Sustainable Stream Management in North-East Queensland:

Stabilisation for Rehabilitation

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NATIONAL LANDCARE PROGRAM

Land & Water Resources Research & Development Corporation

How important are healthy streams?

The answer depends on how highly you value food, clean water, drainage, recreation, energy, fertile land, a pleasing landscape in which to live, communication and transport - because healthy streams (and in that we include rivers) contribute significantly to all of those.

Streams also provide food and habitat for animals and plants, assist in the cycling of nutrients and play a vital role in the conversion of carbon - the fundamental building block of all life.

Healthy streams are, therefore, VERY important. But, unless streams are protected and maintained, their quality declines.

Eroded bank and infestation with para grass in Ross River, Townsville

What can go wrong?

The problems that can beset streams are as numerous as the roles which they play. Many of the problems result from the pressure of human use, especially if that is not carefully planned. For example:

- dams built to store drinking water modify the flow regime and change the stream environment;
- clearing of riparian vegetation and uncontrolled stock access can contribute significantly to poor water quality;
- extraction of sand and gravel, the encroachment of agriculture, urban development and even recreation can lead to erosion, flooding, loss of instream habitat, sedimentation and reduced water quality;
- activities in the catchment, and diffuse and point-source pollution, can affect stream, estuarine and marine environments; and
- degradation of streams can result in damage to property, roads and bridges, loss of productive land, lowered amenity value, decreased ecotourism and loss of essential species.

Clearly, *all* of these problems have costly social, economic and environmental implications - and *all* are evident in north-east Queensland streams.

Overbank erosion from flood outflow on Haughton River near Giru

Why are the streams of north-east Queensland special?

The combination of climate, geology, ecology and landuse of north-east Queensland means that the streams of the region require special treatment, tailored to the often extreme natural conditions.

North-east Queensland has:

- **Some of the highest annual rainfall in Australia** - on average, more than 2,000mm of rain falls each year in many catchments in the region, with some receiving up to 4,000mm;
- **Marked annual and seasonal variability** - rainfall and streamflow patterns vary significantly between years and between seasons;
- **A regular threat of cyclones** - with highly damaging winds, heavy rainfall and major flooding;
- **Channel capacities which decrease downstream** - leading to overbank and distributary flood flows;
- **Floodplains consisting predominantly of alluvial deposits** - which allow streams to migrate and change their course relatively quickly through the landscape, and which are prone to bank slumping and scouring;
- **Large areas of high conservation value** - in particular the Wet Tropics Rainforest and Great Barrier Reef World Heritage Areas, which support diverse aquatic and terrestrial plant and animal communities; and
- **High dependence on agriculture and tourism/ecotourism** - both of which have the potential to impact strongly on, and benefit from, streams.

Bank erosion affecting sugar cane land on Mossman River near Mossman

Helping streams function well

Many of the problems associated with streams arise from their inherent instability - that is, their tendency to change over time. This tendency is often exacerbated by human use. Effective stream management aims for a sustainable compromise between natural stream functions - including instability - and human use.

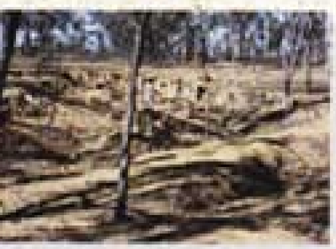
Historically, approaches to stream management have overlooked the naturally dynamic nature of streams and attempted to rigidly control them. Treatments were often based on techniques developed for conditions which differed greatly from those found in north-east Queensland, failing to take into consideration the range of factors which influence the behaviour of streams. In many cases they were ineffective - and in some they actually made worse the problems they attempted to solve.

Effective stabilisation and rehabilitation of streams require environmentally-sensitive approaches. In many cases, vegetation may be used successfully in combination with other techniques. Environmentally-sensitive approaches are based on working *with* the natural changes in a stream, not against them.

The broad framework for selecting and implementing appropriate treatments, and examples of some of the stream stabilisation work undertaken in the region are summarised in this brochure. For further details and examples, see *Stream Stabilisation for Rehabilitation in North-East Queensland*, published by the Land and Water Resources Research & Development Corporation, Canberra.

How problems can occur

Problems with streams occur when there is a conflict between the way streams naturally function and the way they are used by humans. Problems may arise from natural processes or they may be human-induced.



Indirect Pressure: Overgrazing leading to erosion and sedimentation

Problems can arise when:

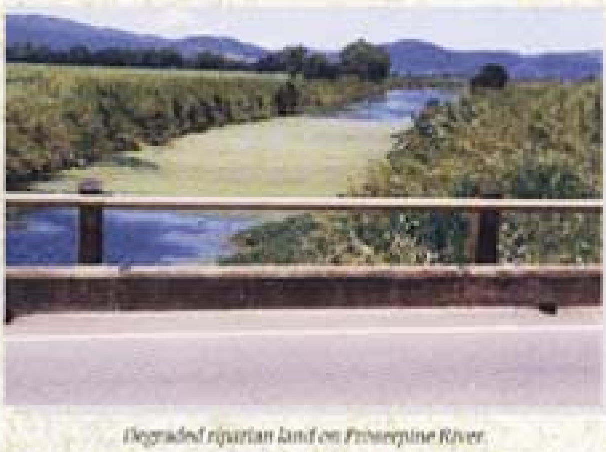
- **pressures applied by humans impinge on natural stream processes** (for example, when flow regulation for irrigation and water supply, increased sediment and nutrient runoff from agriculture in the catchment, or extraction of sand and gravel from stream beds alters the natural streamflow patterns, increases sediment loads in the water, changes the shape of the stream bed or banks, and degrades stream habitats);
- **natural stream processes affect human use of the stream and surrounding land** (for example, when floods, erosion, sediment transport and migration of the stream channel flood urban developments, erode agricultural land, clog pumps with sediment, and move streams away from bridges);
- **natural stream processes *combine with* human pressures to impinge on human uses of the streams and surrounding land** (for example, when flooding and erosion, accelerated by urban encroachment and catchment landuse change, affect water supply and road infrastructure).

Problems can arise from 'direct' pressures - that is, activities in or close to the stream - or 'indirect' pressures - that is, activities elsewhere in the catchment. Where the problems relate to direct pressures, a local response may suffice. Where the problems relate to indirect pressures, the response will need to be catchment-based.

Whatever the causes of the problem, the outcome can be severe environmental, social and economic damage. Understanding the cause is a large part of finding the right solution.

The types of problems arising from human pressures are listed on page 5. Examples of such problems in north-east Queensland are provided on page 6.

Direct Pressure: Urbanisation on the Ross River in Townsville



Degraded riparian land on Proserpine River.

The types of problems arising from human pressures - major relationships

Problem / Pressure	Flow Regulation, Water Storage and Diversion	Channelisation and River Works	Aggregate Extraction, Mining	Agriculture, Urban Development, Infrastructure	Recreation and Boating	Introduction of Feral Animals, Fish and Plants	Modification of Water and Sediment Flow	Pollution
Streambank and Streambed Instability								
Bank Scour		●		●	●		●	
Bank slumping				●				
Overbank erosion				●				
Bed erosion	●	●	●				●	
Sedimentation	●	●	●				●	
Habitat Degradation								
Riparian habitat degradation	●	●		●	●	●		●
Instream habitat degradation	●	●	●	●	●	●	●	●
Water Quality and Flow Regime								
Degraded water quality	●		●	●	●	●	●	●
Altered flood patterns	●						●	
Socio-economic Factors								
Loss of land and infrastructure				●		●	●	
Reduced recreational value	●		●	●		●	●	●
Reduced conservation value	●	●	●	●	●	●	●	●

Examples of stream problems in north-east Queensland

Problem	Examples
Bank Scour	Common on coastal floodplain streams from Daintree to Pioneer Rivers; particularly outside of bends where degraded riparian vegetation leaves banks unprotected.
Bank slumping	Common following flooding in larger streams such as the Burdekin, Herbert and Pioneer Rivers.
Overbank erosion	Common in streams with downstream-decreasing channel capacity and distributary flows (eg. Herbert, Haughton, Burdekin, Don and Proserpine Rivers).
Bed erosion	Uncommon on coastal floodplains, except at bridges and other structures; gully erosion in upland areas such as the Atherton Tableland.
Sedimentation	Common in lowland streams from the Daintree to Pioneer Rivers, particularly in the estuarine reaches; instream vegetation often grows and flooding is more severe. Sediment sources include roads, stock tracks, bare paddocks, urban developments and eroding banks.
Channel avulsion	Threat of major course changes in the Herbert, Haughton and Burdekin Rivers. Channel cutoffs are imminent on the Daintree, South Johnstone and Herbert Rivers.
Riparian habitat degradation	Ubiquitous on lowland streams from the Daintree to Pioneer Rivers. Streambanks are altered and riparian vegetation width and integrity is severely reduced. Main cause is clearing and stock grazing of streambanks.
Instream habitat degradation	Severe sedimentation and invasion of exotic grasses in many lowland streams. Bed morphology is affected by aggregate extraction in the Mulgrave and Gregory Rivers. Loss of habitat for in-shore fisheries.
Degraded water quality	Contaminants such as organic matter, biocides, heavy metals and nutrients may be introduced from urban, agricultural and industrial activities. Nutrient, sediment and chemical loadings are elevated in many lowland streams; concern about transfer of sediments and nutrients to the Great Barrier Reef.
Changes in the frequency, magnitude and duration of floods	Dams constructed on the Barron, Burdekin and Proserpine Rivers have altered downstream flood and flow regimes; concern about the effects on instream fauna and growth of vegetation in the stream.
Loss of/damage to land and infrastructure	Loss of agricultural land and crops, and damage to farm infrastructure common from the Daintree to Pioneer Rivers. Catchment clearing can lead to large changes in streamflow.
Reduced recreational value	Riparian and instream habitat degradation and degraded water quality reduce recreation values on most lowland streams from the Daintree River to the Pioneer River.
Reduced conservation value	Riparian and instream habitat degradation and degraded water quality reduce conservation values on most lowland streams from the Daintree River to the Pioneer River.

Finding the appropriate solution

The identification and implementation of appropriate solutions to stream problems requires:

- detailed understanding of the ways streams naturally function;
- awareness of the present and anticipated human use of the stream;
- appreciation of how pressures and treatments interact with natural functions;
- understanding of the cause(s) of the stream management problem; and
- clear definition of the management objectives.

Revegetation on Gleminson Creek near Malanda

Understanding the way in which a particular stream naturally works requires a knowledge of the size and shape of the catchment, the range of stream flows, stream channel characteristics and the ecology of the stream. Similar information is needed to understand what changes human intervention in the natural process are likely to bring about. It is only with such information that steps can be taken to limit the damaging impact of human activity on streams and to reap the benefits which come with natural stream functions.

Stream management strategies may include stabilisation, rehabilitation, catchment management and flood mitigation. This brochure and the accompanying reference publication, *Stream Stabilisation for Rehabilitation in North-East Queensland*, focus on stream stabilisation for rehabilitation, which includes:

- revegetation;
- alignment training;
- bank protection and stabilisation; and
- grade control.

These stream bank stabilisation measures will all benefit from the incorporation of vegetation and the rehabilitation of the physical and biological condition of the stream. In some cases, the use of vegetation will be effective on its own. Non-intervention can also be an appropriate option.

The following five phase/10-step process is recommended for developing appropriate solutions to stream management problems.

Pile groynes on the Mulgrave River

Project phases and steps

The concept phase

covers the steps from recognising that a problem exists to identifying likely solutions

It involves estimating the magnitude of the problem; identifying its impact on human activity, the natural and human-induced causes of the problem; and the short-listing of management options against selection criteria which reflect the desired outcomes.

The feasibility phase

involves working out which of the possible solutions is the best one for the specific site

The steps involve the theoretical testing of options,on the short-list and the selection of the one option, or combination of options, which best meets the selection criteria, values and constraints of the project. The use of native vegetation is likely to be a component of many, if not all, treatments.

The implementation phase

sees the solution being put into practice

Implementation involves the preparation of detailed designs of the treatment(s) as well as detailed plans about how the treatment is to be implemented (in terms of, for example, protection of the site during construction and/or replanting).

The monitoring and maintenance phase

involves checking that the treatment implemented is operating as expected

Inevitably, even the best-designed treatments will require maintenance (especially in the early stages) and monitoring for unforeseen outcomes. The tasks involved in this phase need to be detailed in the implementation plan and performed regularly so that any unwanted results can be identified and addressed quickly.

The review phase

assesses the overall success or failure of the treatment

Documenting the successes and failures of the project, what changes were made from the initial plan during the course of the project as a result of monitoring, and what would be done differently in future is valuable information for stream management practitioners, and should be made public for others.

Throughout the project, consultation with a range of experts and with stakeholders will be necessary in order to avoid further problems arising from the 'solution'.

Likely Suitability of Strategies and Treatments to meet Stream Management Objectives

Suitability relates to the treatment site. Offsite effects of treatments should be evaluated (eg. poorly planned rock revetment may transfer an erosion problem downstream).

Combinations of strategies and treatments will often be required to meet desired objectives for a site (eg. rock revetment and vegetation may be used in conjunction with a pile groyne structure). Vegetation should be considered as an adjunct to all treatments.

Objectives	Streambank Stabilisation Strategies/Treatments														Other Strategies			
	Revegetation	Alignment Training				Bank Protection and Stabilisation					Grade Control		Channel Modifications		Non-Intervention	Catchment Management	Stream Restoration	Flood Mitigation
		Rock Groyne	Pile Groyne	Retard	Embayment	Rock Revetment	Rigid Revetment	Bank Batter & Berms	Sub-surface Drain	Chute or Spillway	Bed Chute	Drop Struct	Clear & Desnag	Excav. Chann. & Cutoff				
Physical - Control Streambank & Streambed Stability																		
Streambank erosion	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●
Streambed erosion	●										●	●			●	●	●	●
Overbank erosion	●				●	●			●					●	●	●	●	
Sedimentation	●	●	●	●	●								●	●	●	●	●	
Channel avulsion	●					●	●			●					●	●	●	●
Ecological - Enhance Environmental Characteristics																		
Instream habitat	●	●	●	●	●				●	●	●				●	●	●	
Riparian habitat	●	●	●	●	●						●	●			●	●	●	
Water quality	●	●	●	●	●	●		●			●	●			●	●	●	●
Socio-economic - Enhance Human Utility																		
Waterway Conveyance													●	●	●	●	●	●
Protect land & utility	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Protect infrastructure	●	●	●	●	●	●	●		●		●	●				●	●	●
Recreation value	●														●	●	●	
Conservation value	●		●	●											●	●	●	

Case Study 1 - Herbert River Anabranch

The rehabilitation site on the Herbert River Anabranch is located in the Wet Tropics. Much of the native vegetation on the Herbert River floodplain has been cleared for the cultivation of sugarcane. A significant portion of the riparian forest has been cleared, leaving thin broken corridors, largely infested with exotic species.

Sections of the bank have failed due to slumping. Substantial seepage flows occur from the permeable strata at the base of the slumps during and after rainfall and flood events.

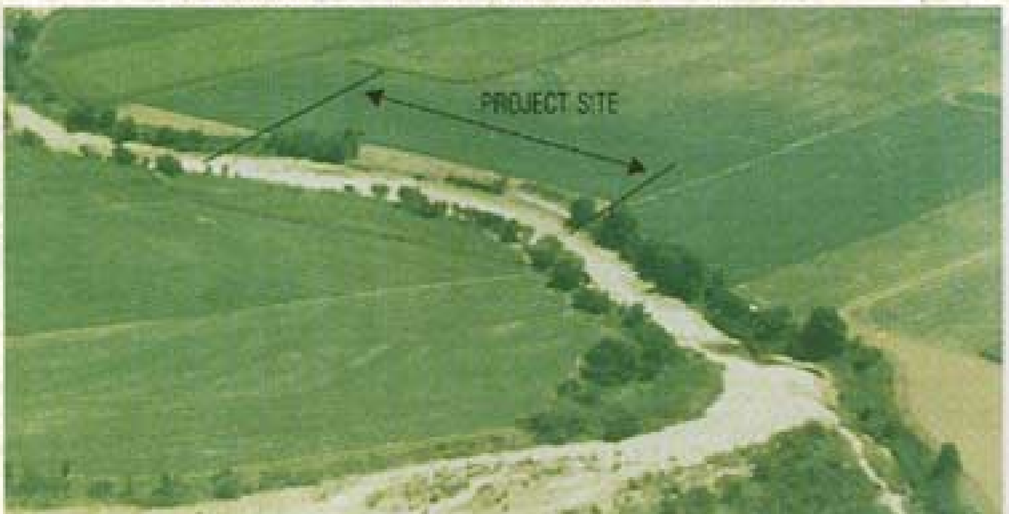
Remedial works were implemented at the site following bank failure in a flood in February 1994.

Trial stabilisation works: Treatment 1 in the foreground

Four different treatments were installed as trials for monitoring and demonstration over a 300 metre length of slumped bank. A section of relatively stable, untreated bank with some native vegetation was also retained. Each treatment included a 10 metre wide revegetated strip on the top of the bank where the landholder released the land from cultivation. The treatments were:

1. rock revetment, longitudinal subsurface drainage, bank battering and revegetation;
2. rock revetment and revegetation (rock placed from within the stream);
3. revegetation; and
4. lateral subsurface drainage (installed by directional drilling from the top of the bank).

The works have provided useful information on the relative costs and merits of various treatments. The conventional rock revetment and longitudinal subsurface drainage pipe can be used effectively with revegetation of the upper bank (Treatment 1). Rock revetment was successfully placed from within the stream to preserve the existing native vegetation on the bank (Treatment 2). The revegetation (Treatment 3) has performed satisfactorily to date. The lateral subsurface drainage pipe, although relatively expensive in this installation (Treatment 4), was very effective in removing subsurface water and may be a viable treatment for protecting infrastructure in steep sites, where access can only be readily obtained from the top of the bank. The monitoring data have assisted in an understanding of subsurface water responses to flood conditions, and in the modelling of streambank conditions. Collaboration with the landholder has enabled re-establishment of a reasonable riparian zone width at the site.



Aerial view of site: Herbert River in the foreground

Case Study II - O'Connell River

The rehabilitation site on the O'Connell River is located in the moist central coast region. Its floodplain has been extensively cleared for sugarcane farming, and cultivation often extends to the very edge of the streambank, destroying native riparian forest. Cattle grazing is common in the hinterland. Sand and gravel have been extracted from the river upstream of the site.

Rock revetment

The bank at the site has migrated up to 300 metres since 1935; a flood in 1991 eroded up to 60 metres of streambank, lowering the natural levee and threatening avulsion into the adjoining depression. Streambanks are subject to fluvial erosion and to slumping typical of tidally-influenced alluvial banks.

Remedial works at the site were implemented in 1996. An ecologically-sensitive approach was adopted, and treatment options that would protect the aquatic habitats as well as meet utilitarian requirements such as erosion protection, were favoured.

The remedial works were installed over 2,100 metres of eroded bank. A bank protection strategy using rock revetment was adopted for the upstream section, while alignment training retards were adopted for the more severely eroded downstream section. Vegetation establishment retards were used in conjunction with the rock revetment, with the aim of increasing flow resistance, encouraging sediment deposition, and enabling permanent vegetation growth. In addition to these functions, the alignment training retards were intended to shift the erosive currents away from the bank and reinstate instream habitat. Each component included a 20 metre wide revegetated riparian strip where landholders have released the land from cultivation.

A moderate flood in March 1997 caused little damage. The rehabilitation program has provided a useful demonstration of how various treatments can be integrated in an ecologically-sensitive manner. Collaboration with the landholders has enabled a reasonable riparian zone to be re-established at the site.

Aerial view of site. Bank erosion extending into cane land on right

Pointers to hassle-free projects

Problems are less likely to occur in projects when -

1. Landholders, community groups and government agencies are involved in identifying problems, setting objectives, and determining appropriate stabilisation and rehabilitation treatments.
2. A strategic approach, which attempts to address problems before they become severe, is taken.
3. Where necessary, multiple objectives, which incorporate ecological, aesthetic and cultural values, are adopted.
4. Intervention is combined with natural recovery. This approach is more likely to be effective than is either a policy of absolute control or a policy of abandonment to complete naturalness.
5. Hydrological, geomorphological, ecological and socio-economic factors are taken into account. This may involve seeking specialist advice to ensure that natural stream processes are considered, and that the causes, not merely the symptoms, of problems are addressed.
6. Any treatment implemented allows both human and ecological stream functions to be maintained in the long term.
7. Projects are planned and implemented in the light of both the site and the catchment, recognising the different influences and processes that occur at these different scales.
8. All involved in the project operate according to agreed environmental requirements and in accordance with health and safety requirements.

Further assistance

- ***Stream Stabilisation for Rehabilitation in North-East Queensland*, published by the Land and Water Resources Research & Development Corporation (LWRRDC), Canberra.**
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