken strands of wire</td><td></td></tr>
<tr><td>Poorly anchored fencing posts</td><td></td></tr>
<tr><td>Animal entry points</td><td></td><td>Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):</td><td></td></tr>
<tr><td>Signs of rusting of the wire</td><td></td><td>Level of structural functioning (1 = 100% to 6 = non-functional):</td><td></td></tr>
<tr><td colspan="4">Maintenance requirements and/or design amendments/changes to intervention required to improve functioning, e.g. add an additional strand to the fence</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Sloping of Gully Walls:</th><th>Tick</th><th colspan="2">Comments</th></tr>
<tr><td>Topsoil not in place</td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="2">Inadequate establishment of vegetative cover (refer to revegetation section)</td><td rowspan="2"></td><td>Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):</td><td></td></tr>
<tr><td>Level of structural functioning (1 = 100% to 6 = non-functional):</td><td></td></tr>
<tr><td colspan="4">Maintenance requirements and/or design amendments/changes to intervention required to improve functioning</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Revegetation:</th><th>Tick</th><th colspan="2">Comments</th></tr>
<tr><td>Poor vegetation cover (i.e. extensive bare ground)</td><td></td><td colspan="2"></td></tr>
</table>

High invasive alien plant cover in the revegetated area		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Poor representation of the native species		Level of structural functioning (1 = 100% to 6 = non-functional):	
Approach amendments, e.g. revegetate with a more appropriate species			

Other	Tick	Comments	
Cracks evident within the structure, i.e. water leaking through the structure			
Water flowing under the structure			
Water flowing through the structure			
Water flowing around the structure			
Structure looks warped/distorted (e.g. slumped at one side)			
Erosion upstream, e.g. caused by cattle paths			
Backfill material has sagged below the level of the adjacent ground			
Damage to geotextile, e.g. vandalism, fires, etc.			
Evidence of erosion where water enters the channel downstream of the intervention			
Accumulation of debris and/or vegetation encroachment on spillway thereby reducing the width of flow over the spillway			
Evidence of immediate downstream impediment, e.g. tree or remnants of an intervention			
Erosion upstream, e.g. caused by cattle paths			
Materials used during implementation not removed, e.g. sand bags			
Evidence of immediate downstream impediment, e.g. tree or remnants of an intervention		Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):	
Inappropriate deactivation of diversion canal		Level of structural functioning (1 = 100% to 6 = non-functional):	
Maintenance requirements and/or design amendments/changes to intervention required to improve functioning			

Additional issues/threats

Issue number:	**GPS coordinates:**	**S ° ‘ “**	**E ° ‘ “**
Description of the Issue (e.g. headcut 30 m downstream, of structure)	**Description of the threat to specific interventions (include interventions number/s) and achievement of the overall rehab objectives (headcut threatening to erode up into the structure…etc.)**		
	Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):		
	Level of threat that the issues pose to achievement of the rehabilitation objectives (1 = no threat to 6 = highest):		
Issue number:	**GPS coordinates:**	**S ° ‘ “**	**E ° ‘ “**
Description of the Issue	**Description of the threat to specific interventions (include interventions number/s) and achievement of the overall rehab objectives**		

<table>
<tr><td rowspan="3"></td><td colspan="4"></td></tr>
<tr><td colspan="3">Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):</td><td></td></tr>
<tr><td colspan="3">Level of threat that the issues pose to achievement of the rehabilitation objectives (1 = no threat to 6 = highest):</td><td></td></tr>
<tr><td>Issue number:</td><td>GPS coordinates:</td><td>S ° ‘ “</td><td colspan="2">E ° ‘ “</td></tr>
<tr><td>Description of the Issue</td><td colspan="4">Description of the threat to specific interventions (include interventions number/s) and achievement of the overall rehab objectives</td></tr>
<tr><td rowspan="3"></td><td colspan="4"></td></tr>
<tr><td colspan="3">Level of threat that the issues pose to the structure (1 = no threat to 6 = highest):</td><td></td></tr>
<tr><td colspan="3">Level of threat that the issues pose to achievement of the rehabilitation objectives (1 = no threat to 6 = highest):</td><td></td></tr>
</table>

Assessment of the level to which the interventions overall are achieving their purpose

The current situation: Referring back to the original objective and strategy, rate the current level to which the structures overall are achieving their purpose by considering: (1) the current integrity of the interventions and the degree to which each is achieving its specific purpose (both assessed above) and (2) any additional issues assessed above.	Tick	**Comments**
1: the interventions fail entirely to achieve their intended purpose (function)		
2: the interventions fail mostly to achieve their intended purpose but not entirely		
3: The interventions go approximately "half way" to achieving their intended purpose		
4: the interventions achieve most of their intended purpose, but not entirely		
5: the interventions succeed entirely to achieve their intended purpose		
A future situation: Rate the level to which the structures are likely be achieving their intended purpose in 10 years by considering: (1) the current level to which the structures overall are achieving their intended purpose (assessed immediately above), (2) the threats to the interventions and (3) any additional threats assessed above.	Tick	**Comments**
1: the interventions fail entirely to achieve their intended purpose (function)		
2: the interventions fail mostly to achieve their intended purpose but not entirely		
3: The interventions go approximately "half way" to achieving their intended purpose		
4: the interventions achieve most of their intended purpose, but not entirely		
5: the interventions succeed entirely to achieve their intended purpose		
List in priority order any maintenance, amendments or new interventions which are recommended in the light of all of the preceding assessments.	**Comments**	

Glossary of Terms

Term	Explanation
Apron	An area laid down immediately downstream of a weir, protected by concrete or rock-filled gabions, which is generally utilised to protect the foundation of the intervention from damage caused by flows of water over the spillway
Backfill	The material used to refill an excavated area
Berm	An artificial ridge or embankment, usually utilised to control the direction of water flows or raise the level of water within a river/stream channel
Chute	A formalised channel used to transport water from a higher to lower elevation level, often used to stabilise gully head erosion by counteracting the erosive energy of falling water
Concrete capping	Concrete layer applied to outside of a gabion structure type
Diversion canal	An artificial waterway used to divert water from its natural course, usually a temporary measure adopted to bypass water around a structure during the construction phase
Drop inlet structure	Structure utilised to safely pass water to a lower elevation by controlling the energy and velocity of water as it passes over
Eco Log	A sack filled erosion control device, shaped like a log and constructed out of biodegradable materials
Erosion	Movement of soil, rock or dissolved material from one location to another through surface processes such as water flow
Foundation	The rock, soil or concrete upon which an intervention rests
Freeboard	Height difference between the normal water level and/or spillway and the crest of the intervention
Gabion basket	A box shaped structure constructed from a wire cage filled with rock material
Headcut	Erosional feature migrating in an upstream direction that has created a sharp vertical drop in elevation
Heel	An extension of the base of an intervention located on the upstream side of the intervention. Often used to prevent undercutting
Key Wall	An extension of the spillway portion of the weir that extends into the bank of the stream/channel to prevent subsurface flows bypassing the structure
Rock pack	Collection of loose rocks used to stabilise areas of erosion
Sediment fence	A temporary sediment control structure (usually constructed with a geotextile material) utilised to trap sediments from entering into downstream aquatic ecosystems

Term	Explanation
Shoulder wall	Portion of wall (weir) that defines the width of the spillway, connected at right angles to the spillway. Used to retain the soil adjacent within the adjacent stream/channel banks and protect the banks from splash action of flows over the spillway
Slumping	The process of structure leaning or collapse
Spreader canal	An artificially excavated channel designed to receive concentrated flows and redistribute these across a designated area when water fills the canal and overtops its banks
Soil tunnelling	Underground soil pipe created by the concentrated movement of water through an easily erodible layer of soil
Spillway	Dam walls – structure placed downstream of the wall in order to provide a safe release of excess water from the dam into the downstream environment. Weir – the area of the structure over which the water passes. The height of the spill way defines the level within a channel to which the water will be raised by the weir
Stilling basin	Structure placed on the downstream side of a spillway/weir in order to dissipate the energy of water exiting the spillway/passing over the weir
Toe	An extension of the downstream base of an intervention often used to prevent undercutting
Weir	Barrier across the horizontal width of a river or stream that alters the flow characteristics, which usually results in an increase to the water level
Wing wall	An extension of the spillway portion of the weir that extends into the adjacent banks in order to direct diffuse flows of water into the stream/channel upstream of a structure. Often used to prevent the erosion of channel water re-entry points downstream of a structure

APPENDIX 5A: WETLAND INDEX VALUE

Definition:
Wetland Index Value provides an indication of the extent of functional wetland vegetation present within the understudied wetland.

Underlying Definitions:
Most descriptions of a wetland plant refer to the wetness period that a species is able to survive under. A widely accepted definition considers wetland plants as 'growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content' (Cowardin et al., 1979). Wetland plants exist across a continuum that ranges from tolerance to dryland conditions only to tolerance of permanently inundated conditions. Five wetland plant categories (wetland indicator status) have been defined along this continuum that reflect the affinity of a plant for wetland conditions (Tiner, 1999). To calculate the WIV value, the wetland indicator status of the recorded vegetation needs to be determined based on the following classes defined by Van Ginkel et al*.* (2010):

- Obligate – plants that always occur in wetlands;
- Facultative positive – plants that usually occur in wetlands;
- Facultative – plants that are equally likely to occur in wetland and terrestrial habitats;
- Facultative negative – plants that usually occur in terrestrial habitats; or
- Terrestrial – plants that always occur in terrestrial habitats.

Relevance:
The WIV may be used to determine whether wetland habitat is present onsite prior to and after wetland rehabilitation has been completed. Such information may be used to provide an indication of whether wetland rehabilitation has resulted in a system moving towards functional wetland habitat. In addition to determining whether an area has changed from terrestrial vegetation to functional wetland vegetation, WIV can also be used as an index of the level of wetness of an area. Areas supporting functional wetland vegetation may range from being strongly dominated by obligate species at the highest level of wetness to being dominated by Facultative positive and Facultative species at a lower level of wetness. Given the critical influence of level of wetness over wetland functioning, WIV has indirect relevance to the provision of ecosystem services by a wetland.

Drivers-Pressure-State-Welfare-Response Framework:
Artificial drainage channels and infilling are some of the key pressures which tend to impact upon the state of wetlands by reducing the level of wetness of a wetland area, in many cases to beyond the point at which functional wetland vegetation is supported. Whether an area supports functional wetland and the level of wetness of the area are fundamental to the state of an ecosystem, and the influence that this state has on the ecosystem services supplied by the wetland (e.g. a largely permanent wetland will supply a high level of regulating and supporting benefits related to water quality enhancement). These services, in turn, influence welfare, depending in part on the demand for the services. In the case of the Greater Edendale Mall wetland (Janks et al. in Deliverable 9), the pre-rehabilitation pressures that were negatively impacting the level of wetness included a dam wall that isolated downstream wetland habitat, infilling within portions of the wetland and an artificial drain. To improve the integrity and functioning of the wetland, the rehabilitation activities deactivated the drainage network and excavated areas of infill. The WIV method was used to

determine whether rehabilitation activities had resulted in an increased abundance of functional wetland habitat.

Current trends:

The WIV value was utilised at the GEM development site to determine whether rehabilitation activities had increased the extent of functional wetland habitat within the development site. The WIV was derived from three areas of the wetland within both the pre-rehabilitation and post-rehabilitation landscape. The index values for each area were compared directly as illustrated in **Table 5a**:1 below. All three transects scored lower WIV wetness scores after rehabilitation, indicating that the proportional abundance of wetland species had increased in the post-rehabilitation landscape. Transect 1 was considered to contain dryland vegetation in the pre-rehabilitation landscape, as this area of the wetland was downstream of the dam wall and had become desiccated. The WIV value indicated that this area has improved to functional wetland vegetation in the post-rehabilitation landscape. Both Transect 2 and Transect 3 which are located upstream of the dam wall, housed functional wetland vegetation in the pre-rehabilitation landscape, which has improved to a greater proportion of functional wetland vegetation in the post-rehabilitation landscape.

Table 5a:1 WIV values derived from vegetation abundance data collected along 3 transects pre- and post-rehabilitation activities

Landscape	T1	T2	T3
Pre-Rehabilitation	3.85	1.61	1.77
Post-Rehabilitation	1.21	1.44	1.53

Units:

WIV

Data required:

In order to derive a WIV value, the following data is required:

- Proportional abundance plant species data represented as a percentage value; and
- Each recorded plant species needs to be classified according to the affinity of each plant for wetland conditions.

Method:

All plant species recorded during the vegetation surveys should be assigned to one of the five abovementioned classes. Based on the approach defined by Carter et al. (1988) WIV calculations should be undertaken as follows: each of the abovementioned indicator classes should be assigned an ecological index ranging from 1 (obligate) to 5 (non-wetland); the proportional abundance values recorded for each of these indicator classes at each plot should then summed and entered into the following equation, which makes use of a weighted average, to calculate the WIV score for the plot:

WIV = (1 x PA:O/100)+(2 x PA:FP/100)+(3 x PA:F/100)+(4 x PA:FN/100)+(5 x PA:NW/100)

Where:
WIV = Wetland Index Value
PA:O = Sum of the proportional abundance of plants of the obligate indicator status recorded in the plot
PA:FP = Sum of the proportional abundance of plants of the facultative positive indicator status recorded in the plot
PA:F = Sum of the proportional abundance of plants of the facultative indicator status recorded in the plot
PA:FN = Sum of the proportional abundance of plants of the facultative negative indicator status recorded in the plot
PA:NW = Sum of the proportional abundance of plants of the non-wetland indicator status recorded in the plot.

Target:
The WIV scores should be interpreted as follows:
- <2.5 – wetland;
- 2.5 – 3.5 – transitional;
- >3.5 – terrestrial.

In the case of the GEM wetland, the target was to observe an average WIV score of less than 2.5 for each transect, which would indicate that the three areas that were sampled support functional wetland vegetation.

References:

Carter, V., Garrett, M.K., Gammon, P.T. (1988). Wetland boundary determination in the Great Dismal Swamp using weighted averages. *Water Resources Bulletin* 24: 297-306.

Cowardin, L.M., Carter, V., Glolet, F.C., Laroe, E.T. (1979). *Classification of Wetlands and Deepwater Habitats of the United States*. Washington D.C., USA: U.S. Department of the Interior Fish and Wildlife Service.

Cowden, C., Kotze, D., Pike, T. (2013). *Assessment of the long-term response of two wetlands to Working for Wetlands rehabilitation*. WRC Report No. 2035/1/13. Pretoria: Water Research Commission.

Tiner, R.W. (1999). Wetland Indicators: *A Guide to Wetland Identification, Delineation, Classification and Mapping*. Washington D.C., USA: Lewis Publishers.

Wentworth, T.R., Johnson, G.P. (1986). *Use of vegetation in the designation of wetlands*. Final Report U.S. Fish and Wildlife Service. Florida: St. Petersburg: National Wetlands Inventory.

APPENDIX 5B: FLORISTIC QUALITY ASSESSMENT INDEX

Definition:
Floristic Quality Assessment Index provides an estimate of habitat quality by assessing the extent to which an ecosystem is similar to the benchmark/desired condition based on the abundance of weedy, pioneer or alien invasive plant species.

Underlying Definitions:
In order to derive the FQAI, the coefficient of conservatism for each plant species needs to be recorded. This requires an understanding of the following definitions:

- Alien invasive plant – taxa that are non-native opportunistic invaders;
- Ruderal or weedy plants – native taxa that are found in disturbed environments;
- Occasional ruderal or weedy plants – native taxa that are typically associated with a specific plant community, but tolerate moderate disturbance to that community;
- Plant species intolerant of disturbance – plant with high degrees of fidelity to a narrow range of ecological parameters; and
- Plant community – a collection of plant species growing together in a particular location that show a definite associate or affinity with one another.

Relevance:
Vegetation is a key component of a wetland, both in terms of representing important taxa in their own right, as well as providing habitat for many other taxa. Vegetation also affects many important wetland functions such as sediment trapping. Of particular relevance to wetland rehabilitation is the recovery of vegetation, through a shift from a state dominated by pioneer/weedy species (tolerant of human disturbance) to a benchmark condition.

The FQAI is a biological index that provides an indication of the extent to which an ecosystem is similar to the benchmark/desired condition based on the plant taxa present within the ecosystem. Often, the aim of rehabilitation is to improve an ecosystem towards a benchmark/desired state. The FQAI index is useful for the assessment and monitoring of wetland ecosystems for tracking wetland rehabilitation projects over time.

Drivers-Pressure-State-Welfare-Response Framework:
The drivers of change to the FQAI indicator are strongly correlated to disturbance. Disturbance to wetland ecosystems include urbanisation, abstraction, dams, cultivation, drainage and overgrazing. The FQAI indicator will respond positively to low levels of disturbance and negatively to high levels of disturbance (i.e. the highest FQAI value will be derived in low disturbance conditions and the lowest FQAI value will be derived in high disturbance conditions). The indicator may be used to track rehabilitation projects over time. The use of this indicator will provide a greater understanding of landscape stressors and is useful for assessing compliance with regulations.

Pressure, particularly in the form of large-scale anthropogenic clearance of vegetation, typically favours vegetation dominated by pioneer/weedy species and diminishes the natural vegetation. Rehabilitation, on the other hand, is designed to encourage the recovery of natural vegetation. This effect on the state of the wetland has important implications for welfare. Vegetation strongly dominated by pioneer/weedy species (many of which are annual species) tends to have a lower value both for provisioning services (e.g. providing grazing for livestock) and regulatory services (e.g. covering and binding the soil against erosion). The reduced services, in turn, will impact on human welfare, with the impact on human welfare depending on the specific demand for these services, i.e. the higher the demand, the higher the potential impact. Determining the floristic quality of a wetland ecosystem will also provide an indication of the biodiversity maintenance services supplied by the wetland, which are generally taken to benefit society at large.

Current trends:
The FQAI indicator was utilised at the GEM development site to determine whether rehabilitation activities had improved the wetland to a point closer to the benchmark/desired state. The FQAI was derived from three areas of the wetland within both the pre-rehabilitation and post-rehabilitation landscape. The index values for each area were compared directly as illustrated in **Table 5b.1** below. The comparison indicated Transect 1 contained a high proportional abundance of alien invasive and ruderal or weedy plants in the pre-rehabilitation landscape. This area of the wetland has improved significantly towards the benchmark condition in the post-rehabilitation landscape. Transect 3 has improved slightly towards the benchmark condition in the post-rehabilitation landscape. Transect 2 scored lower in the rehabilitation landscape indicating a higher proportional abundance of alien invasive and ruderal or weedy plant species in post-rehabilitation landscape.

Table5b.1: FQAI values derived from vegetation abundance data collected along three transects pre- and post-rehabilitation activities

Landscape	T1	T2	T3
Pre-Rehabilitation	36.47	64.33	67.83
Post-Rehabilitation	57.72	55.96	69.69

Units:
FQAI

Data required:
In order to derive a FQAI value, the following data is required:

- Plant species presence/absence data; and
- Each recorded plant species needs to be classified according to the tolerance for disturbance classes mentioned above.

Method:
The recorded plant species should be assigned a 'coefficient of conservatism', a subjective rating of the plant species' preference for non-degraded natural communities, ranging from 0 to 10, with the higher values assigned to those species less tolerant of degradation (Miller and Wardrop, 2006). The assigned coefficient of conservatism should be based on professional opinion in accordance with the following classes adapted from Miller and Wardrop (2006):

- Alien invasive plants (0);
- Ruderal or weedy plants (1);
- Occasionally ruderal or weedy plants (5);
- Plant species intolerant of disturbance (10)

The recorded vegetation data at each plot should utilise the following equation to calculate the FQAI score for the plot:

$$FQAI = (C/10) \times (\sqrt{N}/\sqrt{S}) \times 100$$

Where:

C = Mean coefficient of conservatism (as determined by dividing the sum per plot by the native species richness)
N = Indigenous species richness
S = Total species richness

Target:

The target is to improve (increase) the FQAI value as a result of rehabilitation activities. Ideally, FQAI values should be compared to reference wetland systems, which would represent the target.

References:

Cowden, C., Kotze, D., Pike, T. (2013). *Assessment of the long-term response of two wetlands to Working for Wetlands rehabilitation*. WRC Report No. 2035/1/13. Pretoria: Water Research Commission.

Lopez, R.D., Fennessy, M.S. (2002). Testing the Floristic Quality Assessment Index as an Indicator of Wetland Condition. *Ecological Implications* 12 (2): 487-497.

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APPENDIX 6: FIXED POINT PHOTOGRAPHS GUIDELINE

Fixed Point Photographs (FPPs) provide useful indications of changes at both a landscape and within system level. When collecting FPPs, the following guidelines should be followed, as defined by Cowden and Kotze, 2009:

- Appropriate FPP sites should be established prior to the implementation of rehabilitation activities.
- The FPP sites should be established at various locations throughout the rehabilitation site, at a high vantage point and capture the following:
    - An overview of the rehabilitation site;
    - Anticipated changes in vegetation patterns as a result of the rehabilitation activities; and
    - A view of the rehabilitation interventions (establishment of FPP site locations should anticipate the location of the planned structures).
- The photographs should be collected using the following approach:
    - A permanent field marker should be placed at each FPP site to ensure that subsequent photographs are taken from the exact same location;
    - The location of the FPP sites should be recorded using a GPS unit;
    - The orientation of the photographer should be recorded;
    - A series of photographs should be taken in a panoramic manner from upstream to downstream at each FPP site;
    - The photographs should include the skyline to provide perspective;
    - Fixed features located at a distance should be captured to ensure that subsequent photographs are taken of exactly the same area. Baseline photographs should be laminated and taken in-field as a reference during subsequent monitoring;
    - The photographs should be taken from a fixed height. The height at which the photographs are taken should be recorded;
    - A measure of relative height should be provided (e.g. erecting a ranging rod at a set distance); and
    - The direction of the panoramic series should be recorded to ensure the same view is captured during each monitoring event.

References:

Cowden, C., Kotze, D.C. (2009). *WET-RehabEvaluate: Guidelines for the monitoring and evaluation of wetland rehabilitation projects.* WRC Report No TT 342/08. Pretoria: Water Research Commission.