Sharing knowledge: What can smaller gully and streambank erosion management programs learn from large-scale programs in the GBR catchment?

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Key Points

- A robust, spatially targeted process is required to identify and prioritise remediation sites that have the greatest potential for future erosion and sediment delivery.
- Best-practice design of erosion control is achieved by trialling and monitoring innovative remediation methods, drawing upon local knowledge, and building on existing expertise and lessons learned from previous sites.
- Providing landholders with meaningful opportunities to contribute, ongoing access to information and assistance, and complementary incentives to support ongoing land management is key to encourage strong, ongoing landholder participation.
- Revegetation is crucial in achieving long-term outcomes for land stabilisation and erosion control, and landholders need to be trained and supported to deal with issues regarding vegetation establishment and management.
- Ongoing monitoring and maintenance are key to the success of erosion management programs and need to be included in programs with funding allocated.

Abstract

The Great Barrier Reef catchment is the recipient of the most erosion control funding and action in Australia, with significant government investments made into research, monitoring, and implementation of gully and streambank remediation programs. Many similar but smaller erosion management programs operate throughout the rest of the country; however, these programs do not have the same benefits of research and resourcing that GBR catchment programs do.

The number of gully and streambank remediation projects undertaken in GBR catchments, the sizeable body of remediation research that has developed in parallel, and the increasing availability of ongoing monitoring data make this program an ideal candidate to extract insights into gully and streambank management that can be applied elsewhere in Australia.

Through reflection on our experience working with a GBR program, *Landholders Driving Change*, as well as smaller gully and streambank erosion management programs throughout Australia, along with our broader experience in waterway sediment management, we have learned that there are transferrable approaches, tools and principles between remediation programs and projects of different scales. This paper identifies important 'lessons learned' in five key areas which can be applied to aid the delivery of smaller erosion management programs and projects across Australia.

Keywords

Gully erosion, streambank erosion, sediment, rehabilitation, remediation, Great Barrier Reef.

Introduction

Fine sediment liberated by gully and streambank erosion poses a major threat to Australia's waterways, estuaries and the Great Barrier Reef (GBR) in particular (Bartley et al., 2014; McCloskey et al., 2021). The environmental impact of this erosion to the Great Barrier Reef, the world's largest and most diverse reef

ecosystem, has resulted in significant funding for gully assessment, monitoring and rehabilitation research (Wilkinson et al., 2023), which has helped to guide government-funded gully erosion control program across the GBR catchment (Australian Government, 2022).

As such, the Commonwealth Government has invested over $500 m in erosion control projects across the GBR catchment, much of which has been targeted at the catchments that contribute the greatest proportion of the total fine sediment load delivered to the GBR. The number of gully and streambank remediation projects undertaken in GBR catchments, the sizeable body of remediation research that has developed in parallel, and the increasing availability of ongoing monitoring data make this program an ideal candidate to mine insights into gully and streambank management that can be applied elsewhere in Australia.

In this paper we use insights from the Landholders Driving Change (LDC) program, a major gully and streambank intervention program in the GBR, to synthesise lessons that can be applied to smaller, less well-resourced erosion control programs in Australia according to the following five categories:

1. Targeting the 'right' sites through spatial analysis and prioritisation
2. Championing best-practice design of erosion control measures
3. Encouragement of strong, ongoing landholder participation
4. Emphasis on revegetation efforts and maintaining groundcover
5. Implementation of ongoing monitoring and maintenance.

Many of the smaller gully and streambank erosion management programs operate throughout the rest of the country; however, these programs do not have the same benefits of scale, research and resourcing that GBR catchment programs do. This paper details the transferrable 'lessons learned' in the above five areas and how they may be applied to aid the delivery of smaller erosion management programs across Australia.

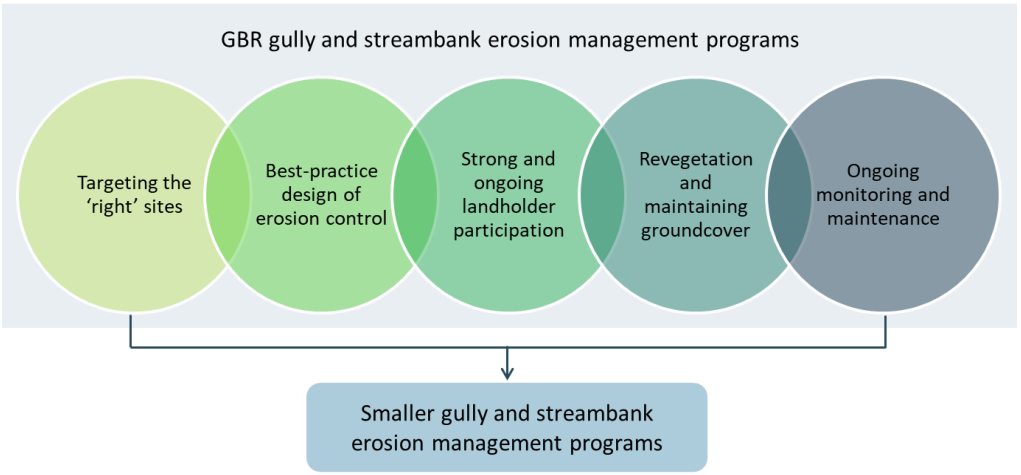

Figure 1. The five best-practice considerations for gully and streambank erosion programs

Targeting the 'right' sites

For erosion control to be cost-effective it must be spatially targeted (Lu et al., 2004). Select site for erosion control is achieved via two steps:

- Priority catchments and sub-catchments with high fine sediment yields and sediment delivery ratios are identified through spatial analysis and then prioritised according to criteria such as sediment delivery to receiving waterways or area of land lost to erosion.
- Selecting sites within those priority catchments through the process outlined below.

Selecting sites with significant active erosion is essential to achieving cost-effective sediment reduction outcomes, avoiding the risk of over-investment in relatively stable sites where gullies or streams may appear to be generating large volumes of fine sediment, but in reality have either stabilised since their initial expansion (e.g. a gully approaching the final stages of a gully-evolution cycle, or a streambank with mass failure which is self-limiting) or are poorly connected to receiving waterways (Wilkinson et al., 2018).

Managers working in GBR catchment benefit from a set of technical guidelines known as 'the Reef Trust Gully and Streambank Toolbox' that were designed for use by local agencies to guide site identification and planning of remediation efforts in GBR catchments (Wilkinson et al., 2022). The toolbox provides a framework for planning and implementing cost-effective erosion control where 'site assessment identifies a favourable ratio of the investment cost relative to the reduction in fine sediment loads delivered to the GBR lagoon' (Wilkinson et al., 2022).

The process for identifying cost-effective sites is simplified as follows:

- Estimate recent average sediment yield.
- Estimate potential sediment savings (reduction in sediment delivery) from erosion control activities expected over the next 30 years, by estimating their effectiveness as a proportional reduction of historical sediment yield (Wilkinson et al., 2018).
- Determine an appropriate budget for investment at the site, by assuming a target cost-effectiveness (in $/tonne/year).
- Cost the erosion control activities in more detail and determine if they can be delivered within the budget. If not, then revise the proposed activities to improve the cost-effectiveness, or seek other sites (Wilkinson et al., 2018).

The toolbox process estimates how much sediment could feasibly be 'saved' (i.e. not eroded) at a site, and then calculates the scale of investment needed to achieve that saving, *assuming some efficiency of works* (the target cost-effectiveness). This approach can be generalised to erosion control works outside of the GBR catchment. In the GBR catchment, the criterion is the volume of sediment that could feasibly be saved, but in other contexts, the criterion may be some explicit volume of sediment (e.g. a saving of 'x' tonnes/year), the assumed cost-effectiveness of works ($/tonne/year) or some other limiting criteria, such as metres of eroding streambank/gully saved, or maximum land for revegetation.

While the Toolbox was designed for application in the context of Government-funded programs within the GBR catchment, this general process can be scaled and transferred to other erosion management programs across Australia. An example of a tool that has been developed in a context outside of the GBR is the NSW Local Land Services Gully Erosion Assessment and Control Guide (Southeast LLS, 2018), intended to help users assess and identify actively eroding sites and common management options. However, it does not provide metrics for quantifying sediment load reductions or a process for determining cost-effectiveness of management options. A more formalised 'calculator' such as the toolbox process would provide a more robust way to target funding to projects based on an assessment of benefits and cost.

Key insight #1: Apply a robust and quantitative process to identify sites that have the greatest potential for future erosion and sediment delivery (i.e. not just those that 'look' the worst), and use the ratio of required investment to expected benefit (e.g. reduction in sediment yield) to prioritise sites and evaluate cost-effectiveness of works.

Best-practice design of erosion control measures

Successful and cost-effective erosion control must be well-designed and implemented. Erosion control measures should target multi-system benefits such as supporting geomorphological and ecological processes,

carbon sequestration and flood mitigation. Exactly which benefits are relevant and can be quantified will depend on the context, but the bundling of benefits and inclusion in any cost-benefit calculations (or cost effectiveness) for a site has the potential to provide a more holistic account of the works in their local context, and to make investment in erosion control more palatable.

The success of GBR gully and streambank erosion control projects can be attributed to several factors, including:

- Piloting and monitoring innovative remediation methods
- Building on existing expertise and lessons learned from previous trials
- Drawing upon the knowledge of graziers and technical specialists (NQ Dry Tropics).

Significant Government-funded investment has been made into establishing demonstration sites across the Burdekin Region which showcase different methods of treating large-scale features according to erosion and soil type (NQ Dry Tropics). This proves useful in determining which methods may be transferable to other similar areas.

However, not all erosion management programs across Australia are as well-resourced as those in the GBR catchment and seldom have local demonstration sites to draw from, making it difficult for smaller programs to pilot and implement innovative remediation methods or trial innovative (but potentially risky) erosion control methods. In cases where landholders must contribute a significant proportion of the funds towards the erosion treatments applied through programs, it can be difficult to fund an 'experimental' approach while working within these constraints. Importantly, there is additional risk presented by the dynamic nature of waterways and catchments. If control structures fail, it can reflect poorly on local agencies implementing erosion management programs, and without landholder involvement these programs cannot succeed.

In these cases, the definition of a 'demonstration site' can be re-framed to be a successful site, local agencies can do the work to document these sites and provide the information to landholders. Moreover, trialling new methods may be more palatable when they are low-cost and sites in which trials are implemented would otherwise not be candidates for erosion control (i.e. there is little to lose form a landholder's perspective). Erosion control is but one of the benefits from the trial sites, and the costs of the trial can be recouped though instruments such as carbon credits or potentially publicly traded biodiversity certificates.

Key insight #2: Trial and monitor innovative remediation methods where possible, build on existing expertise and lessons learned from previous sites, and draw upon the knowledge of local landholders and technical specialists.

Strong and ongoing landholder participation

For landholders and local communities to be on board with erosion management projects, it is important to provide them with the opportunity to contribute to the design and delivery of projects in a way that responds to local needs, issues, and opportunities (Office of the Great Barrier Reef, 2024).

There are many different types of landholders, with varying motivations, capacity to change and history of engagement, as well as land condition and management practices (Coggan et al., 2018). In considering landholder engagement within erosion management programs, local agencies should first attempt to understand local landscapes and enterprises, including social, cultural and economic characteristics (Coggan et al., 2018). This will help guide the type of landholder engagement and involvement, as well as incentives that may be provided to landholders for increased participation.

Strong and ongoing local participation is the cornerstone of GBR gully and streambank erosion control programs such as LDC. The LDC Program is inherently landholder-focused, with their involvement occurring from the start of the design process and encouraged throughout the whole of the program (NQ Dry Tropics).

Landholders engaged through the LDC program are also supported through the Bowen, Broken, Bogie (BBB) Catchment Grazier Support Program, which aims to provide all local graziers with education, training, technical support and incentives to help them adopt improved land management practices (NQ Dry Tropics). By aligning these two programs, LDC achieves greater outcomes. Approaches to landholder support include:

- Providing property mapping, and training activities designed to encourage graziers to get involved.
- Engaging with and supporting land managers to undertake activities to develop their skills and knowledge and implement practice change.
- Delivering a comprehensive technical advice and support program that works with individuals and groups.
- Supporting landholders to adopt industry best practice and establishing systems to reward and recognise these achievements.

In smaller programs throughout Australia, it could be difficult for ongoing landholder engagement to be prioritised after initial construction periods. Managers are often able to allocate capital expenditure to complete the initial works but seldom have the budget for long-term maintenance and engagement with landholders. This can lead to landholders feeling challenged by the tasks of ongoing maintenance of erosion control works, such as ensuring vegetation establishment, weed control, fencing, and grazing management. Frequent interaction with landholders is important in the years following completion of remediation works to help them deal with issues they're experiencing, and also to share in their successes.

The following recommendations can be scaled and applied to other erosion management programs across Australia to improve landholder participation in remediation efforts:

- Investigate collaborative approaches with landholders.
- Implement a suite of complementary incentives to support landholders in ongoing land management for water quality benefits (Coggan et al., 2018).
- Provide ongoing access to information and assistance regarding best-practice land management practices (including exclusion fencing, stocking rates, and controlled grazing of riparian areas).
- Provide grants tailored with payments associated with achieving key inputs or outcomes (Coggan et al., 2018).
- Support recognition and reward of high performers or those that have made large changes in land management (Coggan et al., 2018).

Many of the above activities may be better coordinated through local Landcare groups or their equivalent, particularly in the cases where education and monitoring will not be given ongoing funding from the agencies responsible for completing the initial capital works.

Key insight #3: Provide landholders with meaningful opportunities to contribute to projects, ongoing access to information and assistance regarding best-practice land management practices, complementary incentives to support ongoing land management, and recognition/reward of high performers.

Revegetation and maintaining groundcover

The success of revegetation efforts aligns closely with landholder participation and their outcomes are linked. It is crucial for erosion management programs to place emphasis on the importance of revegetation in achieving long-term outcomes for land stabilisation, and to support landholders in adopting grazing land management practices which support revegetation efforts. All capital works may eventually fail (i.e. they have

a design life) and established vegetation provides the long-term erosion resistance at a site (as well as other co-benefits).

In GBR gully and streambank erosion control programs, almost all sites are designed with exclusion fencing to control livestock access and allow revegetation (Wilkinson et al., 2018), which has been a key factor in the success of remediation projects. Where permanent exclusion is not planned, grazing regimes are agreed upon with landholders to reduce the impact of grazing on erosion control outcomes (Wilkinson et al., 2018).

Practices which are essential for landholders to adopt in supporting revegetation efforts include:

- Encouraging and maintaining groundcover for soil stability – groundcover will have improved survivability if guidance and support is provided to landholders regarding establishment and maintenance.
- Managing uncontrolled stock access to remediation sites – stock access should be controlled through fencing while vegetation establishes, and informed management of controlled grazing after fencing is removed, to reduce negative impacts to revegetation efforts.
- Encouraging and maintaining diverse riparian vegetation – in streambank remediation projects, maintaining riparian vegetation is essential to provide soil and bank stability, prevent weed growth, and support biodiversity and ecosystem services.

Programs where landholders are trained and supported to deal with issues regarding vegetation establishment, weed control, fencing, and grazing land management will have a higher chance of continued success.

The key point here is that the use of native vegetation as both groundcover and larger, more established trees is crucial to the long-term success of erosion control in almost all settings. The benefits of establishing or restoring native vegetation in waterways and eroding landscapes has been well-established and is often championed by agencies undertaking land management. The GBR experience provides an example of where the effectiveness of vegetation in reducing erosion is quantified explicitly (in tonnes of sediment not eroded). Vegetation is perhaps the most cost-effective means of reducing sediment yield from eroding gullies and landscapes long term.

Key insight #4: Revegetation is crucial in achieving long-term outcomes for land stabilisation and erosion control, and landholders need to be trained and supported to deal with issues regarding vegetation establishment, weed control, fencing, and grazing land management.

Ongoing monitoring and maintenance

Site monitoring is important not only to demonstrate completion of the construction phase of a given project, but also to identify any required maintenance works, engage the landholder and local community, evaluate project success, and continue advancing our understanding of how best to achieve erosion control outcomes (Wilkinson et al., 2022). GBR gully and streambank erosion control programs such as LDC incorporate effective monitoring practices in which each site is monitored before and after installation (typically for several years) to:

a. Keep track of works integrity, grazing management, and vegetation condition and cover (Wilkinson et al., 2018)

b. Understand landholder perspectives about the project

c. Identify maintenance requirements

d. Take photo points to paint the site's 'story'.

Post-treatment monitoring has been successful in prompting landholders and project leaders to revisit sites, to check for failures in grazing management and structures. Un-treated 'control' sites have also been established where available and enable comparison of changes due to treatment and climate (Wilkinson et al., 2018).

Investments into monitoring programs such as the Burdekin Major Integrated Project Gully Maintenance and Monitoring ($500,000 over 2022-2025) has enabled learnings on the long-term effectiveness and maintenance of gully remediation works to be shared with groups undertaking similar on ground projects (Office of the Great Barrier Reef, 2024).

Ongoing monitoring and maintenance are crucial to the success of erosion management programs, and the effectiveness of treatment works at reducing sediment yield is dependent on the duration of site maintenance (Wilkinson et al., 2022). The effectiveness is higher if project oversight remains ongoing for many years after the conclusion of the installation of treatment works.

As such, similar approaches to monitoring and maintenance as described above should ideally be included in program design for erosion management programs across Australia, with funding allocated to ensure ongoing monitoring and adaptive management is carried out. This monitoring should be performed yearly for at least 2-3 years after installation of remediation works, and especially after major disturbance events like floods (Moore & Rutherford, 2017) (or after every Wet Season in the case of climates such as Northern Queensland). For programs which have limited funding, or where it is otherwise infeasible for local agencies to re-visit sites, landholders could be incentivised to perform simple photo monitoring themselves and provide the photos to agencies.

Key insight #5: Ongoing monitoring and maintenance (for at least 2-3 years post construction) is key to the success of erosion management programs. This should be included in programs with funding allocated, or where funding or resource constraints inhibit local agencies from re-visiting sites, landholders can be incentivised to perform simple monitoring themselves.

Conclusions

The impact of fine sediment liberated by gully and streambank erosion to the Great Barrier Reef, the world's largest and most diverse reef ecosystem, has resulted in significant investment in erosion control in the GBR catchment. The number of GBR gully and streambank remediation projects undertaken, the sizeable body of remediation research that has developed in parallel, and the increasing availability of ongoing monitoring data make this program an ideal candidate to mine insights into gully and streambank management that can be applied elsewhere in Australia. This paper has highlighted five key insights:

1. Apply a robust and quantitative process to identify sites that have the greatest potential for future erosion and sediment delivery (i.e. not just those that 'look' the worst), and use the ratio of required investment to expected benefit (e.g. reduction in sediment yield) to prioritise sites and evaluate cost-effectiveness of works.

2. Trial and monitor innovative remediation methods where possible, build on existing expertise and lessons learned from previous successful sites, and draw upon the knowledge of local landholders and technical specialists.

3. Provide landholders with meaningful opportunities to contribute to projects, ongoing access to information and assistance regarding best-practice land management practices, complementary incentives to support ongoing land management, and recognition/reward of high performers.

4. Revegetation is crucial in achieving long-term outcomes for land stabilisation and erosion control, and landholders need to be trained and supported to deal with issues regarding vegetation establishment, weed control, fencing, and grazing land management.

5. Ongoing monitoring and maintenance (for at least 2-3 years post construction) is key to the success of erosion management programs. This should be included in programs with funding allocated, or where funding or resource constraints inhibit local agencies from re-visiting sites, landholders can be incentivised to perform simple monitoring themselves.

These insights can be applied to aid the delivery of smaller, less well-resourced gully and streambank erosion management programs across Australia.

Acknowledgments

The author would like to acknowledge the support of NQ Dry Tropics in preparing this paper.

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