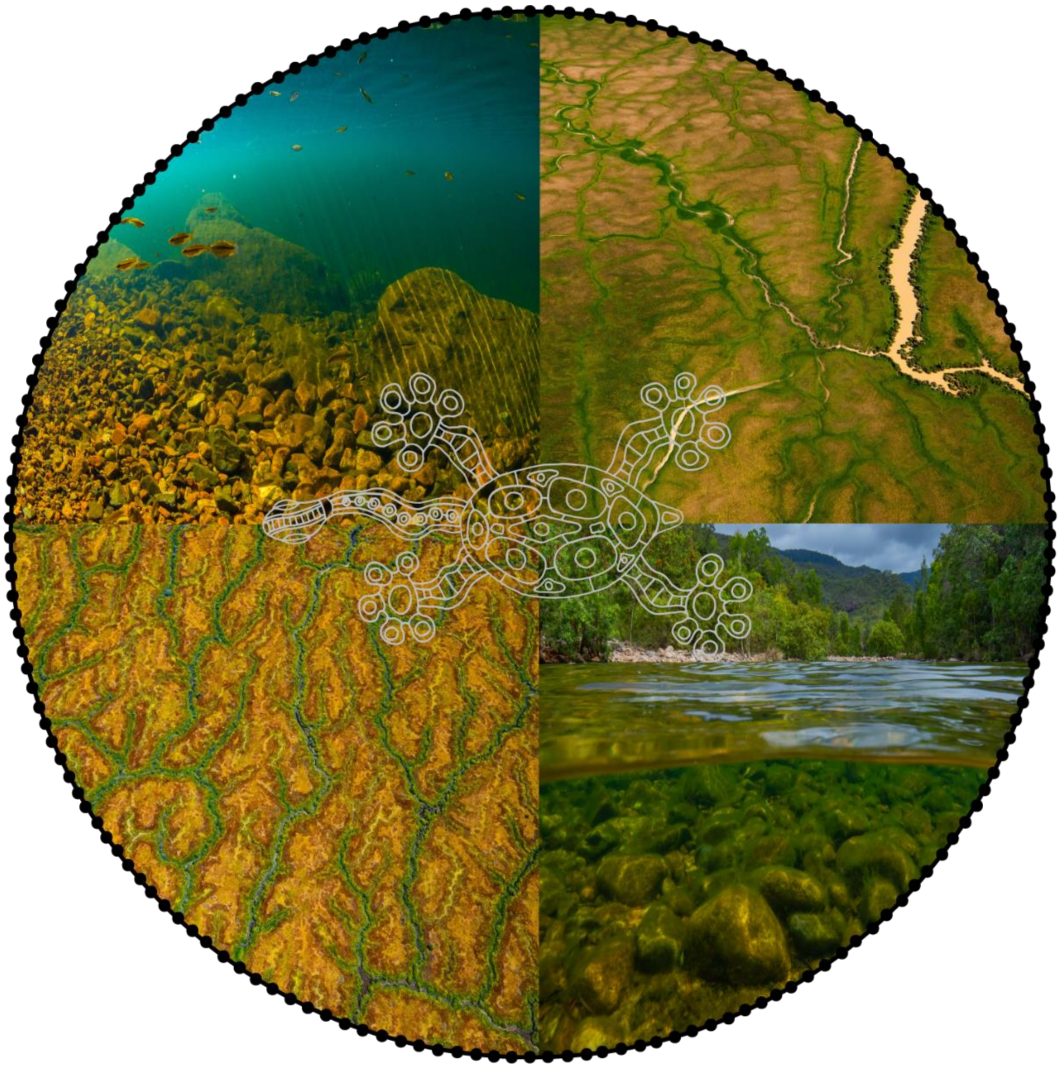


Queensland River Rehabilitation Management Guideline

Version 1.0

Queensland Government

Image of a Queensland map divided into drainage basins with inset photos showcasing the wide diversity of rivers throughout Queensland. Photos by Gary Cranitch, Queensland Museum. Image compiled by Trent Munns.

Prepared by: Joanne Burton, James Grove, Marijke Heenan, Cathy Ellis, Natasha Jones, Remy Usher, Rachel Miller, Trent Munns, Mike Ronan. Department of Environment and Science

The Department of Environment and Science acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.

The department is committed to respecting, protecting and promoting human rights, and our obligations under the Human Rights Act 2019.

Disclaimer
This document has been prepared with care, based on the best available information at the time of publication. The department holds no responsibility for any errors or omissions within this document. Any decisions made by other parties based on this document are solely the responsibility of those parties.

If you need to access this document in a language other than English, please call the Translating and Interpreting Service (TIS National) on 131 450 and ask them to telephone Library Services on +61 7 3170 5470.

This publication can be made available in an alternative format (e.g. large print or audiotape) on request for people with vision impairment; phone +61 7 3170 5470 or email <library@des.qld.gov.au>.

Citation

Department of Environment and Science 2022, *Queensland River Rehabilitation Management Guideline, Version 1.0*, DES, Brisbane, Queensland.

Acknowledgements
This project was funded by Reef Trust, Department of Agriculture, Water and Environment, and the Office of the Great Barrier Reef, Landscape Sciences and Wetlands, Department of Environment and Science. We would like to acknowledge the initial work undertaken to develop the Qld River Rehabilitation Management Guideline (QRRMG) by Dr Michael Cheetham, Dr Andy Markham, Assoc. Professor Andrew Brooks, Julian Martin, Dr Ben Pearson, Dr Tim Pietsch, Jim Tait, Dr Geoff Vietz, and Luke McPhail. Many others, who are not named here individually contributed to the development of the Whole-of-System, Values-Based Framework which underpins the Aquatic Ecosystem Rehabilitation Process detailed in the QRRMG. We value the contributions made through workshops and conversations by the stakeholders, including local governments, Natural Resources Management groups and John Locke of Biocultural Consulting. We thank the QRRMG Review Panel for their time and valuable recommendations which have improved this document. Thank you also to the Queensland River Management Framework Reference Panel. We look forward to a continued relationship with all to continually improve and update the QRRMG and associated resources to support the sustainable management of Queensland's rivers.

Front cover image
Depicts selected riverine environments throughout Queensland, *top left quadrant* – Alligator Creek (Mount Elliot), *top right quadrant* – Channel Country (Lake Eyre Basin), *bottom right quadrant* – Paradise Waterhole, Crystal Creek (Paluma National Park), and *bottom left quadrant* – Channel Country (Lake Eyre Basin), overlayed by a freshwater long-neck turtle representing the connection between land and water. Turtle designed by John Locke. Photos by Gary Cranitch, Queensland Museum. Image compiled by Trent Munns.

June 2022

Contents

Introduction

Guideline scope and purpose

The *Queensland River Rehabilitation Management Guideline* (*QRRMG*) provides a consistent and transparent approach to river rehabilitation including the development of a river rehabilitation plan. It is based on the *Whole-of-System, Values-Based Framework* (the *Framework*) and provides a comprehensive and integrated, values-based approach to the river rehabilitation component of river management. The approach, called the *Rehabilitation Process*, and the underpinning *Framework* has been designed to ensure that management decisions are informed by linking an understanding of the biophysical components (parts) and processes of rivers to the broader landscape, and to an understanding of the ecosystem services society derives from rivers. This enables consideration of the value of these services to different beneficiaries and the threats and pressures on them.

There are many ways and reasons why rivers are managed, and a broad range of stakeholders and beneficiaries that are involved in their management (Chan, Satterfield and Goldstein 2012; González del Tánago et al. 2016; Kenter et al. 2015; Rutherfurd, Ladson and Stewardson 2004). This guideline is primarily intended for those parties that are responsible for creating management plans for the rehabilitation component of river management. This may include technical managers, funding agencies, Natural Resource Management groups, local governments, consultants, First Nations people, and land care groups. The use of a consistent approach for creating a rehabilitation plan enables transparent, consistent, and effective evaluation by government agencies. Beneficiaries and stakeholders, including landowners, can also be better engaged by having a clear process even if they are not responsible for the plan creation.

The *QRRMG* recognises that there is a significant existing body of literature on how to undertake river rehabilitation management (e.g. Ciotti et al. 2021; Gilvear, Spray and Casas-Mulet 2013; Lovett and Price 1999; Rutherfurd, Jerie and Marsh 2000; Stewardson et al. 2004; WMO 2012). It does not intend to provide an in-depth review of pressures on rivers. In addition, it does not provide the technical details on how to undertake interventions. Instead, accessing appropriate technical experts and legal guidance is recommended. The *QRRMG* provides a high-level summary of the seven step *Rehabilitation Process* including the rationale for each step and what each step involves. It is complemented by an interactive website (https://wetlandinfo.des.qld.gov.au/wetlands/management/) which provides further details for each step and links to appropriate resources which can be updated as technologies and new information arises. The *QRRMG* provides a process that can reinforce a proactive rather than reactionary approach to river management, while recognising and allowing for either approach to be adopted.

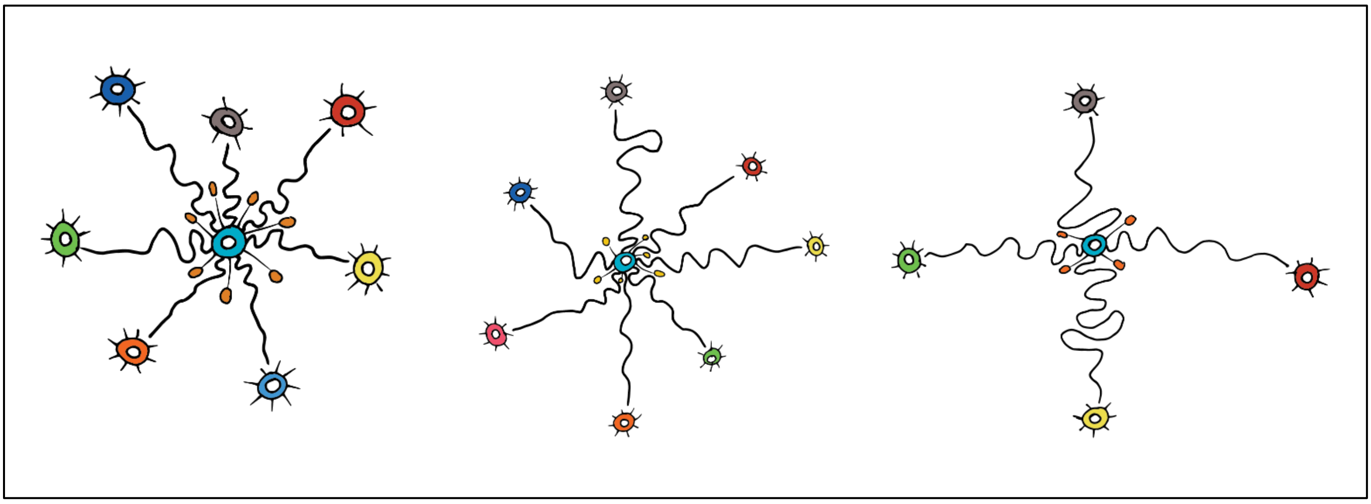


Figure 1 *Artwork representing First Nation connections between catchments. (Source: John Locke)*

River variability and uses

The rivers of Queensland are diverse and have been part of First Nations peoples' identity for millennia (Figure 1). There have been intense periods of land clearance across Queensland (mid-1800s to mid-1900s), including on floodplains and on the banks of rivers, for agriculture and urbanisation. This has resulted in changes to the way both land and rivers are used as a resource and valued. Many river systems have experienced changes, some with dramatic deepening and widening, others filling with sediment causing more frequent flooding. The effects of this land clearance can still be seen in most river systems across the state, and continues to propagate through the river systems, so it should be considered in any management activities.

The nature of rivers can vary significantly, not only between different regions but also along the length of a single system (Bourke and Pickup 1999; Frissel et al. 1986; Fryirs and Brierley 2021). This means that the ways rivers respond to disturbances are complex and diverse (Figure 2 and Figure 3). Any management intervention needs to consider the catchment within which a river is situated, the rivers characteristics (components and processes), the range of services and values it provides to beneficiaries and stakeholders and the range of pressures that it may have been or may be subjected to.

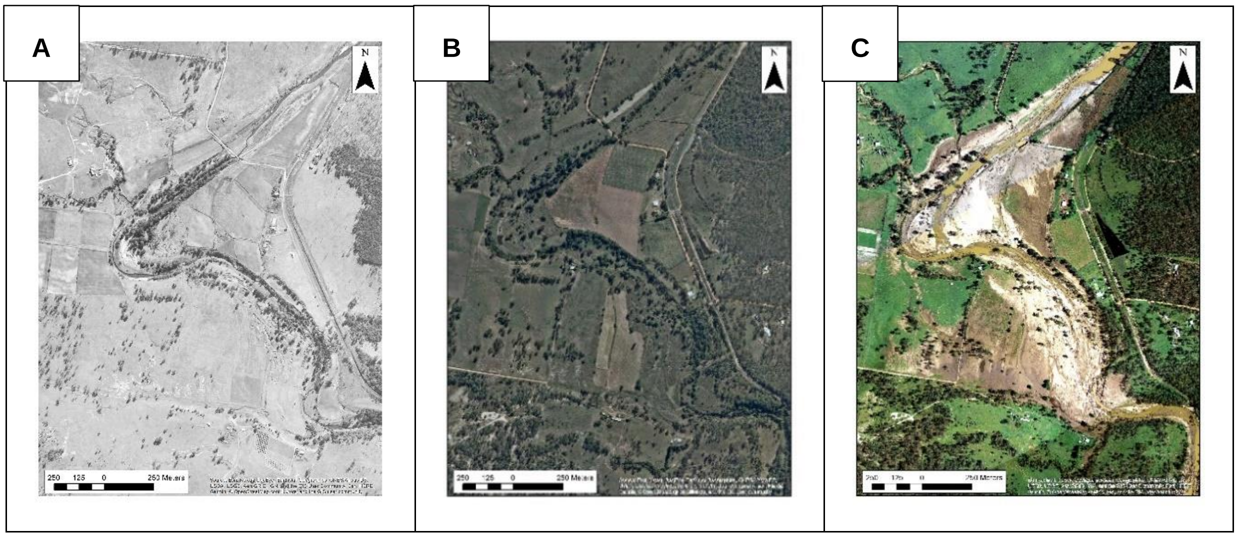


Figure 2 *Aerial imagery of the Lockyer Creek near Upper Lockyer from different time periods showing: A) 1951 - low levels of vegetation cover, B) 2009 - preflood channel and floodplain condition, C) 2011 - post flood sediment deposition on the floodplain and channel erosion. (Source: https://qimagery.information.qld.gov.au/)*

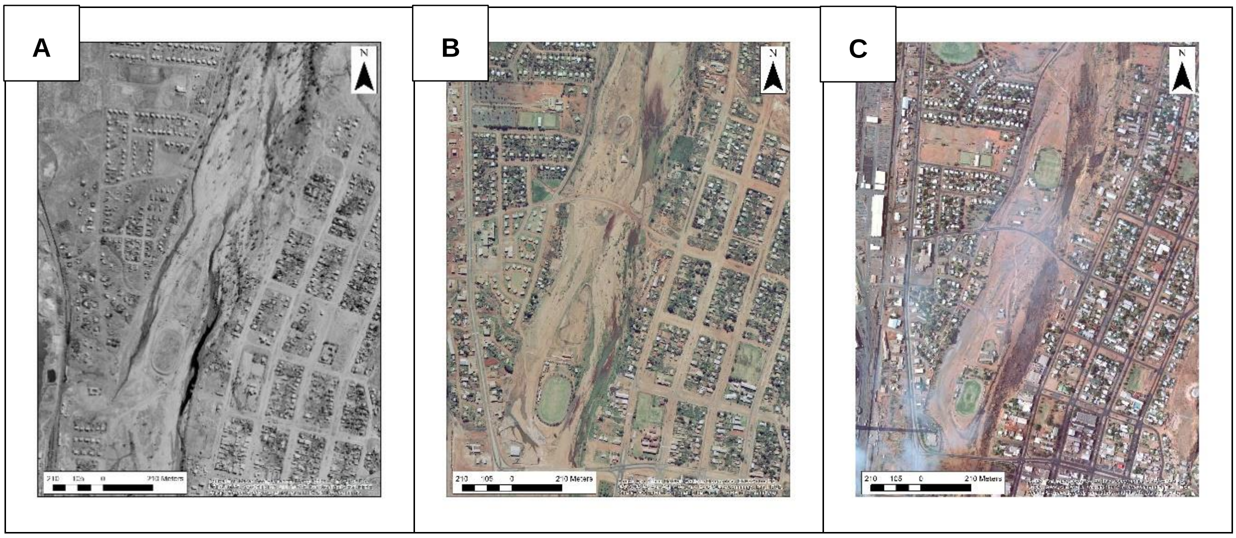


Figure 3 *Aerial imagery of Leichhardt River near Mt Isa from different time periods showing: A) 1956 – low levels of urbanisation, B) 1968 – increasing urbanization and recreational use of the channel and floodplain, C) 1994 – further modification of the floodplain and channel for housing, industry, and recreation. (Source: https://qimagery.information.qld.gov.au/)*

Defining river rehabilitation

It is acknowledged that terms such as river, creek, stream, waterway, watercourse and others can be used interchangeably. In this document the term river is used and considers the whole river system from the headwaters to the upper limit of tidal influence, including the channel and the adjacent flood inundation area. The adjacent land may contain a floodplain and riparian zone.

Rehabilitation is an action, or actions to repair, enhance and/or replace ecosystem processes and/or components, to improve intrinsic values and/or ecosystem services. Restoration is an action, or actions to bring back a former, original, normal, or unimpaired condition (based on SRG SERA 2021). The restoration of river systems back to their pre-disturbance condition is a worthy goal, but frequently unrealistic because of substantial changes in flows of sediment and water.

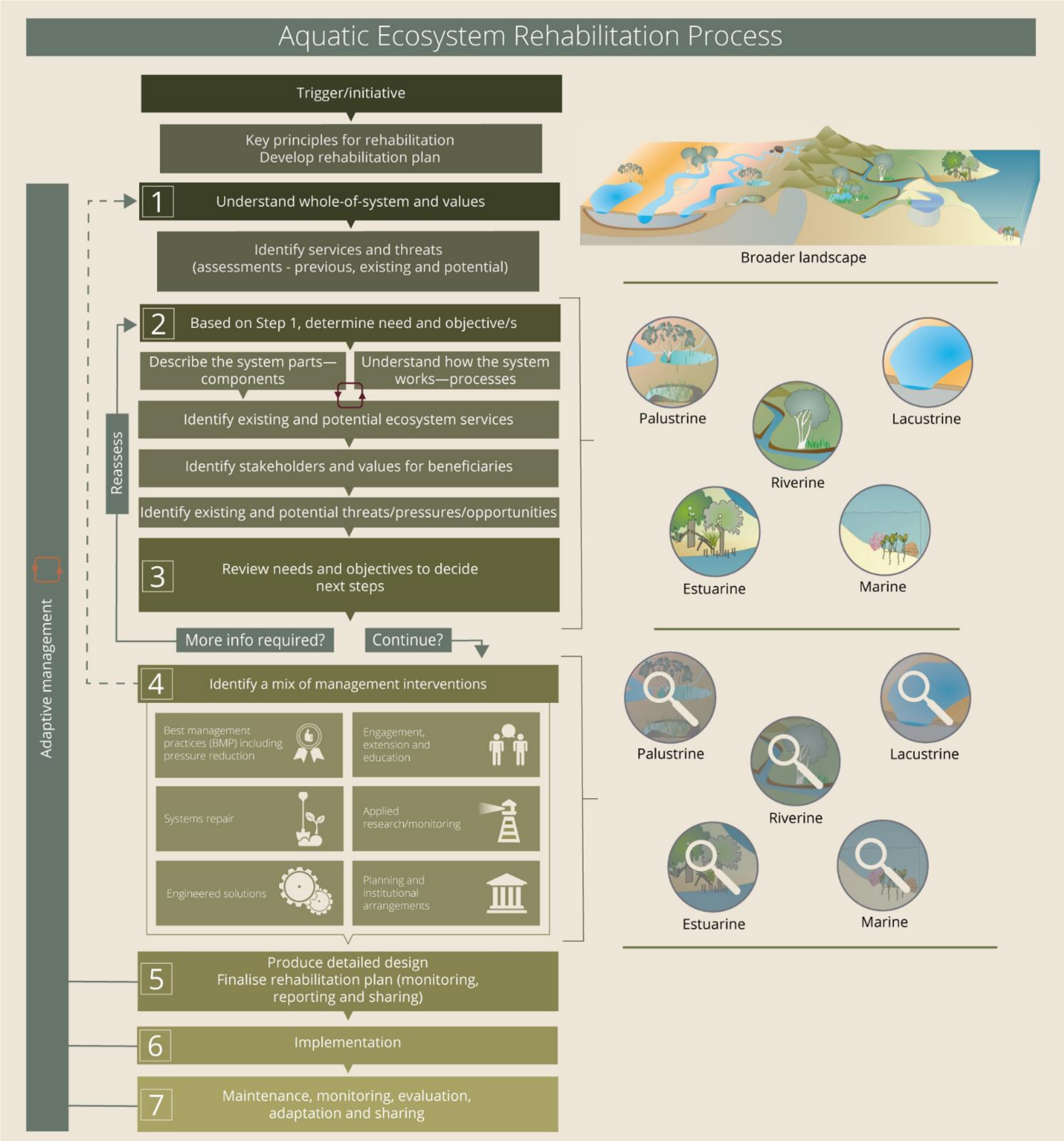
The techniques of river rehabilitation continue to improve based on research, monitoring, and technological developments. The use of vegetation has significant advantages as a management tool and this approach is encouraged where possible. More specialised approaches are sometimes needed to improve the condition of the river and adjoining lands so that the river can recover more quickly from a disturbance while reducing the need for continual maintenance.

The Rehabilitation Process

The *QRRMG* provides a high-level description of the *Rehabilitation Process* (Figure 4) within a river rehabilitation context, including the rationale for each step and what each step involves. The Aquatic ecosystem rehabilitation section of Wetland*Info* has been designed to complement the *QRRMG*. It provides further details for each step and links to appropriate resources which will be updated as technologies and new information arises. In addition, there are three electronic tools to assist with operationalising the *Rehabilitation Process* for a project:

- Aquatic Ecosystem Rehabilitation Mapping Report
- Aquatic Ecosystem Rehabilitation Plan
- User Defined Factsheet – Aquatic Ecosystem Rehabilitation Process and Whole-of-System, Values-Based Framework.

Together these resources support and enable the user to develop a customisable project specific rehabilitation plan that applies the key principles of river rehabilitation, considers each of the steps in the *Rehabilitation Process* and aligns with the *Framework*.



Department of Environment and Science, Queensland (2022)
Aquatic Ecosystem Rehabilitation - Process Diagram (version 1.0) Wetland*Info* website

Figure 4 *The key components of the seven-step Rehabilitation Process that are consistent across the five different aquatic ecosystem types in Queensland.*

What triggers or initiates river rehabilitation?

Rationale for inclusion

River rehabilitation can be triggered by an event (current or in the past) or begin through an initiative to address a responsibility or a need. Natural triggers can include disasters such as cyclones, floods and fire. Societal triggers and initiatives can include the need to protect at-risk infrastructure, market mechanisms, and drivers such as government policy, legislation or planning requirements (e.g. environmental offsets, water quality improvement and biodiversity protection). The trigger or initiative needs to be understood as this sets the context for the initial project goals or objectives. Examples of two triggers for river rehabilitation are shown in Figure 5.

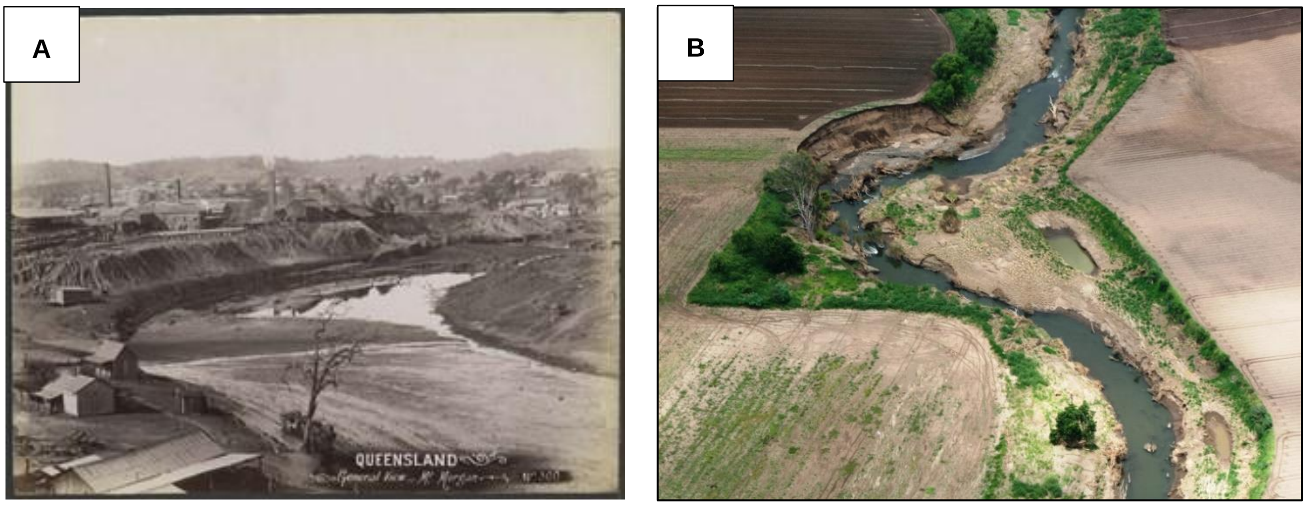


Figure 5 *Examples of two triggers for river rehabilitation: A) photograph of Mt Morgan ca. 1905 showing the impact of historic gold mining on the Dee River that has changed the form and processes in the channel and on the floodplain at the site and downstream (Source: National Library of Australia), B) A creek in the Lockyer Catchment following the 2011 floods indicating high rates of riverbank erosion and showing few native trees and shrubs on the floodplain and in the channel (Source: Jon Olley).*

Description of what is involved

The clearer the trigger or initiative, the easier it is to identify who or what will benefit from rehabilitation, and what services are being targeted. Documenting the trigger or initiative that started the *Rehabilitation Process* in a rehabilitation plan will ensure that the project remains in scope. Further investigation (for example, how climate change is affecting flood frequency and intensity) may identify that the trigger or initiative is only part of a broader issue. This may require modifications to the project.

In cases where the initiative is based around the prediction of an event, there is often more time to develop a deeper understanding of the issues and how to respond to them. Natural disasters can result in the perceived or real need for near instantaneous responses. Reacting rather than responding to such events (e.g. a large flood event), can lead to costly interventions that may not have been needed or that have unintended consequences. A proactive alternative is to pre-plan using the *Framework* so that relevant information and data is available to inform disaster management responses. A triage approach, where issues are identified, ranked and addressed based on risk, can be applied after a disaster event. This information can also be used to develop a longer-term plan that prevents reoccurrence and improves resilience to future events.

Key river rehabilitation principles

Rationale for inclusion

The overarching goal for river rehabilitation management is the wise and sustainable use of rivers. The Ramsar Convention (1971) prescribed the 'wise-use' and management of wetlands (see glossary). The *Rehabilitation Process* applies seven key principles to underpin this goal.

Description of the principles

1. Create a clear strategy/plan

Undertaking a rehabilitation project, even a small one, can involve a lot of work. Planning the project properly will save time, money and frustration. It is important to outline the purpose of rehabilitation, and the services or values to be maintained or improved in a rehabilitation plan. In addition:

- Seek expert advice/ensure appropriate skills are available: River rehabilitation can be technically challenging as these are complex systems, involving the interaction of water, plants, animals and humans. Management interventions should be developed and implemented by appropriately qualified people (e.g. fluvial geomorphologists, hydrologists, botanists, ecologists, engineers, social scientists).

- Check legal obligations: Ensure that the actions to be undertaken do not cause environmental harm or break the law. Federal, State, and local legislation, policy and planning need to be considered in any rehabilitation activity. Legal requirements may impose significant time and financial constraints on projects. It is recommended that pre-lodgement advice is sought through the State Assessment and Referral Agency to identify any impacts on potential state triggers that may result in the need for a development approval.

- Use best management practices: It is tempting to use tried and tested methods or simple activities that may have worked elsewhere. Consider what intervention options are best suited to the project.

- Include maintenance: Any river rehabilitation project needs to consider both the initial works and the ongoing maintenance requirements to achieve the long-term outcome, and factor the costs of both, into the rehabilitation plan.

- Monitoring, evaluation and adaptation: Rehabilitation should integrate monitoring, evaluation, and adaptation in the rehabilitation plan. This includes collecting baseline river condition information before rehabilitation works begin and monitoring for changes after works have concluded. This information can lead to the improvement of future management activities. Celebrate the success of implementation but continue to monitor to ensure long-term outcomes are achieved.

2. Understand your system at multiple spatial and temporal scales

Rivers can provide numerous ecosystem services that are valued in varying ways by different beneficiaries. They also actively respond to changes that occur both locally and/or further away at varying timescales. Understanding the form and processes of the site and its broader landscape (catchment) can improve outcomes. This includes knowing past activities, interventions, and disturbances. The future impacts of climate change and the timing of implementation also need to be considered.

3. Consider if intervention is necessary

Any river rehabilitation project needs to consider the dynamic nature of these systems. For example, rivers naturally move across floodplains over time through the processes of erosion and deposition; therefore, is intervention necessary? If it is deemed necessary, avoid only managing current issues. Instead, consider goals and objectives that relate to the medium to long term. Include consideration of the future impacts of climate change and how it may alter aquatic ecosystem dynamics. Also consider what management intervention(s) would reduce the need for interventions after triggers such as floods and cyclones.

4. Involve First Nations People and other stakeholders

All river rehabilitation management planning should consider impacts on a broad range of stakeholders (including beneficiaries). Identify and involve stakeholders from an early stage in the process (Figure 6). Take time to understand their different perspectives and possible competing values. Consider that not all community members benefit from the services or values and some people might be negatively impacted by the rehabilitation activities.

First Nations people have a deep relationship with, connection to, and responsibility for aquatic ecosystems. This is part of their identity and therefore the cultural, physical, and spiritual health of First Nations people is intimately connected to the health and wellbeing of these systems. First Nations people have been enduring custodians for tens of thousands of generations. Consideration and incorporation of traditional knowledge and values of First Nations people is fundamental to achieving sustainable river rehabilitation outcomes that respect both Country and people. It is necessary to involve the appropriate First Nations people, and to gain their prior and informed consent to work on their traditional lands. It is important to invest in building a relationship and trust. This may take time and may be guided by the Queensland Government Roadmap for engagement with First Nations People (DES and BioCultural Consulting 2021).

Figure 6 A workshop that involved stakeholders in the design and content of the Rehabilitation Process (Source: International Water Centre).

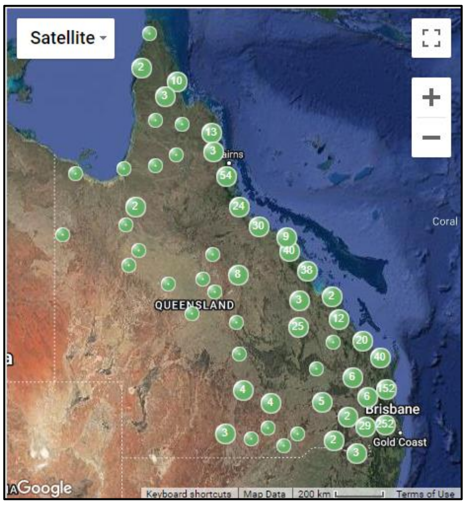


Figure 7 A map view from the project search tool of WetlandInfo that can be used to inform on other projects in an area to guide appropriate interventions and to share project information (Source: DES 2022).

5. Optimise rehabilitation outcomes

Individual rivers cannot provide all ecosystem services at all times. Optimising the key services and values required of the river should dictate the rehabilitation and management actions. Seeking complementary outcomes rather than focusing on a single service and checking for unintended consequences is important (e.g. the planting of some vegetation may encourage some birds but make the site unsuitable for others). Also remember that the maintenance of existing services and values is more cost effective than re-creating them when they have been lost. A cost-benefit analysis of rehabilitation activities should consider any local development works that are planned. Is it cost effective to invest in rehabilitation, or are there other actions that can be undertaken to avoid causing further damage to local aquatic ecosystems?

6. Share

Documenting what has been learned and sharing this information both internally and externally will support the adaptive management and continuity of the individual project and foster a learning environment that benefits the broader rehabilitation community.

It is important to share both successes and learnings, so that lessons from rehabilitation projects can be applied in the future (Figure 7). It is important to wait for an appropriate period to measure outcomes as rehabilitation may be successful in the short term, but this may not be sustained. Alternatively, some actions may take years for the full benefits to be sustained.

7. Adaptive management

River rehabilitation should be undertaken in an adaptive management cycle where management is modified as conditions at the site change or new information becomes available (‘learning by doing’). Monitoring, evaluation and sharing are critical elements of the adaptive management cycle.

Monitoring is essential to inform whether objectives are being met, the trajectory of the system, and for establishing project timeframes. Evaluation is undertaken as the learning step of the adaptive management. Evaluation is the analysis of monitored data and the project targets and goals, leading to the production of options for future measures. At this evaluation stage, a key decision needs to be made on whether the interventions are working, or if other interventions are necessary - providing the option to adjust direction to improve progress towards project outcomes.

The project can be evaluated, restarting an adaptive management loop, for several different reasons. Examples include:

- A threshold in the monitoring: Either an objective has been met, and there needs to be reflection on the efficacy of the process, or the objective has not been met and the reasons why need to be examined.
- Project milestones: Initial targets may have been set, for example, based around one-, five- and twenty-year timeframes. These may be evaluated to assess the initial project establishment and the medium- and long-term targets.
- An unintended consequence has occurred: If monitoring reveals that something unintended, usually detrimental, has occurred, then there may be a need to reassess. An example might be an environmental flow that has engaged the intended floodplain wetlands but has also triggered a spawning event of an invasive species of fish, vegetation, or both.
- A change in the pressures to the system: There may be changes to the site and/or catchment that were not anticipated in the original design. For example, urbanisation in the catchment may increase the amount of stormwater entering the aquatic ecosystem, which in turn may mean the peak discharges the system experiences are higher.
- An alteration in the services desired at the site: An intervention site may need to meet differing social expectations because it becomes more accessible to the public. There may also be a change in the water quality requirements at the site or downstream that mean a different intervention may be necessary.

These evaluation milestones are yet another opportunity for sharing. This is a time to report the success of the project to multiple stakeholders and the community.

Step 1: Understand whole-of-system and values

Rationale for inclusion

Applying the *Framework* when planning for rehabilitation means that any management interventions are more likely to succeed. Rehabilitation activities that are aimed at parts of an ecosystem, with little or no consideration of impacts to the whole ecosystem or catchment (Figure 8), run the risk of unexpected and undesired outcomes.

Description of what is involved

The *Framework* involves identifying the components and processes that make up an ecosystem at multiple scales (spatial and temporal), understanding how these components and processes give rise to ecosystem services (services), and identifying and understanding the values (including intrinsic and existence) and people (stakeholders, beneficiaries) associated with an ecosystem. For example, riparian vegetation (component) and riverine processes (such as flooding) interact to provide the service of flood mitigation which is valued by people. The *Framework* requires an understanding of the past, present and future pressure/threats/opportunities to the services and identifying the actions required to maintain or improve those services and values.

Figure 8 *A photograph representing the whole-of-catchment showing the headwaters in the background and the estuary in the foreground (Source: Gary Cranitch, Queensland Museum).*

Step 2: Based on Step 1, determine need and objective/s

Rationale for inclusion

The clearer the objectives for river rehabilitation, the easier it is to identify and implement management actions. An understanding of the proposed rehabilitation site and its immediate surrounding landscape should be undertaken to determine needs and objectives. The objectives should be linked to the desired outcome, which can be based on the services or values to be achieved.

Description of what is involved

To understand your socio-ecological system at a site the following steps need to be considered.

- Understanding your site: Understanding the type of system that is being rehabilitated reveals its components and processes. This information needs to be considered within the context of Step 1 and informed by the classification and condition of the river.

- Identify ecosystem services: Ecosystem services (services) and intrinsic and existence values are derived from the interaction between the components and processes of an ecosystem. Understanding the services at a site will directly impact the aims and objectives of a rehabilitation project.

- Identify beneficiaries and stakeholders and their values: Beneficiaries benefit from ecosystem services provided by the environment. However, not all people in the system are beneficiaries and some stakeholders may not benefit from, or are negatively impacted by, a service. Identifying and documenting stakeholders and beneficiaries and how they are affected by or benefit from an ecosystem enables clearer objectives to be set for any rehabilitation process.

• Identify existing and potential threats/pressures/opportunities: Pressures can result from underlying human activities and natural processes or components at a variety of scales. Understanding current and emerging pressures to a rehabilitation site will allow for proactive management and minimise risks that the rehabilitation activity will not be effective. There may also be cases where there are opportunities that can be leveraged to maximise river outcomes, for example the closure or change in an industry may alter available water quantity/quality and mean that a change in land-use at the site is possible.

The information and data required for undertaking this step can be quite extensive and contemporary sources should be used. Defining objectives will ensure that management interventions are relevant and linked to desired outcomes (Jones and Kirk 2018). There are many standards to defining objectives, including using SMART principles and Structured decision-making practices (Gregory et al. 2012).

SMART objectives commonly apply the following principles (Bjerke and Renger 2017).

• *Specific*: Keep objectives focused on specific issues, that are clearly understood by all stakeholders. Specific objectives define what is to change and by how much.

• *Measurable*: This is important to be able to determine if the objective has been achieved. Setting a measurable objective includes establishing criteria for measuring progress.

• *Achievable*: The objective should be realistic in terms of the resources, skills and time available.

• *Relevant*: The objective should align with the overall outcome set for the rehabilitation project.

• *Time-bound*: Objectives should have a set date for when they are to be achieved.

Step 3: Review needs and objectives

Rationale for inclusion

The original intent of a rehabilitation plan may change over time, especially after undertaking an assessment of the system as a whole. Using the information that has been gathered about the system, the need for rehabilitation and/or the underlying objectives, need to be re-evaluated.

For example, the project may be: unachievable; at high risk of failure; incompatible with stakeholder requirements; illegal; lack support from stakeholders; or be unable to be maintained.

Description of what is involved

The feasibility of the proposed rehabilitation work needs to be established and objectives and outcomes modified according to the following scenarios:

1. The objectives are correct, and the project can continue to Step 4.

2. The project is unlikely to succeed in its current form but there is sufficient information to revise the needs and objectives.

3. There is not enough information to make a clear decision, and more information needs to be collected.

4. The project is unlikely to succeed and should not go ahead.

Reassessment of the objectives does not prevent rehabilitation activities taking place. The objectives could be modified slightly to align with the values and beneficiaries identified, or the site opportunities or constraints.

Step 4: Identify a mix of management interventions

Rationale for inclusion

Having set the objectives in the previous steps the mix of management interventions can be identified. Rehabilitation should limit risks and fix the problem rather than applying temporary solutions. There are a range of management intervention options available to deliver desired river rehabilitation outcomes. There should be a transparent approach to selecting the appropriate management intervention or mix of interventions, guided by the identified needs and objectives and the available budget.

Description of what is involved

There are six management intervention themes (Figure 9) available to deliver aquatic ecosystem rehabilitation outcomes:

1. Best management practice (BMP) including pressure reduction: practices that prevent impacts on the environment and reduce pressures from the source.

2. Engagement, extension and education: options that build awareness, enthusiasm, relationships, knowledge and capacity for improved management.

3. Systems repair: options involve improving processes and/or components of an ecosystem primarily through natural means such as active revegetation.

4. Applied research and monitoring: options involve providing additional information to solve problems such as filling key knowledge gaps and repeat assessments (monitoring) to discover system trajectories.

5. Engineered solutions: options involve building engineered structures used to modify aquatic ecosystem components and processes.

6. Planning and institutional arrangements: options such as protection of environmental values using regulatory planning, assessment, approval, compliance and enforcement mechanisms administered by Commonwealth, State and local Governments.

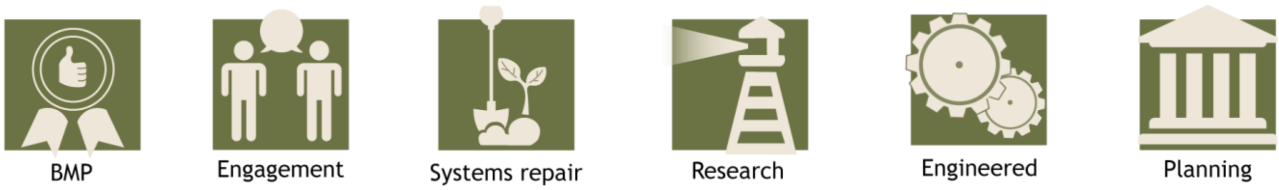


Figure 9 *The six main themes of river rehabilitation management interventions.*

In practice there is often overlap and themes may be used in combination with each other. A range of tools and methods are available for assessing and prioritising management interventions, and factors to be considered are outlined in the *Framework*. In Great Barrier Reef catchments, the Reef Trust Gully and Streambank Toolbox (Wilkinson et al. 2022) can be used to assess erosion potential, sediment loss and prioritise cost effective management interventions.

Management intervention options should be based on the site information, the surrounding landscape, the desired values and services, as well as the resources available. A list of management intervention options together with a timeline and equipment list should be developed. For example, if erosion and sediment is identified as a threat to the values of the river then the plan will need to address both short and long-term sediment control. Short-term approaches may include fencing, while long-term activities may involve adding vegetated filter strips and buffer zones or the placement of boulders and logs to aid stabilisation.

Step 5: Produce detailed design

Rationale for inclusion

Once the mix of management interventions that address the objectives have been identified it is necessary to develop, document and cost a detailed design plan. Designs are needed for all management interventions, not just engineered solutions. Maintenance, monitoring, and engagement activities for the life of the project also need to be designed and costed.

Description of what is involved

Legal and safety requirements as well as timelines for approvals need to be considered. Due to the inherent variability in rivers the detailed design needs to be guided by suitably qualified experts (e.g. a fluvial geomorphologist can design the work but it may need to be signed off by a registered engineer), and can include local knowledge and input.

In simple cases there may be a single site requiring rehabilitation and a clear intervention. Often rehabilitation designs are restricted to a single landholder's property or a reach that is a few kilometres in length. Staging of management interventions needs to be considered in the detailed design for both simple and complex rehabilitation projects. For example, if active revegetation is the intervention option selected, a stock exclusion fence may need to be constructed before vegetation is planted.

To ensure the project is resilient to current and future pressures and the investment in the rehabilitation is realised, interventions need to be designed and constructed to allow for future maintenance, considering the frequency, duration, access, and cost.

The maintenance frequency can be categorised into the following three types (Moore and Rutherfurd 2017):

1. routine, such as weeding, or the removal of debris on structures
2. disturbance related, such as checking fencing after flooding
3. lifecycle maintenance, such as structures that need their condition and effectiveness evaluated periodically.

A condition assessment should have been done as part of Step 2. If it does not already exist, then it should be done in this step and used to inform the development of the Condition Assessment Monitoring Plan (CAMP). The purpose of the CAMP is to record the logic and reasoning for the assessment/monitoring of changes in the condition in a wetland after an event or resulting from management interventions. The CAMP sets out the decisions, the reasoning (rationale) behind those decisions, and what changes are expected against each of the selected biophysical indicators. An important aspect of this process is that it distinguishes the expected change in condition due to management intervention within the context of background variability and suggests the frequency and timing of monitoring to do this. As a result, the return on investment for the project can be evaluated.

The CAMP process has been developed for monitoring of biophysical condition; however, the overall success of projects also depends on stakeholder engagement (e.g. development of social connections, increased knowledge of landholders, good collaborations) and meeting project budget and timelines. Documenting the monitoring design for all aspects of the project is important as this will serve as a record to inform others who may not have been involved in the design of the project or its assessment/monitoring approach.

The final design needs to be properly costed and care must be taken that the costing is for the life of the project to ensure long term objectives can be met. Costings need to include site monitoring and maintenance as well as ongoing stakeholder communication and information sharing. In cases where there are multiple intervention options the detailed design enables them to be compared based on variables such as cost, the amount of disturbance at the site, or the greatest community support.

A final review of the detailed design plan (including ground-truthing) allows for refinement based on the funds available and the timing of actions. This may result in an amendment of the interventions used or staging of the project.

Step 6: Implementation

Rationale for inclusion

The implementation of the project designed in Step 5 can include: on-ground works; systems repair; applied research; engagement, education, and awareness; applied research and monitoring. Decisions now need to be made about the most effective way to implement the project. If the people who developed the detailed design are not involved in the implementation clear instructions need to be produced, and a strategy in place for who to contact if further information is needed.

Description of what is involved

A task plan that includes staging and timing is needed for this part of a project. The plan needs to clearly define the roles and responsibilities of everyone involved in the implementation. This is especially useful when the people who devised the project are not the same as those implementing it.

The details of what is required to prepare the site before works are undertaken, and how the site is to be accessed, should be included in the task plan. The land ownership of the project site should have already been determined, but now the legal status of any land needed to access the site should also be mapped and documented. This process facilitates negotiating access agreements as a component of the legal requirements of the project.

There should be consideration of who is needed at the project site during different time periods and what experience they require. Contractors will be better able to undertake the works if they have previously worked on similar projects, however, there may be stages of the project that also require expert oversight. It needs to be clear who has the authority to undertake different actions, alongside how and when they may be contacted. This is especially the case if the project needs any onsite amendments during construction.

Health and safety requirements need to be followed. Careful consideration should be taken over biosecurity at the site. Work to remove invasive weeds should not introduce alternate threats or spread them to other sites.

Before any interventions are undertaken, it is important to implement the CAMP to ensure the baseline condition assessment is undertaken if it has not been done in Step 2. This will enable the biophysical effectiveness of any changes to be evaluated. Example photographs of two projects are shown in Figure 10 and Figure 11. These photographs can be a component of the CAMP and allow sharing of the project with beneficiaries.

Figure 10 *A mix of management interventions applied at a river rehabilitation site in the Fitzroy River (Source: Kim Piercy).*

Figure 11 *Fish passage structures on Bowenville Gauging Station Weir, Oakey Creek, Queensland including rock ramp and baffles (Source: Andrea Prior).*

Step 7: Maintenance, monitoring, evaluation, adaptation, and sharing

Rationale for inclusion

After the implementation of the intervention, it is tempting to consider that the project is complete. However, long term maintenance and monitoring is required to evaluate progress towards the objectives. Evaluation will help determine if adaptation of the management approach is required. Once the evaluation has been undertaken, which may include demonstrating the intervention is making little difference, the results can be shared.

Description of what is involved

The key activities undertaken in this step are:

- Monitoring – Indicators for biophysical condition, social and project management (Monitoring, Evaluation, Reporting, Improvement - MERI) indicators should be monitored using the design developed in Step 5 (CEWO 2013).
- Maintenance – This can occur in parallel with monitoring and should be implemented in accordance with the detailed maintenance requirements in Step 5.
- Evaluation – The effectiveness of the intervention can be evaluated using the monitoring results. Evaluations should be taken at different times of the project, and these should be guided by the objectives and targets. These evaluation milestones are an opportunity for sharing successes and learnings with stakeholders. While monitoring and evaluation can be undertaken for a single project, there may be efficiencies in combining the process with other projects or as part of the maintenance schedule. There may also be opportunities to

collaborate with universities, government and natural resource management groups and the community including First Nations people to monitor and evaluate projects.

- Adaptation - The evaluation may trigger additional maintenance of the site and/or adaptation of management activities (adaptive management). Evaluation can be used to determine whether the intervention is still appropriate to achieve the outcome. If objectives are not being met, consider if a different approach is required. It is often tempting to continue what was started, especially when using a well-established method, however if it is not being effective the project needs to be able to adapt.

- Sharing - Sharing of information is frequently missed from the final stages of a rehabilitation project. Consider who needs to know and understand the rehabilitation project and its progress. Let them know what did and did not work as well as unexpected outcomes. The location of the site and its intervention details can be added to the existing database of rehabilitation projects in Queensland to aid in the understanding of what types of intervention are taken in different spatial locations.

  Once these activities have been undertaken it is useful to consider the whole-of-system in the evaluation and sharing of the project. Individual interventions may not make a significant difference to components, processes, services and values at the whole-of-system. When viewed in the context of other interventions in the system, consider how the project contributes to the improvement of the whole system.

Conclusion

The *Queensland River Rehabilitation Management Guideline* and associated *Rehabilitation Process* is underpinned by the *Whole-of-System, Values-Based Framework*. The intent of these management guidelines is to provide a consistent and transparent approach to river rehabilitation. The approach allows for management decisions that consider and link the components and processes of a system with the ecosystem services it provides and how they are valued by beneficiaries and stakeholders. This is done at relevant spatial and temporal scales. Information and guidance provided on a suite of different management interventions means that the selected interventions clearly fit the objectives of the rehabilitation. This results in better outcomes.

The application of this approach will improve the success of river rehabilitation projects as well as river rehabilitation policies and programs. It also enables an environment where knowledge can be built in a collaborative and co-ordinated way so that rehabilitation moves away from being reactive to being more proactive. Disasters occur but having a process in place to make rivers more resilient will reduce some of the stresses associated with the event and lessen the likelihood of mistakes being made during rehabilitation activities.

The *Queensland River Rehabilitation Management Guideline* and associated products will continue to evolve and improve as information and outcomes are shared, and as case studies and new research is incorporated. This will ensure ongoing improvement in river rehabilitation management across Queensland.

Glossary

Beneficiaries: Beneficiaries are the people who benefit from ecosystem services provided by wetlands (DES 2022).

Biodiversity: is a variation of species living in a complex ecosystem (Duncan, Thompson and Pettorelli 2015)

CAMP: A Condition Assessment Monitoring Plan. The CAMP is a foundational process that documents the indicators that should be used to assess the present condition and then monitor for change as a result of an intervention. This includes the spatial and temporal monitoring framework (DES 2022).

Ecosystem: a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functioning unit. *Environment Protection and Biodiversity Conservation Act* (1999)

Ecosystem services: the contributions that ecosystems (i.e. living systems) make to human well-being (Haines-Young and Potschin 2018)

Environmental offsets: An environmental offset compensates for unavoidable impacts on significant environmental matters, (e.g. valuable species and ecosystems) on one site, by securing land at another site, and managing that land over a period of time, to replace those significant environmental matters which were lost (Queensland Government 2022).

Environmental flows: relates to the quantity, quality and the timing of freshwater entering aquatic ecosystems, which is linked to supporting and sustaining cultures, economies, livelihoods, and well-being (Arthington et al. 2018).

Flood mitigation: measures to prevent or reduce flood damage (Bubeck, Botzen and Aerts 2012). This may be through the operation of reservoirs to reduce flood peak flows, or through the zonation of flood risk areas for planning so that inappropriate development does not occur.

Ramsar convention: The Convention on Wetlands of International Importance is treaty between nations aimed at conserving natural resources. The signing of the Convention on Wetlands took place in 1971 at the small Iranian town of Ramsar. Since then, the Convention on Wetlands has been known as the Ramsar Convention. (DAWE 2022)

Rehabilitation: the manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions of degraded wetland. Rehabilitation results in a gain in wetland function (DES 2022).

Restoration: a bringing back to a former, original, normal, or unimpaired condition (SRG SERA 2021).

Riparian: of, relating to, or situated or dwelling on the bank of a river or other body of water (DES 2022).

Stakeholders: Stakeholders are those who are directly impacted by and/or influence wetland decision-making (DES 2022).

Values (ecosystem): These represent the importance, worth, or significance that an ecosystem has for an individual, group or entity (Jones and Kirk 2018). Values can include those benefits ecosystems provide to people and provide context to ecosystem services by linking them directly to the people or entities they benefit.

Water quality: the chemical characteristics of water in terms of suitability of the water for various intended uses (Freeze and Cherry 1979)

Wise use: the maintenance of ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development (Ramsar Secretariat 2005).

References

Arthington, AH, Kennen, JG, Stein, ED and Webb JA 2018, ‘Recent advances in environmental flows science and water management—Innovation in the Anthropocene’, *Freshwater Biology*, vol. 63, no. 8, pp. 1022-1034.

Bjerke, MB and Renger, R 2017, 'Being smart about writing SMART objectives', *Evaluation and Program Planning*, vol. 61, pp. 125-127.

Bourke, MC and Pickup, G 1999, ‘Fluvial form variability in arid central Australia’, in Miller, AJ and Gupta, A (eds) *Varieties of Fluvial Form*. John Wiley and Sons Ltd., New York, USA.

Bubeck, P, Botzen, WJW and Aerts, JC 2012, ‘A review of risk perceptions and other factors that influence flood mitigation behavior’. *Risk Analysis: An International Journal*, vol. 32, no. 9, pp. 1481-1495.

Chan, KMA, Satterfield, T and Goldstein, J 2012, ‘Rethinking ecosystem services to better address and navigate cultural values’, *Ecological Economics*, vol. 74, pp. 8-18.

Ciotti, DC, Mckee, J, Pope, KL, Kondolf, GM and Pollock, MM 2021, ‘Design Criteria for Process-Based Restoration of Fluvial Systems’. *BioScience*, vol. 71, no. 8, pp. 831–845.

Commonwealth Environmental Water Office 2013, *Commonwealth Environmental Water - Monitoring, Evaluation, Reporting and Improvement Framework. V 2.0.* Commonwealth Environmental Water Holder, Canberra, ACT, Australia.

Department of Agriculture, Water and the Environment 2022, ‘The Ramsar Convention on Wetlands’, https://www.dcceew.gov.au/water/wetlands/ramsar, accessed June 2022.

Department of Environment and Science 2022, WetlandInfo—Glossary of technical terms, https://wetlandinfo.des.qld.gov.au/wetlands/resources/glossary.html#q=, accessed June 2022.

Department of Environment and Science and BioCultural Consulting 2021, *A roadmap for engagement with First Nations People: Integrating knowledge systems into the Queensland River Management Framework*, DES, Brisbane, Queensland, Australia.

Duncan, C, Thompson, JR and Pettorelli, N 2015, “The quest for a mechanistic understanding of biodiversity–ecosystem services relationships”. *Proceedings of the Royal Society B: Biological Sciences*, vol. *282*, no. 1817, pp. 20151348.

Freeze, RA and Cherry, JA 1979, *Groundwater*, Prentice-Hall, Englewood Cliffs, New Jersey, USA.

Frissell, CA, Liss, WJ, Warren, CE and Hurley, MD 1986, ‘A hierarchical framework for stream habitat classification: Viewing streams in a watershed context’. *Environmental Management*, vol. 10, no.2, pp. 199–214.

Fryirs, K and Brierley, G 2021, ‘Assemblages of geomorphic units: A building block approach to analysis and interpretation of river character, behaviour, condition and recovery’. *Earth Surface Processes and Landforms*, vol. 47, no. 1, pp. 92-108.

Gilvear, DJ, Spray, CJ and Casas-Mulet, R 2013, 'River rehabilitation for the delivery of multiple ecosystem services at the river network scale', *Journal of Environmental Management*, vol. 126, pp. 30-43.

González del Tánago, M, Gurnell, AM, Belletti, B and García de Jalón, D 2016, ‘Indicators of river system hydromorphological character and dynamics: understanding current conditions and guiding sustainable river management’, *Aquatic Sciences*, vol. *78*, no. 1, pp.35–55.

Gregory, R, Failing, L, Harstone, M, Long, G, McDaniels, T and Ohlson, D 2012. *Structured decision making: a practical guide to environmental management choices*. John Wiley & Sons., New York, USA.

Haines-Young, R and MB, Potschin 2018, “’Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure’, *Available from* https://cices.eu/

Jones, C and Kirk, N 2018, ‘Shared visions: can community conservation projects’ outcomes inform on their likely contributions to national biodiversity goals?’, *New Zealand Journal of Ecology*, vol. 42, no. 2, pp.116-124.

Jones, NA, Shaw, S, Ross, H, Witt, K and Pinner, B 2016, 'The study of human values in understanding and managing social-ecological systems', *Ecology and Society*, vol. 21, no. 1, p. art15.

Kenter, JO, O'Brien, L, Hockley, N, Ravenscroft, N, Fazey, I, Irvine, KN, Reed, MS, Christie, M, Brady, E, Bryce, R, Church, A, Cooper, N, Davies, A, Evely, A, Everard, M, Fish, R, Fisher, JA, Jobstvogt, N, Molloy, C, Orchard-Webb, J, Ranger, S, Ryan, M, Watson, V and Williams, S 2015, 'What are shared and social values of ecosystems?', *Ecological Economics*, vol. 111, pp. 86-99.

Lovett, S and Price, P 1999, ‘Riparian Land Management Technical Guidelines’, *Volume One: Principles of Sound Management*, LWRRDC, Canberra, ACT, Australia.

Moore, HE and Rutherfurd, ID 2017, 'Lack of maintenance is a major challenge for stream restoration projects', *River Research and Applications*, vol. 33, no. 9, pp. 1387-1399.

Queensland Government 2022, ‘What is an environmental offset and when is it required?’, https://www.qld.gov.au/environment/management/environmental/offsets/what-when, accessed June 2022.

Rutherfurd, ID, Jerie, K and Marsh, N 2000, *A rehabilitation manual for Australian streams,* Land and Water Resources Research and Development Corporation and Cooperative Research Centre for Catchment Hydrology, Canberra, ACT, Australia.

Rutherfurd, ID, Ladson, T and Stewardson, MJ 2004, ‘Evaluating stream rehabilitation projects: reasons not to and approaches if you have to,’ *Australian Journal of Water Resources*, vol. 8, no. 1, pp 57-68.

Standards Reference Group SERA 2021, *National Standards for the Practice of Ecological Restoration in Australia. Edition 2.2.* Society for Ecological Restoration Australasia. Available from URL: www.seraustralasia.org.

Stewardson, MJ, Cottingham, P, Rutherfurd, ID, Schreiber, S 2004, *Evaluating the effectiveness of habitat reconstruction in rivers*, Technical Report 04/11, Cooperative Research Centre for Catchment Hydrology, Canberra, ACT, Australia.

RAMSAR Secretariat 2005, ‘A conceptual framework for the wise use of wetlands and the maintenance of their ecological character - Resolution IX.1 Annex A’, in *9th meeting of the conference of the parties to the convention on wetlands (Ramsar, Iran, 1971) Kampala, Uganda,* 8-15 November 2005, pp. 1-7.

Wilkinson S, Hairsine PB, Bartley R, Brooks A, Pietsch T, Hawdon A and Shepherd R 2022, *Gully and Stream Bank Toolbox. A technical guide for gully and stream bank erosion control programs in Great Barrier Reef catchments. 3rd Edition*. Commonwealth of Australia, Canberra, ACT, Australia.

World Meteorological Organization 2012, ‘Conservation and restoration of rivers and floodplains*’ Integrated Flood Management Tools Series No. 13*, WMO, Geneva, Switzerland.

Bibliography

Bartley, R, Goodwin, N, Henderson, AE, Hawdon, A, Tindall, D, Wilkinson, SN and Baker, B 2016, *A comparison of tools for monitoring and evaluating channel change; Report to the National Environmental Science Programme.* Reef and Rainforest Research Centre Limited, Cairns, Queensland, Australia.

Cottingham, P, Bond, N, Lake, PS, Arthington, A and Outhet, D 2005, *Recent lessons on river rehabilitation in eastern Australia,* Technical Report, CRC for Freshwater Ecology, Canberra, ACT, Australia.

Department of Aboriginal and Torres Strait Islander Partnerships 2004, *Aboriginal Cultural Heritage Act 2003: Duty of Care Guidelines*, DATSIP, Brisbane, Queensland, Australia.

Department of Sustainability and Environment 2005, *Index of stream condition: the second benchmark of Victorian river condition*, DSE, Melbourne, Victoria, Australia.

Elliott, M, Burdon, D, Atkins, JP, Borja, A, Cormier, R, de Jonge, VN and Turner RK 2017, '"And DPSIR begat DAPSI(W)R(M)!" - A unifying framework for marine environmental management', *Marine Pollution Bulletin*, vol. 118, no. 1-2, pp. 27-40.

Fu, B, Wang, S, Su, C and Forsius, M 2013, 'Linking ecosystem processes and ecosystem services', *Current Opinion in Environmental Sustainability*, vol. 5, no. 1, pp. 4-10.

Fuller, IC, Gilvear, DJ, Thoms, MC, & Death, RG 2019, 'Framing resilience for river geomorphology: Reinventing the wheel?', *River Research and Applications*, vol. *35,* no. 2, pp. 91–106.

Gascon, M, Zijlema, W, Vert, C, White, MP and Nieuwenhuijsen, MJ 2017, 'Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies', *International Journal of Hygiene and Environmental Health*, vol. 220, no. 8, pp. 1207-1221.

Grice, T, Marsh, N, Henry, N, Grant, T and Rossrakesh, S 2021, 'Striking the balance between oversimplified and overdetailed: A tale of two report cards', in Boyd, T, Coker, M, Gregor, S, Miller, A, Morris, A, Russell, K, Rutherford, ID, Vietz, GJ, Walker, J and Wood, A (eds.) *Proceedings of the 10th Australian Stream Management Conference*, 2-4 August 2021, pp.836–844.

Jansen, A, Robertson, A, Thompson, L and Wilson, A 2005, 'Rapid appraisal of riparian condition: Version Two', *River and Riparian Land Management Technical Guideline,* No. 4A, Land and Water Australia, Canberra, ACT, Australia.

Kelble, CR, Loomis, DK, Lovelace, S, Nuttle, WK, Ortner, PB, Fletcher, P, Cook, GS, Lorenz, JJ and Boyer, JN 2013, 'The EBM-DPSER Conceptual Model: Integrating Ecosystem Services into the DPSIR Framework', *PLoS ONE*, vol. 8, no. 8, pp. e70766.

Lane, EW 1954, *The importance of fluvial morphology in hydraulic engineering*, United States Department of the Interior: Bureau of Reclamation, Hydraulic Laboratory Report No. 372, Denver, Colorado, USA.

Leisher, C, Hess, S, Dempsey, K, Payne Wynne, ML and Royte, J 2022, 'Measuring the social changes from river restoration and dam removal', *Restoration Ecology*, vol. 30, no. 1, pp. e13500.

Murray Darling Basin Authority 2016, 'Aboriginal Waterways Assessment program', *MDBA Publication No 20/15,* MDBA, Canberra, ACT, Australia.

Parkes, D, Newell, G and Cheal, D 2003, 'Assessing the quality of native vegetation: The 'habitat hectares' approach,' *Ecological Management and Restoration*, vol. 4, pp. S29-S38.

Pollock, M, Beechie, TJ, Wheaton, JM, Jordan, CE, Bouwes, N, Weber, N and Volk, C 2014, 'Using beaver dams to restore incised stream ecosystems,' *BioScience*, vol. 64, no. 4, pp. 279-290.

Sims, AJ and Rutherfurd, ID 2021, 'Local scale interventions dominate over catchment scale controls to accelerate the recovery of a degraded stream', *PLoS ONE*, vol. 16, pp. e0252983.

Thompson, CJ, Croke, J, Fryirs, K, and Grove, JR 2016, 'A channel evolution model for subtropical macrochannel systems', *Catena*, vol.139, pp. 199–213.