

LET'S FIX OUR RIVERS!

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

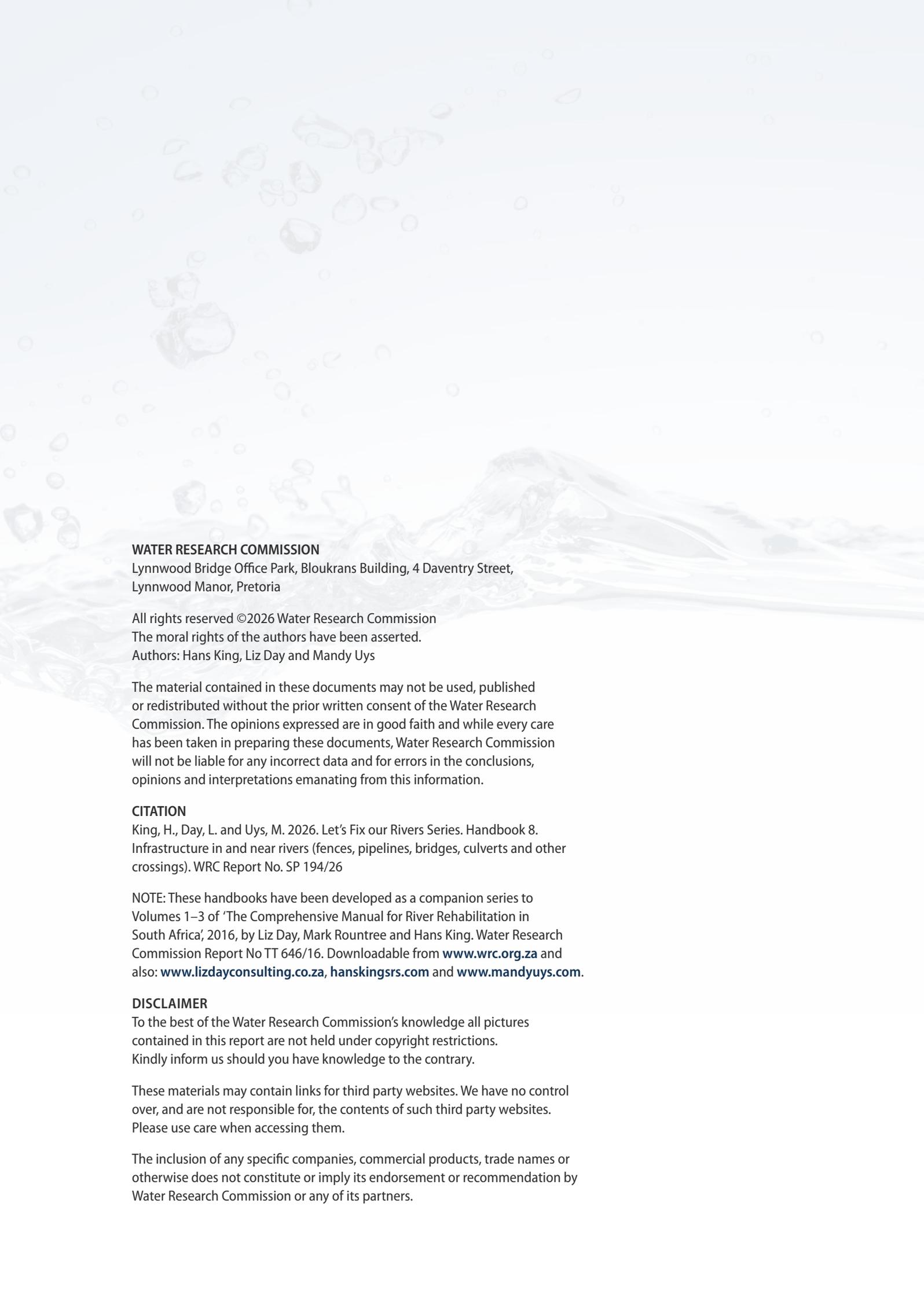


INFRASTRUCTURE IN AND NEAR RIVERS (fences, pipelines, bridges, culverts and other crossings)

Hans King • Liz Day • Mandy Uys

HANDBOOK

08

A decorative background featuring a large, dynamic splash of water at the bottom, with numerous smaller, translucent water droplets scattered throughout the upper and middle sections of the page. The overall aesthetic is clean and fresh, emphasizing water.

WATER RESEARCH COMMISSION

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WHAT IS THE PROBLEM?



The increasing magnitude of storms in many areas as a result of climate change, coupled with loss of resilience of many river systems, means that infrastructure near rivers is increasingly vulnerable to damage.

The poor management of alien vegetation frequently leads to the damage of public infrastructure during floods.

Many rivers are treated like drainage ditches, as though the primary reason for their existence is removing surplus water from the landscape. The value of the river as a resource, and an integral part of the landscape and environment is ignored.

It is very difficult to propose a sustainable and environmentally appropriate solution for the river in the image opposite, where the ten year flood is scarcely contained in the channel, and larger floods will result in damage to crops and loss of soil.

Where stormwater is managed inappropriately, this can lead to un-natural sediment loads in rivers, potentially changing floodpaths.

In the past, infrastructure in and along rivers was planned with relatively little concern for the environment. This was partly due to budgetary constraints, but probably more likely due to an inadequate understanding of how natural systems worked, and the costs associated with the repair of these systems once damaged. The lack of management of alien vegetation along rivers, and the environmental and other damage resulting from it, is a prime example.

Some infrastructure also impacts on habitat connectivity along watercourses, by impeding the movement of fish and other biota in the channel and along riparian corridors.





Minor structures like culverts and pipelines are often constructed across rivers in ways which are unsustainable and when they fail they contribute to environmental degradation.



Urban development in the photo opposite has been located where it is obvious that it will be unsustainable.



Public infrastructure is often located too close to rivers, resulting in eventual great maintenance costs.



Many bridges are placed where their position and orientation will lead to environmental degradation.

For example, the bridge crossing on the river bend in the photo opposite is highly undesirable – a location crossing a straight stretch of river would have resulted in less erosion and risk to infrastructure.



DAMS AND WATER EXTRACTION FACILITIES



COST OF DAM SPILLWAYS

The cost of a sustainably constructed spillway is often half the cost of the construction of a dam.

Often farmers will ignore constructing a spillway or construct an inappropriately small spillway with the belief that “large floods are never experienced here”, to save costs, only to regret it later.

Spillways must be sized according to reasonably expected floods – at least the 1 in 50-year flood (taking global warming into account as well). The spillways of dams which pose a potential safety risk to people downstream (when there are people living in the valley or public roads traversing the valley) need to be designed for an even greater return period, depending on the perceived risk.

Dams and water extraction facilities create ponds of water upstream of the wall at a level higher than that of the river. As water is released back into the river, it accelerates, because of this elevation difference. If due care is not taken, the water will cause erosion of the soil over which it flows. This erosion can lead to degradation of the river downstream, and possibly undermine the spillway structure itself. When available, a location for the spillway where a rock foundation is available is thus often chosen to provide a safe spillway, with less cost.



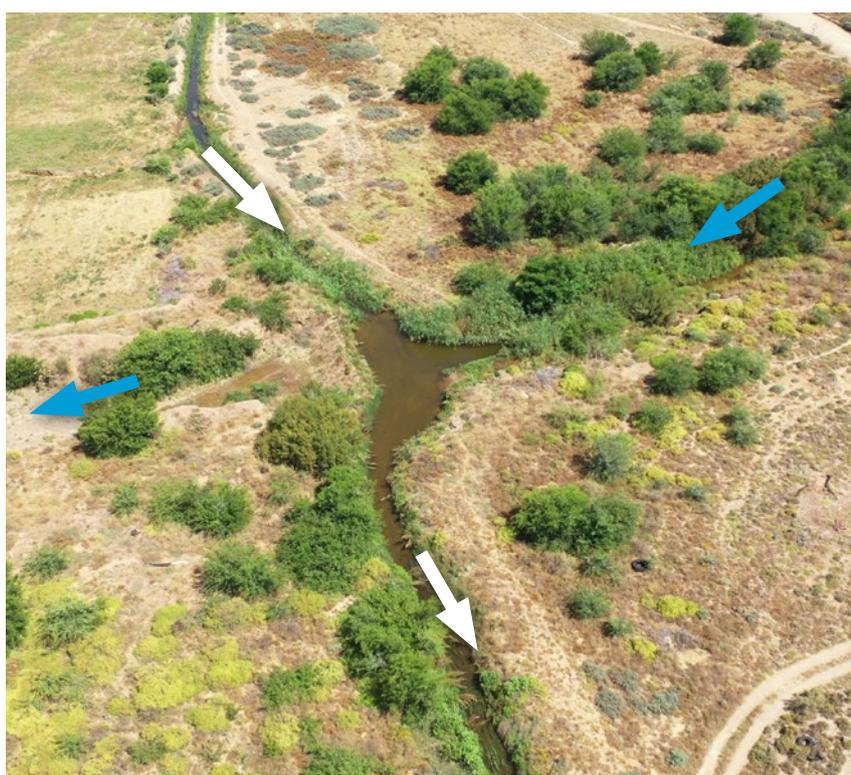
This spillway of a major dam is designed to spread the energy of the water spilling over the water over a long spillway, and so reduce the concentration of energy at any single point. There is also often a reinforced stilling basin downstream of the structure to return the energy state of the water to what occurs naturally in the river. The structure itself is however a major interruption in the river course – where fish migration is important, these structures need fishways. They can alternatively be useful barriers to alien fish movement. **SEE HANDBOOK 3**



The outflow chute of this dam spillway is on rock and stable, but the peat downstream of the rock was washed out several meters deep. The erosion of the peat is causing extensive damage to the environment. A reno or rockfill apron could have dissipated the energy of the falling water exiting the chute and saved the peat from scour.



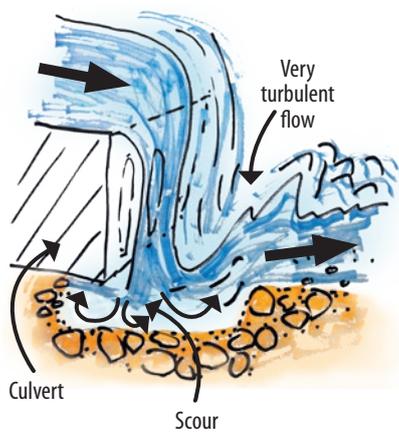
These images show a sump, traditionally constructed in a river, from which a farmer pumps out irrigation water. The berm around the sump is supposed to protect the sump from floods. However, here it deflects the flow of water in the river and leads to the erosion of the opposite river bank. It would have been better to have constructed the sump outside of the river channel, where it would not impede the flow of the river, and to have had a channel from the river feeding it with water or to allow the sump to extract from the water table.



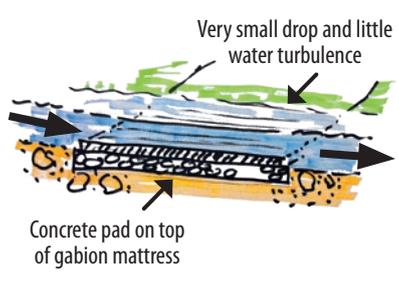
An irrigation canal (white arrows) crossing a watercourse (blue arrows). There is no provision where the two intersect to allow flood water to continue down the watercourse, so after every storm, the earth bank breaks. This formed an un-intended dam, and a spillway had to be inserted into the canal wall to resolve the issue.



LOW-LEVEL RIVER CROSSINGS



Culverts are a traditional solution for creating a road crossing over a watercourse. Unfortunately, when it is washed away or inundated by floods too often, there is a belief that making them larger will solve the problem. In fact, lifting the level of the top of the bridge increases the energy of water falling over it, and increases the risk of causing downstream soil erosion, which is undesirable. **See Handbook 9, Case Study 4.**



An alternative method of producing a stable river crossing is to bury gabion mattresses in the river bed and cover them with slabs of concrete, keeping regular and wide open slots between the concrete slabs for the drainage of the low flow.

Farmers and rural communities often need access through a river during low flow conditions. Structures which provide low flow access are often the source of the destabilizing of rivers. The main issues are:-

- Water falling over any obstruction in a river accelerates as it falls and becomes more turbulent, so it is more likely to scour the river than the river would have done otherwise. This means the river bed downstream of structures may deepen and river banks may get washed out.
- The openings of structures constructed with many small pipes or box culverts (as opposed to fewer but larger flow openings), block easily with debris during floods. This causes the structure to function as a much taller obstruction than was intended, with often serious consequences.
- When a structure is not constructed perpendicularly to the flow direction of the water, the structure will deflect the flow direction into a river bank and cause erosion.
- If the structure is not planned wide enough for reasonably expected floods, flows are concentrated into a too narrow downstream channel, causing erosion and further channel narrowing.

The best advice for low level river crossing structures is to:

- Keep them as low as possible.
- Orient them perpendicularly to the flow direction (as expected during floods).
- Where possible, locate them on a rock outcrop.



Although well meant, this culvert with many small openings will easily block with floating tree branches and other debris during floods and become quite ineffective. The openings also do not span the full width of the watercourse, so will result in the unnatural concentration of flow and downstream erosion. A more appropriate design may have included openings spanning the full width of the wetland and some form of scour protection on the downstream edge of the structure.



Alien vegetation washed down this river during a flood has blocked the culvert inlets, causing the river to overtop the structure and wash away the far road approach to the bridge.

The best solution for this is to regularly remove alien vegetation from the catchment, and in particular, the riparian zone. If that is not possible, construct debris-traps upstream of the structure, or keep the structure low enough that debris gets washed over the structure during floods.



C LOURENS



Lifting water over obstructions (like culverts) increases the energy of the falling water and causes unacceptable downstream erosion damage during floods.



Low water crossings (**left**) have the advantage that, during floods, they disturb the flow of water very little and there is minimal erosion associated with them. Slots across the concrete capping allow low flows through.



This low-level crossing is low and very effective, although the abnormal sediment load in the river is creating an island that is driving the flow into the bank on the right, which is threatening to outflank the structure.



HIGH-LEVEL RIVER CROSSINGS

High level crossings are designed for functionality and a minimum cost. Traditionally, environmental issues have not played a serious role in shaping these structures. Amongst others, important issues that have been neglected are the following:

- Making bridges wide enough so that a river channel is not constrained to a fixed position.
- Making bridge spans wide enough so that the discharge capacity of the structure is not too badly impacted on by flood debris getting trapped on the bridge piers.
- Having adequate provision for discharge capacity and depth of foundations, so that when or if the river bed moves up or down, the structure will still function adequately.
- Locating bridges away from bends in rivers where river bank instability is to be expected.



This bridge is acceptable from an environmental point of view because:

- The bridge is in line and perpendicular to the flow of water.
- It does not constrain the river to a particular section of floodplain.
- The openings are wide, and large floating debris during floods can pass through, while terrestrial fauna can also pass along the river corridor.
- The structure is perpendicular to the flow path of the river and the bridge is not causing undue bank erosion.

With the development of intensive agriculture over many years, conflicts between river position and property rights have developed.

The image on the left is of a river which, during a flood, could not take the sharp bends that were dictated by property rights and fences.

The river took a straight path, ignoring the bridge that had been provided. The image to the right is a plan view of the site.

A more sustainable solution would have been to move the bridge more in line with the river, after resolving the issue of property rights.





When planning bridges, it is important to remember that the river environment during the planning phase is only a snapshot in time, and it is in the nature of rivers to change.

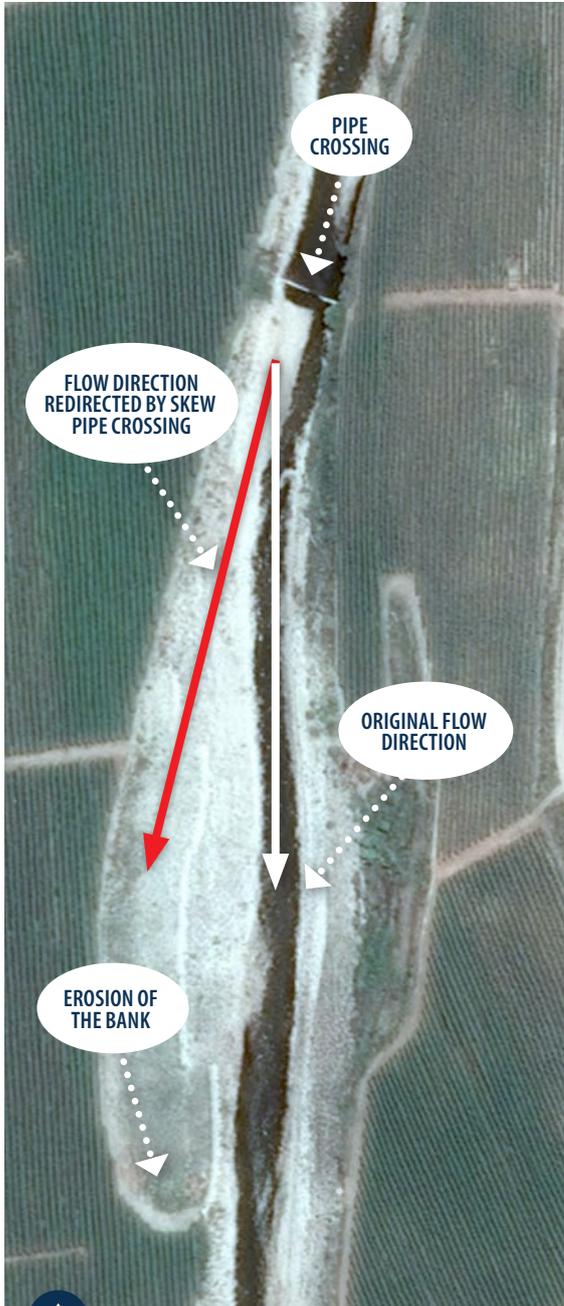
- Above is a lowland river that has moved sideways due to sedimentation in the channel during a flood.
- Below is an image of a channel that regularly silts up because of un-natural upstream soil erosion. The silting up of this channel means there is frequently inadequate flow capacity through the structure, causing water to dam up and spill over the railway.





PIPELINE CROSSINGS AND PIPES ALONG RIVERS

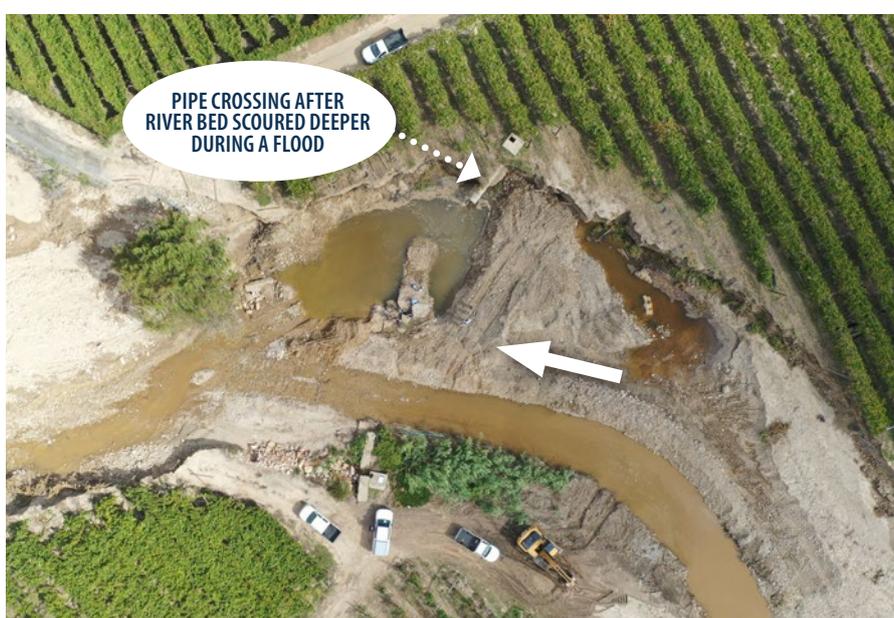
Pipelines crossing rivers are often the source of river degradation downstream. Structures built too high or skew relative to the river's position are inclined to impact negatively on river stability. Pipelines crossing the river at an orientation that is skew to the direction of flow deflect the river onto one of the river banks. Pipelines that are high enough to interfere with the movement of sediment during floods, create turbulence, which results in a sometimes-dramatic drop in river bed level downstream.



A site showing bank erosion resulting from a skew pipeline crossing on river



Part of the remedial work was to construct a weir crossing the stream at right angles to the flow direction, just below the pipeline (**above**).



A series of images showing the failure of a buried pipeline crossing a river. The original pipeline was upstream of a gabion weir (**see top image**), but the discharge capacity of the weir was only adequate for small floods. The details of downstream scour protection for the weir are uncertain.

Downstream scour progressively undermined the weir, and despite attempts to prevent it, a large flood eventually led to the final collapse of the weir and the pipeline.



RIVER CROSSINGS AND ECOSYSTEMS



Bridges, culverts, weirs, dams and fences across river channels can affect river connectivity. This is particularly important in urban and agricultural areas, where rivers often provide the only safe corridors for faunal movement through an ecologically hostile landscape.

This section is about how to limit impacts to the river through rehabilitation or good design.



Healthy rivers have **'ECOLOGICAL CONNECTIVITY'** and **'HABITAT CONTINUITY'**. This means the ecosystem and its habitats are fully connected by free, unobstructed flow of water and sediment both down the river and between the channel, banks and floodplain; and that fish and other animals can move freely throughout the system. **RIVER CORRIDORS** are the open vegetated area alongside the river, which if healthy can **BUFFER** rivers from many land-use impacts.



Rivers can provide huge benefits as ecological corridors through dense urban areas, provided that they have enough space and that bridges and culverts do not block them off

Designing river corridors

River corridors should be designed or rehabilitated to provide:

- **Space** for terrestrial as well as aquatic animals to move along these areas, which are often the only space left in urban areas for wildlife movement and habitat. As a rule of thumb, bigger rivers need wider corridors.
- **Cover for protection of animals from predation and disturbances** – shrubs, trees and sedges provide better habitat than mown lawns – they also **slow** down flood flows.
- **Shade and noise buffers** – well vegetated river corridors reduce urban heat and dampen noise.
- **Amenity value** – they can offer valuable recreational spaces – so long as they are safe, well-used and well maintained.



CULVERTS OR BRIDGES that have their abutments on the edge of the wetted channel completely block the riverine corridor for non-swimming or flying fauna. Right: a faunal corridor that is submerged during floods but otherwise allows connectivity along the river. Wet season flooding is useful because it discourages human habitation.

Designing fences for animal movement

Fences are needed to control access into and from most properties, but they can seriously interrupt faunal movement. Leaving 30 cm × 30 cm gaps in fences, at 10–20 m intervals can at least allow smaller fauna through without creating major security risks (especially if the fence lines are vegetated). This palisade fence has been designed with gaps under the fence in places.

Electric fences can spell death to fauna that get trapped against the wires. Ensure that the lowest electrified strands are at least 30 cm above the ground.



Palisade fences, with bars spaced at least 15 cm apart, and with no electric wires within the lower 30 cm, can provide basic (small to medium) faunal connectivity between sites without compromising site security. Ideally, gaps of 30 cm × 30 cm should be allowed for at intervals along fences.

Designing infrastructure to control faunal movement

Sometimes interventions that prevent faunal access or plant invasion are useful!

Left: These weirs have been constructed as fish barriers, to keep alien fish from moving upstream and impacting on threatened indigenous fish.

Right: a fishway enabling indigenous fish to move up-river.



Walls with a wide (> 15 cm) overhang have been constructed to prevent endangered Western Leopard Toads moving up into dangerous roads. Fences can also be covered with smooth plating that can't be climbed by toads or other small fauna.



Toad tunnels, designed for the safe passage of toads and other small fauna under roads. Temporary wet-season barriers funnel toads to crossing points.





Adding culverts below roads to allow terrestrial as well as aquatic connectivity for small animals (here, otters and mongooses) can lessen the impacts of major road crossings.



Paths used as a barrier to the spread of kikuyu grass into riverine corridors are effective if actively managed.



Boardwalks across wetlands allow flow and small fauna to pass unimpeded under walkways that add amenity value.



FURTHER READING

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LINKS TO THE 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

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:** 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.
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.
Infrastructure	Structures such as roads, railways, bridges, pipelines etc. constructed to support society (all or just a portion)
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.
Stormwater	Surface runoff from rainfall which can then enter the stream channel network.
Sump	An (artificial) depression in the ground where water is collected with the purpose of pumping it further for agricultural or domestic use.
Water extraction facility	A structure created with the purpose of extracting water from a river for irrigation or other use.
Watercourse	A natural channel along which water flows (whether from rainfall or seepage).
Spillway	A part of a dam structure, that has the purpose of allowing surplus water to exit the dam once the dam is full.

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What you need to know to get started

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Understanding South African Rivers

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

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Dealing with river erosion in
South Africa

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Responding to sediment problems
in South African rivers

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Addressing changes in river channel,
floodplain and wetland form

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Responding to changes in water
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