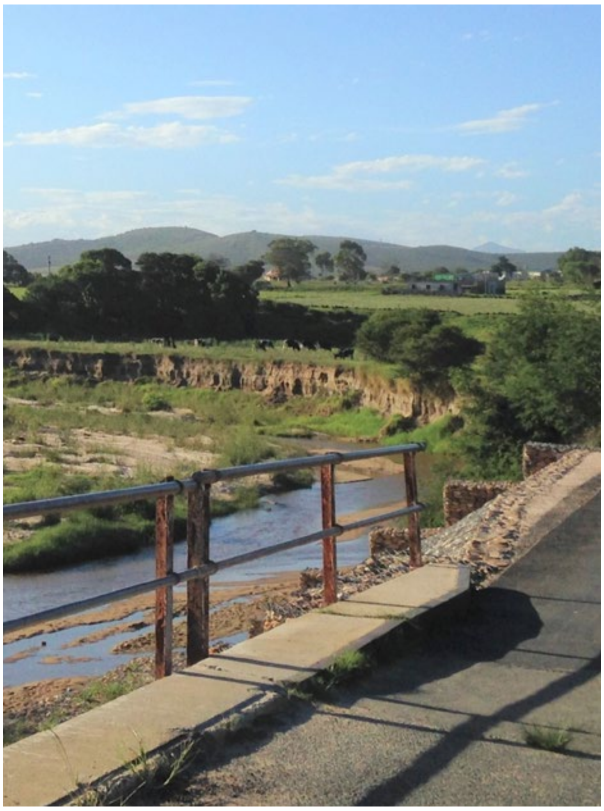
LET'S FIX OUR RIVERS!

A COMPANION SERIES TO THE WRC COMPREHENSIVE MANUAL FOR RIVER REHABILITATION IN SOUTH AFRICA




HANDBOOK 04

DEALING WITH RIVER EROSION IN SOUTH AFRICA

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WATER RESEARCH COMMISSION

SP 189/26

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EROSION AND HOW IT HAPPENS IN RIVERS

Since the earth was formed, soil erosion has been a major landscape-forming force, but this is a slow process and has happened over many, many years. This book is not intended as a guide to combat the erosion that has always taken place naturally, but rather as a guide to combat the erosion that has been accelerated by human impacts in the natural environment.

The process of soil erosion can be driven by water or wind. Several factors influence the erodibility of sediment by water. These include particle size and size distribution, the presence of organic matter, vegetation, and the chemical nature of the soil.

Common human activities that encourage soil erosion include:

- Increasing flow velocities through the unnatural concentration of water.
- Loosening and breaking-down of the soil structure by ploughing lands or bulldozing of rivers.
- Stripping of vegetation by overgrazing or trampling of vegetation by domesticated animals.
- Planting non-indigenous plants or trees on river banks (roots either overstabilise bank or do not have the ability to hold the soil).

1. **PARTICLE SIZE:** The larger the particle, the more energy (or flow velocity) required to move it. So, in rivers, small particles are washed away in small floods, but not the large rocks. During very high levels of flooding, even the big rocks may be moved.
2. **SOIL PARTICLE SIZE DISTRIBUTION:** Soils with a good particle size distribution form a tight matrix. Flowing water only has access to the sides of the particles on the outside of the matrix, and so the soil erodes less easily.
3. **ORGANIC MATTER:** Organic matter in the soil helps bind particles and reduces the potential for erosion (but not all rivers are naturally associated with organic deposits).
4. **VEGETATION:** Vegetation has two stabilising impacts on a soil. The roots of the vegetation reach out below the soil surface and bind clumps of earth and protect it from erosion. The foliage (leaves, branches, stems) disperses the energy of falling raindrops and flowing water and so protects the soil from erosion.
5. **CHEMICAL NATURE OF THE SOIL:** Sometimes chemical compounds in the soil (e.g. gypsum) cement the soil particles together, while with other soils the soil particles repel each other when in the presence of water (dispersive clays).

Carbonate collecting in the soil creates the hardpan layer (seen in the bottom of the gulley in the image to the far left), while electrostatic charges due to salts in the soil cause the soil particles to repel each other when wet, i.e., the soil displays the tendency to be dispersive (seen in the image left).

The large rocks packed along the river bank in this image are only moved by extremely fast flowing water.

Woody alien plants (such as the Black Wattle above left) disturb a large area of soil when they get blown over, exposing it to erosion. Indigenous wetland vegetation such as Palmiet reed (*Prionium serratum*), shown as drying out in the photo, have long fibrous roots which bind the soil together, even when the plant foliage is shredded by extreme flood flows.

The woody alien vegetation, when upright, traps all sorts of debris during floods. This creates an obstruction in the watercourse that can result in erosion. Indigenous wetland vegetation tends to be flexible and to lie flat during floods, protecting the soil from erosion, and not creating a blockage.

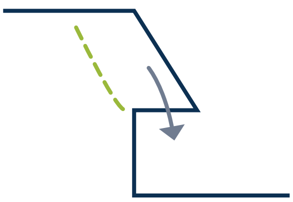
CAUSES OF RIVER BANK EROSION

The factors resulting in unnatural and accelerated soil erosion are either related to the increase of flow velocity, or the diminished resilience of soil to erosion because the natural vegetation has been removed. With regard to river bank erosion, the most significant factors are usually combinations of:-

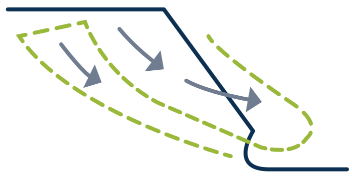
- The increase in river flow velocities during floods because of the deepening and narrowing of river channels to make space for farming or urban developments or because of increased flows from catchment hardening;
- Obstructions in rivers (e.g. tree stumps), and inappropriately sharp bends in rivers created to make way for the development of infrastructure in the riparian area or on property boundaries;
- The modification (or hardening) of catchments, sometimes leading to greatly increased storm flow rates, and then also flow velocities and soil erosion;
- The replacement of indigenous wetland vegetation with woody alien vegetation that does not lie flat during floods and diverts the flow of water towards one or the other riverbank, or when washed out, leaves large sections of soil without plant cover;
- The unnaturally increased sediment loads in rivers which are due to impacts from upstream land or riverbank erosion. These sediments accumulate and lead to higher flood levels as well as the formation of sediment islands which deflect the flow of water into the riverbank and may also attract alien vegetation, worsening the problem;
- The inappropriate design of cross channel structures such as roads and bridges, or infrastructure within the floodplain (e.g. roads, tracks).

The way a river bank erodes is governed by various factors, amongst which the channel form and bank soil characteristics play a significant role. Generally, the erosion of the riverbank begins with the loosening and removal of the toe (base point) of the bank which then destabilizes the rest of the riverbank above. The bank above either slides or topples into the void left by the eroded toe and the process then repeats itself **(see the WRC River Rehabilitation Manual, Volume 1, Chapter 3)**.

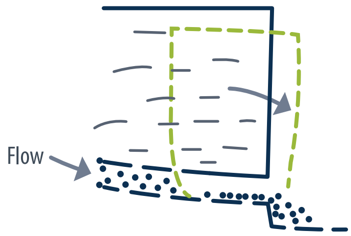
The undermining of the riverbank (to the left) has been driven by the stand of alien trees colonising the sediment on the opposite bank (to the right), deflecting the flow of the river. This has led to the collapse of the riverbank.



The high and steep riverbank is unstable and slips into the river below.



Peat soils commonly have highly permeable layers of river gravel and stone beneath them, or sometimes transecting them. Once an edge of the peat is exposed by erosion, subterranean water pressure releases via the gravel layer and washes it out at the exposed face. Once this happens the block of peat above breaks off and the face of the erosion advances uphill.



In arid areas like the Karoo, an unusual form of erosion occurs. Once small gulleys form in the landscape, they prevent the ponding of water on the soil when it rains. As the soil is hydrophobic, with no ponding of water, no water penetrates the soil, and the plants die back. Once the plants have gone, the rate of erosion increases and the gulleys become larger. This leads to the formation of 'bare patches' and associated river bank erosion.

ADDRESSING RIVER BANK EROSION

The three most important guiding principles for combatting river bank erosion are:

- Provide for wider and slower flowing rivers.
- Remove alien vegetation from the riparian zone.
- Address upstream sources of sediment being released unnaturally into the river, as these frequently contribute to the tendency for downstream bank erosion.

River bank erosion techniques can be either "indirect" or "direct". The indirect techniques involve doing something remote to the actual site to stop the erosion. These measures could include removing alien vegetation, removing sandbars, or constructing groyne structures with vegetation planted in-between. Direct techniques include river bank reshaping and armouring with a variety of products ranging from natural vegetation, to concrete blocks, rock riprap, and concrete or gabion longitudinal structures. These options all have their own benefits and disadvantages. Sustainability, economy, and environmental acceptability are factors that must always be considered when choosing between the options. The advice of someone with experience in using different techniques is invaluable when making this decision.

Volume 2, Chapter 4 of the WRC River Rehabilitation Manual gives a detailed description of alternative strategies that may be employed to control bank erosion, and discusses their relative merits.

INDIRECT APPROACH

The alien vegetation (to the right) is deflecting the flow of water into the riverbank on the left, undermining the toe and making the riverbank unstable. A practical solution would be to clear the alien vegetation, and perhaps fill the eroded riverbank with surplus soil that has accumulated around the alien trees, and then to establish indigenous wetland vegetation along the toe area.

INDIRECT APPROACH

Groyne structures have been installed here to guide water around a bend in a river and protect the river bank from erosion **(see page 18).**

Should structural interventions be chosen, they need to be planned by an experienced professional to make sure that the structure can withstand reasonably expected floods, fulfils expectations of durability, does not create a situation that initiates fresh erosion elsewhere, and as far as possible allows for ecological connectivity (movement of fauna up and along river banks).

DIRECT APPROACH
Concrete blockwork retaining wall protecting river bank from erosion. This solution is usually only appropriate where the river channel is confined in urban areas. The structure allows for very limited planting.

DIRECT APPROACH
A gabion retaining wall protecting the river bank from erosion downstream of a road culvert.

DIRECT APPROACH
Rock riprap protecting the riverbank from erosion downstream of a road culvert. This protects the bank but provides little opportunity for planting, so making for an ecologically sterile riparian section, unless efforts are made to include top soils with the riprap **(see Handbook 9, Case Study 4).**

CAUSES OF RIVER BED EROSION

As with riverbank erosion, the artificial incision of river channels also involves increased flow velocities but by a different mechanism. When water falls over a head-cut (that is the top end of the gulley where erosion is very active), it accelerates and its erosive power increases, usually causing further erosion of the head-cut. When rivers are forced to flow in artificially narrow and deep channels, the flow velocity increases and so the erosive power of the water and the ability of the water to transport sediment also increases. The deeper the channel incises, the more water is trapped in the channel instead of being allowed to overflow into the floodplain. This water has increasing erosive power and perpetuates the cycle of channel incision.

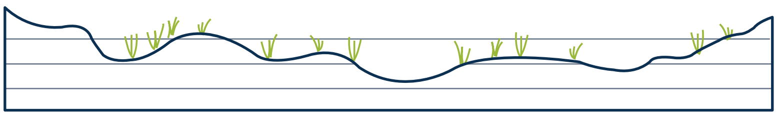
The pre-existing balance between sediment brought down the river and that leaving the site thus alters, and the river bed drops in response to this. The condensing of multi-channel (or braided) streams into narrow and deep single channels is one example of this. The presence of woody alien vegetation on river banks effectively also reduces a river's flow width and causes the river to incise.

Chapter 5 (Volume 2) of the WRC River Rehabilitation Manual provides a detailed description of alternative strategies that may be employed to control river bed incision, and their relative merits.

Karoo gulley incision frequently gets slowed down temporarily when harder soil layers are experienced.

WIDE FLOW AREA

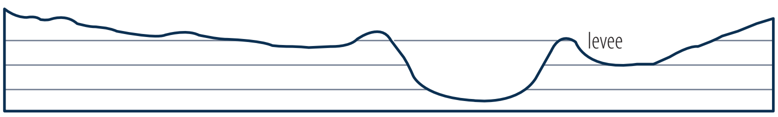
High surface roughness → Low flow velocity



NATURAL STATE RIVER PLUS WETLAND

NARROW AND DEEP CHANNEL

Low surface roughness → High flow velocity



CONDENSED RIVER WITH INCISED CHANNEL

CONDENSED RIVER
A long-since condensed river (probably condensed by farmers expanding their vineyards into the river channel) can scarcely accommodate the 1 in 10-year flood. The shape of the river channel (deep and narrow) results in abnormally high flow velocities and regular erosion of the river bed.

Little Karoo gulley incision, probably because of the ground having been ploughed some time ago. In this arid ecoregion, erosion is difficult to address. Plant growth is very slow, and incision and loss of soil is permanent.

Erosion in dispersive soil – this deep, wide gulley formed in 3 years once the original gulley penetrated through the top 500 mm of stable transported soil. This highlights the need to act fast to address erosion before it progresses.

In peat valley-bottom wetlands, once the gravel layer beneath the peat is exposed by channel incision, erosion can progress quickly. This gulley, caused by failure of a small dam and encroachment of alien vegetation, resulted in head-cut formation and took just 9 years to form.

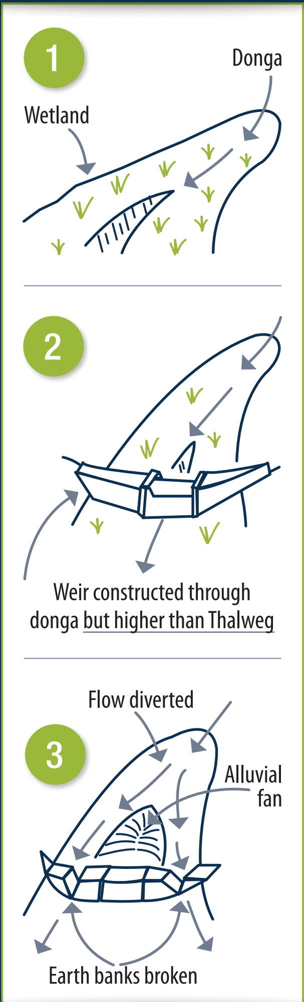
ADDRESSING RIVER BED EROSION

In practice, most river bed incision problems get addressed by the construction of weirs to restore the river bed to its original level. There are however various other techniques, such as the use of precast concrete paving blocks; riprap (large rocks installed in the river bed) to increase channel roughness; and erosion-resistant in-channel vegetation. The diagram "Options to reduce flood risks at a site" from the Rehabilitation Manual **(reproduced on page 22)** provides ratings of several different options, from most ecologically desirable to least. The applicability of all these options should always be related to the actual site, its up- and downstream conditions, and its own conditions, opportunities, and constraints.

Chapter 5 (Volume 2) of the WRC River Rehabilitation Manual provides a detailed description of alternative strategies that may be employed to control riverbed incision and their relative merits.

River incision can be controlled with the placing of large rocks to create flow resistance and slow down the flow velocity of the river **(see Handbook 9, Case Study 2).**

River incision can also be controlled with a concrete lined canal. These are very expensive to construct, separate river flows from groundwater and do not support ecological processes or biodiversity. Today the tendency is for these structures to be replaced with more environmentally acceptable solutions, where space permits.



Schematic showing that when the flow capacity of a weir is less than the flow experienced, or when the spillway is too high relative to the surrounding landscape, there is a great danger that water will create a flow path around the structure and the intervention will fail.

Fish ladders are a very important consideration when constructing weirs in a river where fish need to migrate upstream to spawn. Note though that not all rivers support fish that need to migrate upstream, and that in some rivers, barriers to upstream migration are useful controls of alien fish such as bass. Consulting a fish specialist or checking on the National Freshwater Ecosystem Priority Areas (NFEPA) data for catchments of concern from a fish conservation perspective is essential.

A gabion weir to halt the formation of a gulley in a wetland.

Concrete erosion control weirs in the Karoo are not only installed to prevent river bed incision, but in doing so they prevent the migration of side gulleys into the veld. These side gulleys would in turn lead to the drying out of the soil, vegetation die-back and the formation of 'bare patches'. This process commonly causes the degradation of large areas of the Karoo.

THE IMPACTS OF RIVER BANK AND BED EROSION

Human-induced erosion in rivers is a major issue affecting not only the river environment, but also infrastructure and landuse in adjacent areas. This erosion has both direct (at-site) and indirect (off-site) impacts on the environment. The indirect impacts are seldom understood, let alone quantified. This makes it difficult for authorities and other organisations that could assist in addressing the problem, as they often see less value participating in addressing the primary erosion issue, and do not understand the downstream and indeed catchment-level impacts.

FOOD FOR THOUGHT

Although the erosion of the river bank in the image of off-site erosion **(see Image 3, below)** is "secondary erosion," resulting in part from the erosion in Image 1, what happened to all the soil that was washed out of the 11 m high bank?

Could it have contributed to the further erosion of riverbanks downstream?

1. On site damage – a gulley 600 m long, 50–100 m wide, and 6 m deep in what was a natural wetland, resulting from a drainage ditch dug between the wetland and a new citrus orchard. This damage happened in 3 major floods over 20 years. The ditch created a path along which the whole wetland drained. The concentration of all the water along this line resulted in abnormally high flow velocities and consequent soil erosion.

2. For several years it was common to find huge chunks of peat, washed out from the wetland upstream, forming blockages in the river channel.

3. Off-site damage – one such blockage caused by the deposition of river boulders and other sediment in the river channel 1 km downstream from the erosion in image 1, deflected the flow into the riverbank where a road had been for many years. This erosion took 4 years to completely undermine the road.

THE DIFFERENCE BETWEEN ON-SITE AND OFF-SITE DAMAGE (DIRECT AND INDIRECT DAMAGE): The direct impact is the damage at the site where erosion is seen initially. The indirect impact refers to the additional erosion downstream which occurs because of blockages in the river arising from sediment released by the initial erosion.

Direct (on-site) damage to infrastructure can be sudden, and devastating.
The photo above also shows why developments and infrastructure need to be set well back from river floodplains, to allow space for flood processes.

The on-site damage to the environment can also be sudden. The erosion of the wetland shown on the left was initiated by a poorly constructed road crossing, further downstream. The road changed the gradient of the channel, making it steeper and initiating a headcut. The headcut worked its way upstream. Today very little of the peat soil remains as it has all been washed away. The gully drains water from the surrounding wetland, drying it out and making the peat vulnerable to fires that can burn underground for years.

Surface erosion of cultivated lands – this soil eventually ends up in rivers, causing blockages and secondary erosion, and may silt up dams. Many rivers draining water from communal lands (where overgrazing is often problematic) are known to have abnormally high sediment loads for the same reason.

The erosion on the lands could be reduced by improved land use management practices (such as minimum tillage of cultivated lands or reducing the stocking rate on natural grazing). Alternatively, measures could be implemented in the river to reduce the transport of sediment. Ideally the problem must be addressed at its source (i.e. the erosion must be stopped on the land).

BEST PRACTICE FOR CONSTRUCTION IN RIVERS AND WETLANDS

Any developments or remedial actions in the river channel (in this case, addressing river erosion), can require extensive earthworks in the river. It is important that best practice measures are applied, to prevent additional impacts and erosion.

IMPORTANT ENVIRONMENTAL CONSIDERATIONS FOR PROJECT PLANNING

It is important that the following considerations be addressed:–

- Wherever possible plan for construction during the dry season, but have contingency plans in place for unexpected high flows.
- Make sure that you have the right legal authorisations for what you need to do – **refer to Chapter 8 of Volume 1 of the WRC River Rehabilitation Manua**l and consult local DWS, DFFE and municipal officials or Environmental Assessment Practitioners.
- As per protocol, a construction environmental method statement must be agreed on before the work can begin. The objective of this is to ensure that there is minimal harm to the environment during construction. Plan activities around the seasons – **refer to Handbook 1** for planning methods.
- Decide on which alien vegetation can and should be removed, and how.
- Rescue indigenous plants, nursery them where feasible, and start propagation at the required scale – or appoint someone to do this **(see Handbook 3 and Chapter 12 of Volume 2 of the WRC River Rehabilitation Manual).**
- Remove alien vegetation from the river or wetland. Specifically alien vegetation like Spanish Reed (*Arundo donax*) must be treated with herbicide timeously before any earthworks takes place, otherwise the roots will be distributed and grow new plants (contact a specialist in this regard). Due to concerns about herbicides in river and wetland environments, herbicides must however generally only be used with great caution and ideally avoided. Specialist advice should be sought.
- The execution of the project should start from the upstream end and progress downstream, so that the work can be completed in stages and handed over to the rehabilitation contractor who can immediately (if the season permits) begin replanting vegetation.
- Plan and agree on temporary site diversion/drainage channels ahead of time – make sure that the width and slope of channels is such that the river does not unnecessarily wash loose sediment downstream.
- The contractor must be compelled to minimise contaminants entering the watercourse. Pumps and similar equipment must have drip trays to prevent oil and fuel leaking into the river. The topping-up of machinery with diesel must be done at a safe distance away from the river.
- Litter bins must be placed within easy access of all work areas, and especially when gabion baskets are used, wire cuttings must be collected and disposed of daily.
- Before any plant moves onto site, demarcate all 'NO GO' areas with tape or brightly coloured bunting and vigorously enforce the importance of this boundary with contractor and personnel.

Safety barriers around deep excavations are essential.

The stabilization of this stretch of river was successful because special care was taken to rescue, propagate and restore the vegetation.

Establishing vegetation in wetland and river rehabilitation projects can be an ideal employment creation and training opportunity.

BANK EROSION CASE STUDY – REHABILITATION USING GROYNES

1 This 2016 image shows how alien vegetation (on the left bank in the image of the Brandwacht River near Mossel Bay) was largely responsible for driving the river into the opposite bank (to the right in the image). The public road (which may also have contributed to changes in flow) was in serious danger of being washed away by the next flood. The use of groynes was decided on to address this erosion.

2 The rehabilitation solution being implemented: The extent of construction damage while implementing these projects can be disturbing, and calls for careful planning and strict environmental controls.

LESSONS LEARNED FROM THIS PROJECT

- Do not allow alien vegetation to get established in a river – it causes immense damage.
- Long low groyne structures such as those used in this project are very effective in controlling the flow direction of the water while still allowing the redevelopment of the margins of the river as a wetland.
- During construction, it is common to be discouraged by the extent of the construction damage - but as seen in the case study, it is clearly worthwhile.

3 Post rehabilitation, the groyne structures guide the fast flowing water in the channel towards the bridge (which crosses the river), while still allowing floods to occupy the full floodplain.

4 A field of groyne structures successfully guiding the river to the bridge and preventing migration of the channel and further erosion.

FOOD FOR THOUGHT

How effectively could this project have been executed using alternative construction materials and techniques while considering issues of project cost, the potential for rehabilitating the natural environment, and resilience to withstand larger than expected floods?

- Concrete retaining wall
- Gabion retaining wall
- Rock riprap
- Precast concrete blocks

All of these could have been applied but with high ecological and construction costs. Options that require bank and channel lining should be seen as a last resort. An alternative with lower construction costs, much greater opportunity for wetland rehabilitation is obviously more attractive.

RIVER BED EROSION CASE STUDY – REHABILITATION USING WEIRS

1. The erosion started in 2003 when a small dam downstream of the wetland collapsed. No funding was available at that time to repair the damage, and it was not foreseen that the gulley would spread so quickly (600 m in 9 years).

2. The top of the gulley in 2011 – it was still to extend by 100 m before construction could begin. Just before construction began, the gulley was 600 m long and 13 m deep at the deepest point. Water passing down the gulley fell 21 m in total.

LESSONS LEARNED FROM THIS PROJECT

The main lesson learned from this project was that timeous interventions for initially relatively insignificant soil erosion sites are really important. Once soil has been lost to agriculture and to the environment, it cannot be replaced.

3 The same area in 2017, one year after construction. The channel width and slope was designed to be non-eroding during the 1:50 year flood. The sides of the gulley had to be collapsed to create a side slope suitable for revegetation.

The WRC's NatSilt Programme aims at reducing the accumulation of sediment in water storage dams. Its objectives include capacitating communities on how they can play a role in preventing land degradation and dam siltation **(https://natsilt.wrc.org.za/projects/).**

2015
BEFORE INTERVENTION

2017
AFTER INTERVENTION – The ecosystem is permanently altered but stabilised

FOOD FOR THOUGHT

- About 150 000 m^3 of soil washed out from this site over 9 years. A lot of that load would have been deposited downstream on the way to the sea. How much more erosion was caused by those deposited islands of sediment? What was the total damage (on-site as well as off-site) as a result of this disaster?
- Peat wetlands such as those affected here store water in the rainy season which gets released in the drier months – to what extent has the damage to this wetland impacted on the flow of the river downstream?

SOFT OPTIONS FOR ADDRESSING SOIL EROSION IN RIVERS

SOFT OPTIONS INCLUDE –

- Removing alien vegetation along river channels and within riparian and floodplain areas
- Landscaping (bank re-shaping) and revegetating
- Using vegetation in tandem with engineered materials in a way that the material provides temporary support to the soil and vegetation while the vegetation gets established.

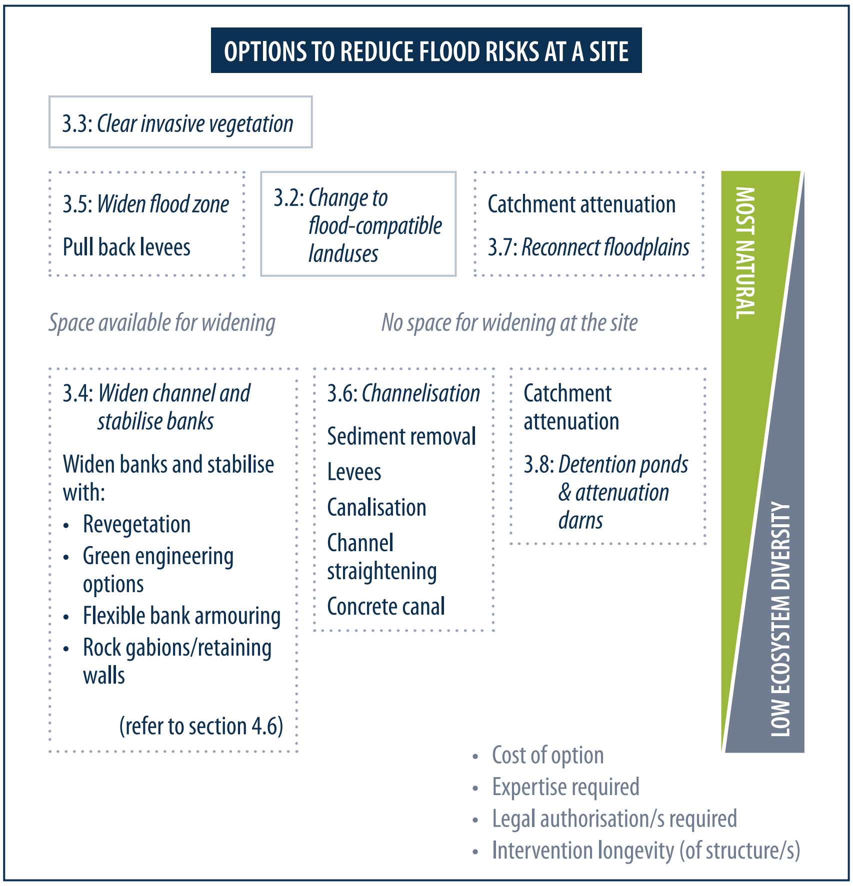
Soft options for erosion control are "non-engineered options" that, depending on the nature and extent of erosion, are often easy and cheap to implement, but do not necessarily always offer the long-term durability of "engineered structures". Soft options may well need a lot of maintenance, or be replaced, after severe rain storms. Soft options are most successful when followed up with intense planting of indigenous wetland and riparian vegetation.

Soft options should always be considered before hard-engineered options. If they are feasible, soft options are usually a cheaper alternative to hard engineered structures, and they often have other ecological, aesthetic, amenity and socio-economic environmental benefits as well.

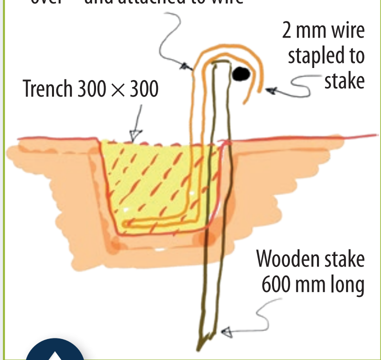
As with all erosion control interventions, it is important to be certain of what is driving erosion before trying to remedy it.

Chapter 5 of Volume 2 of the WRC River Rehabilitation Manual provides a detailed description of alternative strategies that may be employed to control river bed incision and bank erosion and their relative merits.

The logging of unstable slopes can be a means of flattening the slope so that vegetation may be established.



This graphic from the Volume 2, Chapter 3 of the WRC River Rehabilitation Manual presents different options for remedying river erosion and rates them according to their desirability.



Placing silt nets on the contour can prevent the formation of rills while vegetation gets a chance to get established. The left image shows the silt net being installed 'on the contour' (with a good portion of the net buried to prevent failure by tunnelling – see image above), the image to the right shows the same slope 2 years later.

A landscaped channel in soft and disturbed peat soil lined with a geo-web during construction, filled with gravel (upper left image). This was planted with indigenous wetland plants and two years later, despite several severe storms, was looking very stable. The cost of this operation was about a tenth of the cost of an additional weir, which would have been an alternative engineered structural solution to the problem.

RIVER BANK AND BED STABILIZATION – WHAT NOT TO DO

There are many interventions that are carried out to prevent soil erosion and river degradation, and undertaken with the best of intentions, but can end in disaster. They are illustrated here to warn the reader of the consequence of these in-appropriate actions.

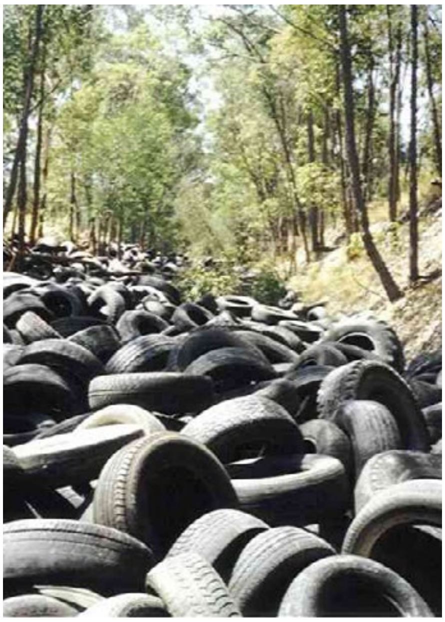
Do not develop infrastructure and permanent crops too close to rivers – give rivers space to do what happens naturally.

Permanent structures should only be erected outside of the 1:100 year floodline (or further away to cater for the impacts of climate change and allow for ecological buffering). Even if the river seems small and distant most of the time, remember that at times it will flood.

Alien vegetation grows tall quickly and out-competes indigenous wetland vegetation for sunlight – so displacing the indigenous vegetation. Changing the indigenous vegetation in favour of alien plant growth may result in river blockages, erosion and high costs to repair the damage.

Do not remove indigenous wetland and riparian vegetation – apart from legal consequences, you will find that without the vegetation the river becomes unstable and will cost you money to fix.

Bulldozing a river 'open' may give you short term relief from flooding, but the loosened sediment will be washed downstream where it will cause the erosion of your neighbour's river banks when it forms plugs in the river. Bulldozing the river also creates an ideal habitat for woody alien vegetation to get established – and this may cause river erosion problems.




Filling a gulley with old car tyres or old tree stumps may make you feel that you have addressed the problem of erosion. You have not! Water flows around the tyres and will widen the gulley. Also, the tyres and stumps may well wash downstream in a large flood, and cause further damage, as well as degrade into undesirable by-products that remain in the environment for a long time.


When you need to manage erosion, whether with a structure such as a gabion retaining wall or a groyne, or just by clearing the channel of debris and landscaping in terms of a Management and Maintenance Program (MMP), you are well advised to get the opinion of someone with appropriate experience. The gabion wall (on the far left) has been undermined and will result in further erosion. The stormwater channel (to the left) has been poorly located and is causing erosion. Both of these need further expensive rehabilitation.

Dumping orchard cuttings on a river bank will not solve erosion problems, because during a big flood they will wash away. When that happens, they will become someone else's problem, causing a blockage in the river, and more erosion. Rather consider planting the bank with indigenous vegetation that will slow down flows, bind soils and trap sediment. You can also secure commercially available 'coir-logs' to a terraced bank and plant between these.

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LINKS TO THE WRC RIVER REHABILITATION MANUAL

- **VOLUME 1:**
  - **Chapter 4:** What is rehabilitation?
  - **Chapter 5:** Assessing the site
  - **Chapter 6:** Planning a rehabilitation activity?
  - **Chapter 7:** Options for rehabilitation
  - **Appendix 1:** Legislative requirements for river rehabilitation in South Africa

- **VOLUME 3:** Rehabilitation case studies
  - **Chapter 4:** Managing eroding banks (Lateral Erosion)
  - **Chapter 5:** Managing river downcutting (Incision) and Gulleys

LINKS TO THIS SERIES

- **HANDBOOKS 3–8** for ideas on how to address issues
- **HANDBOOK 2** for a discussion on how to assess your river and understand its drivers and cause of the problem
- **HANDBOOK 9** for case studies

GLOSSARY OF TERMS

Base Flow	The long-term flow in a river that continues after storm flow has passed.
Catchment	The upstream land area contributing to runoff at a particular point in a river system.
Floodplain	A relatively level alluvial (sand or gravel) area lying adjacent to the river channel, which has been built up over time by the watercourse depositing alluvial (water-transported) sediments.
Groyne structure	A finger-like structure protruding into a river from an eroded riverbank, which reduces bank erosion by deflecting the flow of water away from the bank
Habitat	The natural home of species of plants or animals.
Hydrology	The study of the occurrence, distribution, and movement of water over, on and under the land surface.
Peat wetland	A peat soil is a dark brown or black organic soil layer, composed of partly decomposed plant matter (in South Africa, a minimum of 20% organic carbon), and formed under permanently saturated conditions. Peat wetlands are a distinctive wetland type characterized by the presence of peat soil.
Rehabilitation	An intervention that promotes the recovery of ecosystem functions and values in a degraded system to regain some of the ecological and other values the system provided in its natural pre-impact state.
Riparian	A riparian zone is that area that is transitional between the aquatic area and the terrestrial area. Vegetation is expected to change from species adapted to wetter sites near the channel to species adapted to drier sites in the terrestrial zone, with a mixture of species occurring in between.
Runoff	Surface runoff from rainfall which can then enter the stream channel network.

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HANDBOOK 01 Planning a river rehabilitation project: What you need to know to get started

HANDBOOK 02 Understanding South African Rivers

HANDBOOK 03 Rewilding rivers: the role of habitat, plants and animals in river rehabilitation

HANDBOOK 04 Dealing with river erosion in South Africa

HANDBOOK 05 Responding to sediment problems in South African rivers

HANDBOOK 06 Addressing changes in river channel, floodplain and wetland form

HANDBOOK 07 Responding to changes in water quality and flow in urban, farming and rural environments

HANDBOOK 08 Infrastructure in and near rivers (fences, pipelines, bridges, culverts and other crossings)

HANDBOOK 09 River rehabilitation case studies

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