RIVER MAINTENANCE PLANS: SOME PERSPECTIVES FROM FARMING CONTEXTS IN THE WESTERN CAPE

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ABSTRACT

River maintenance plans (RMPs) approved under the 2010 NEMA EIA regulations hold considerable promise for introducing the principles and practices of ecosystem-based planning to the management and rehabilitation of rivers in agricultural settings. Such plans would be drafted in terms of Activity 18 of Listing Notice 1, which exempts holders of an approved RMP from having to obtain environmental authorisation to excavate, move or deposit more than 5 m^3 of material in a watercourse.

Farming is heavily dependent on the resources embedded in rivers and floodplains. However, this has resulted in the displacement of an estimated 50% of the valley bottom and floodplain wetlands that once occurred in Western Cape. Most of the remaining systems are heavily to critically modified. By the same token, agricultural development in floodplains is also at risk from floods. In November 2008, for example, floods caused R980 million's worth of damage to table grape, wine and fruit farms in the Cape Winelands District Municipality.

Regulatory control has been markedly ineffectual in stemming the degradation of rivers and wetlands on farmland. However, there is little prospect of improvement as long as we remain uncritically wedded to the current system of environmental impact regulation. Ideally, we need to redefine our focus towards pursuing an agro-ecosystem approach that is premised on desirable environmental and socio-economic outcomes. RMPs offer immense potential to this end. However, RMPs that are not designed to give effect to best management outcomes also carry risks of entrenching inherently unsustainable practices, and of avoiding impetus to improve practices that are increasingly destructive as their intensity and scale increases with improving technology.

RMPs that focus on restoring or maintaining functional relationships within ecosystems, using adaptive management and carrying out management actions at a scale that is relevant to the issues being addressed have much potential to promote efficient co-operative action in support of healthy, useful rivers.

The agricultural sector is one to which issues around river maintenance are highly pertinent. River maintenance on farms is both proactive and reactive. Proactively, it typically entails clearing channels or bulldozing levees as flood protection. Reactive maintenance often follows flood damage. It can entail excavating debris from irrigation sumps, protecting eroded river

banks with bulldozed alluvium or reinstating damaged causeways. Locally, impacts may be limited. However, if mechanical manipulation of rivers is added to the effects of degraded floodplains, cumulative impacts can be significant, unpredictable and highly damaging. Effects may include greater damage from relatively smaller floods, accelerated erosion and sedimentation, and increased instability and loss of ecological integrity to riparian ecosystems.

It follows that RMPs must be informed by the physical and ecological processes that drive and maintain aquatic ecosystems. Those aspects, therefore, of the river or wetland environment that require 'maintenance', or will be affected by it, need to be managed in relation to the broader dynamics, stability and desired state of the system. This means that there needs to be a minimum level of understanding about system level processes and dynamics, before recommendations regarding particular reaches or sites can be made with any certainty about their outcome. In addition, minimum sustainable thresholds of river function need to be recognised in any long term maintenance plan, bearing in mind that significant long-term encroachment into the floodplain is often the root cause underlying both the need for ongoing maintenance and the impacts to farming activities resulting from flood damage.

The following steps are recommended to ensure an inclusive, ecosystem-based approach to the formulation and adoption of RMPs:

1. **Define the study domain, preferably from a whole-catchment perspective, and at the level of geomorphological reach as a minimum;**
2. **Identify an accountable, representative body that should take unbiased custodianship of the RMP and drive its implementation;**
3. **Identify key stakeholders;**
4. **Divide the river into useful management units;**
5. **Undertake a rapid baseline (Ecostatus) assessment, which should incorporate review of historical changes in land use and river morphology;**
6. **Identify major drivers of river disturbance and instability – human and natural, and their primary and secondary effects;**
7. **Identify conservation priorities and/or obligations within each management zone on the basis of the Ecostatus assessment and existing conservation plans and catchment management strategies;**
8. **Identify areas in different reaches where management or rehabilitation interventions are necessary and/or appropriate;**
9. **Solicit input from stakeholders on their priorities and objectives;**
10. **Set management objectives based on the dual needs for ecological and economical sustainability**
11. **Define best practice measures for rehabilitation and maintenance implementation;**
12. **Formulate practical management guidelines with implementers;**
13. **Design a plan for ecological monitoring which is specifically linked to the stated objectives; and**
14. **Develop an implementation programme and review mechanism.**

INTRODUCTION

River maintenance plans (RMPs) approved under the 2010 NEMA EIA regulations hold considerable promise for introducing the principles and practices of ecosystem-based planning to the management and rehabilitation of rivers in agricultural settings.

The notion of a formally-recognised 'maintenance plan' first made its appearance with the publication of the 2010 amendments to the NEMA EIA regulations. In short, the holder of such a plan – provided it has been "agreed to" by the relevant environmental authority – may *inter alia* excavate or otherwise move more than five cubic metres of material in a watercourse without having to obtain environmental authorisation in order to do so (Box 1).

If one is effectively absolved of having to obtain environmental authorisation in the circumstances set out in Activity 18 (which has no evident relationship with the exemption provisions of NEMA),[1] the question then arises as to what extent the provisions of NEMA section 23 (the objectives of integrated environmental management) and section 24 (e.g. the minimum mandatory procedures for environmental assessment and reporting, and the content of environmental management programmes)[2] would apply to the formulation of a management plan for maintenance purposes.

Current thinking would seem to suggest that the submission of a management plan for the purposes of "maintenance" in terms of Activity 18 of Listing Notice 1 does not constitute an application for environmental authorisation.

BOX 1: Activity 18, Listing Notice of GN R. 544 (18 June 2010) as amended by Correction Notice 2, GN R. 1189 of 10 December 2010.

The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than five cubic metres from

(i) a watercourse;
(ii) the sea;
(iii) the seashore;
(iv) the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater-

but excluding where such infilling, depositing, dredging, excavation, removal or moving
(a) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or
(b) occurs behind the development setback line.

Key concepts relating to Activity 18, Listing Notice 1

The key concepts that define Activity 18 of Listing Notice 1 (GN R. 544 of 18 June 2010) in relation to its 'maintenance provisions' are discussed below.

'Material'

'Material' has a broad, unspecified definition and conceivably could incorporate both inorganic (such as tyres, ash or rubble) as well as organic matter (e.g. vine cuttings, manure or fruit). It would be interesting to address the question as to whether the term 'material' is sufficiently elastic to incorporate gabions. The listed materials (soil, etc) need no introduction.

The activities

The actions on which this listed activity hinges are self-evident and generic: 'in-filling','depositing', 'dredging', etc. It would seem to be immaterial as to whether the activities in question are carried out mechanically or by hand. What is less certain, though, is whether the 5 m^3 threshold refers to a single "in-filling' event, or if a series of discreet events that over an unspecified period of time add up to the threshold would trigger the requirement for environmental authorisation. As to a coarse rule-of-thumb to assess the volumes involved, a mechanical excavator with a 600 mm bucket scoops about 0.12 m^3 of soil at a time (Röscher, *pers comm*). It would take a standard-sized excavator about 40 scoops to meet the 5 m^3 threshold, obviously less in the case of a larger bucket.

[1] NEMA s 24M
[2] NEMA sections 24(4)(a) and 24N respectively

'Watercourse'

The definition of 'watercourse' was corrected by Correction Notice 2, GN No. R. 1159, of 10 December 2010, and is virtually identical to the definition of 'watercourse' provided by the National Water Act 36 of 1998 (Box 2).

BOX 2: Definition of a "watercourse", Listing Notice 1 of GN R. 544 (18 June 2010) as amended by Correction Notice 2, GN R. 1189 of 10 December 2010.

"(W)atercourse" means –
(a) a river or spring;
(b) a natural channel or depression in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse as defined in the National Water Act, 1998 (Act No. 36 of 1998) and a reference to a watercourse includes, where relevant, its bed and banks;

'Maintenance purposes'

The NEMA EIA regulations do not define 'maintenance'. Neither is the term defined in the guidelines to the 2010 amendments to the EIA regulations that were published by the national Department of Environmental Affairs in 2010 (DEA, 2010).

Activity 16 of Listing Notice refers to 'maintenance' in coastal settings, and specifically in the context of maintaining facilities such as slipways, stabilising structures and buildings exceeding a specified threshold. Activity 17, in turn, refers to the use of material or revegetation in support of "restoration and maintenance" of indigenous coastal vegetation. In each of these cases, the act of 'maintenance' – although not defined – is linked to an identifiable situation or objective: in the former case, 'maintaining' infrastructure within 100 m in land of the high water mark, or in inshore waters, and in the latter, the outcomes associated with ecological restoration of sandy shore ecosystems.

Activity 18, however, does not provide any guidance as to when and why the in-filling etc of soil and other material would constitute 'maintenance' – other than that these actions may be carried without environmental authorisation in specified environmental contexts for 'maintenance purposes' and, crucially, in accordance with an agreed management plan. Put differently, Activity 18 endorses – subject to specific conditions – excavations and other earth-moving activities in, among others, watercourses where such actions would constitute 'maintenance', but without going as far as stating what is being 'maintained', and to what end. This does introduce a considerable element of uncertainty to the interpretation and application of the 'maintenance' provisions of Activity 18 but, paradoxically (and positively), opens a range of possibilities that would otherwise not necessarily be available were this listed activity to have been defined more restrictively. This point is developed later in the paper.

Meanwhile, even a superficial attempt at conceptual analysis would show that 'maintenance' can legitimately hold diverse meanings, depending on the context in which the term is applied, and to what end. From this, it follows that Activity 18 potentially supports a medley of interpretations of 'maintenance' that are all quite valid when relayed to a conventional or model case application of the word.

A dictionary definition of 'maintenance' refers to "the process of maintaining or preserving someone or something or the state of being preserved"; alternatively, 'maintenance' means "the process of keeping something in good condition" (Pearsall (ed), 1998). Used in the context of rivers, 'maintenance'as defined here can conceivably take on various practical forms, each representing a different type and degree of intervention. Some examples are presented below to illustrate what is meant here. The objectives of the river manager would seem to be crucial in defining what constitutes 'maintenance' and to what end it is undertaken.

At the less invasive end of the scale, river ’maintenance’ for a municipal engineer or manager may entail no more than excavating treated sewage sludge from an urban river or removing sediment and reeds that have clogged a channel upstream from a bridge. The objectives of ‘maintenance’ in these cases could be informed by a concern for water quality in the first instance and, in terms of both examples, to constrain peak flows to the channel and to reduce the risk of flood damage.

Considerably more manipulation of the channel and banks may take place in response to flood damage, but could still comfortably be defined as ‘maintenance’ from the perspective of the responsible manager. Such post-flood actions can range from attempting to replace an eroded river bank with material bulldozed from the channel to reinstating a gravel causeway (‘drift’) that has been washed away by flood waters.

It may even be convincingly argued that the installation of gabions or even concrete cladding to protect the erosion-prone river bank in the former case still constitutes ‘maintenance’ from the perspective of a responsible manager, as would the replacement of a gravel drift with an appropriately anchored and protected concrete causeway.

A conservation manager who undertakes a medley of actions such as alien clearance, erecting weirs to restore degraded wetlands or release of indigenous fish species bred in captivity to repopulate a rehabilitated watercourse may also reasonably argue that this, too constitutes ‘maintenance’, but in pursuit of the achievement of ecological objectives. Ideally, the conservation manager’s concerns for preventing further degradation of an aquatic ecosystem, pursuing its rehabilitation and generally tailoring ‘maintenance’ to ecological and hydrogeomorphological objectives should be of equal relevance to those responsible for keeping watercourses and associated infrastructure in urban and agricultural settings in good condition.

The examples presented here serve to place ‘maintenance’ in actual, recognisable contexts where the act or process of keeping infrastructure and, potentially, the watercourse or wetland (natural or not) in which it is located in ‘good condition’ may be guided with different outcomes in mind, but, in all cases, can be reduced to some or other form of ‘maintenance’ that can be recognised as such depending on the objective in question. Whether all these interventions are necessarily the most defensible environmental option is, for the sake of conceptual clarification, not relevant.

The conundrum that creeps in, of course, is that regardless of the formal or commonsensical interpretation that one assigns to ‘maintenance’ (be it a dictionary definition, or part of a job description), the NEMA EIA regulations offer little clue as to what this term actually means in the context of Activity 18. All we know is that ‘maintenance’, as understood here, is some- or other - how functionally related to excavations in watercourses and the other environmental circumstances specified in the definition of the activity.

What we can also conclude is that it is permissible to undertake these actions (in-filling, deposition, dredging, etc of more than five cubic metres of material (with ‘material’ not being defined) as long as they are in pursuit of the “purposes of maintenance” – which is not defined – and in accordance with a management plan that has been agreed to by the “relevant environmental authority”.

A clear challenge, therefore, is to formulate a definition of ‘maintenance’ that is premised exclusively on the movement of sediment and other material in watercourses. As a minimum, such actions in support of ‘maintenance’as provided for in Activity 18 must demonstrably not entail ‘construction’ or ‘expansion’ as defined by the EIA regulations (Box 3), for the moment this happens the relief provided by Activity 18 may be annulled and it could become necessary to apply for environmental authorisation in terms of NEMA section 24(1). The question as to whether a proposed action constitutes ‘maintenance’ or ‘construction’ or ‘expansion’ is a source of perennial debate in EIA practice.

Practical examples in this regard from the Western Cape include reporting undertaken for the:

- Management of urban rivers in the Drakenstein Municipality (Aurecon, 2010);
- Repair of flood-damaged roads in the Cape Winelands District Management Area (Aurecon, 2010); and
- Maintenance and management of surface stormwater systems in the City of Cape Town ((Arcus Gibb, 2012).

As this paper concentrates exclusively on the movement of sediment in support of 'maintenance' objectives, questions arising from maintenance that may trigger listed activities (e.g. the installation of gabion bank protection, resized stormwater drains or construction of silt traps) are not dealt with any further.

BOX 3: 'Construction' and 'expansion' (GN R. 544, 18 June 2010)

"construction" means the building, erection or establishment of a facility, structure or infrastructure that is necessary for the undertaking of a listed or specified activity but excludes any modification, alteration or expansion of such a facility, structure or infrastructure and excluding the reconstruction of the same facility in the same location, with the same capacity and footprint...;

"expansion" means the modification, extension, alteration or upgrading of a facility, structure or infrastructure at which an activity takes place in such a manner that the capacity of the facility or the footprint of the activity is increased...

'Like-for-like'

Prior to the gazetting of the 2010 NEMA EIA regulations, reference to 'maintenance' was commonly associated with arguments as to why a particular project did not trigger a listed activity and, therefore, the requirement for environmental authorisation. Such discussions would typically hinge on issues such as whether a prescribed threshold would be exceeded and if proposed repairs or replacement of infrastructure were consistent with the 'like-for-like' principle.

This principle is explained as follows

> If repairs are done in such a way that the structure is the same as it was before the flood damage, we regard it as maintenance and it is not listed. If repairs involve an increase in capacity such as bigger culverts or wider bridges, or additional protection measures such as gabions where there were none before, it is regarded as listed... (D. Swanepoel, pers. comm.)

In this context, 'maintenance' by and large served as a device for arguing why a proposed intervention did not trigger one or more listed activities, even if it entailed perpetuating a situation that entailed ongoing environmental degradation, as in the case of some bridge repairs, for example. However, in terms of Activity 18 of Listing Notice 1 of the 2010 NEMA EIA regulations, 'maintenance' that entails the movement of sediment in watercourses is singled out as being of sufficient concern to require regulation via the mechanism of an environmental management plan. In this sense, the discourse on'maintenance' has been broadened from a restrictive, predictable and rather sterile debate around whether or not activities may be listed, to one in which 'maintenance'-related activities in rivers and wetlands have in their own right become subject to environmental scrutiny and a refreshing form of 'customised' control.

'Management plan'

Section 24N of NEMA, together with Regulation 33 of GN R.543 (18 June 2010, as amended), stipulates comprehensive minimum requirements for environmental management programmes and the procedures in terms of which they must be formulated and submitted to a Competent Authority as part of the prescribed process of applying for environmental authorisation.

However, Activity 18 simply refers to "a *management plan* (own emphasis) agreed to by the relevant environmental authority". The EIA regulations do not specify what the objectives or content of such a "management plan" must be (although Regulation 33, read with NEMA s 24N, define what, at a minimum, an environmental management programme that is submitted in support of an application for environmental authorisation would have to a adhere to) (see Box 4 for a summary of the elements of an EMP as prescribed by NEMA).

This paper takes the view that management plans drafted for 'maintenance' purposes in the context of aquatic ecosystems must be informed – at the functionally appropriate scale – by the physical and ecological processes that drive and maintain such systems, and that those aspects of the river or wetland environment that require 'maintenance', or will be affected by it, need to be managed in relation to the broader dynamics, stability and desired state of the system. This means that there needs to be a minimum level of understanding about system level processes and dynamics, before recommendations regarding particular reaches or sites can be made with any certainty about their outcome.

BOX 4: Environmental Management Programmes (EMPs) (cf. NEMA s 24N)

An EMP must (in summary) contain:

- Measures for management, mitigation, protection and remediation
- Particulars and expertise of the drafter of the EMP
- Description of aspects of the activity that are covered by the EMP
- Persons responsible for implementing the EMP
- Monitoring measures and compliance reporting
- Environmental rehabilitation (or, alternatively, restoration) measures
- Actions to modify, stop or otherwise control processes or activities that may cause pollution or environmental degradation
- Actions to remedy such pollution or environmental degradation
- Steps for complying with prescribed environmental management standards or practices
- An implementation schedule
- Environmental awareness-raising about risks and preventative measures

Recommendations regarding key elements of such maintenance management plans are presented in greater depth later in the paper.

The next sections introduce typical maintenance practices in rivers on farms in the Western Cape, and describes the impacts of bulldozing on river stability and the condition and functioning of in-stream and riparian habitats.

'MAINTENANCE' IN RIVERS AND WETLANDS ON FARMS IN THE WESTERN CAPE

This section provides a brief explanation of agricultural dependence on floodplains in the Western Cape and how this translates into specific management challenges for farmers who are forced to contend with issues such as erosion, siltation and flood damage in general. A summary is also provided of typical activities that, in agricultural contexts, would be understood to constitute 'maintenance' – with the emphasis, that is, on 'maintaining' river channels and floodplains in support of agricultural objectives rather than repairing or otherwise caring for built infrastructure such as pump foundations, weirs or concrete drifts.

Agriculture's historical and practical dependency on floodplains

There is a close and rationally explicable relationship between agriculture and its historical utilisation of floodplains and 'riverscapes' (Ward, 1998) in the Western Cape.

The region has limited rainfall and soils are generally shallow and unsuitable for cultivation. Given that the deepest and best soils are found in river floodplains, these areas have been extensively developed over many decades and support some of the province's highest earning production sectors such as deciduous fruit and wine and table grapes (King 2009).

Transformation of wetlands in the province gives a crude yet useful measure of agriculture's footprint with respect to its dependency on these ecosystems. For example, 51% of valley bottom wetlands and 41.1% of floodplain wetlands in the Western Cape are classified as 'heavily to critically modified' (Snaddon, pers. comm), whereas only 17.4% of the former and 33.3% of the latter are considered to be in a 'natural', or 'natural to 'moderately modified' condition. Not all degradation to wetlands can, of course, be attributed to agriculture. Overall, however, agriculture represents the single biggest user of land in the Western Cape (89.3% in total, of which 70.4% is attributed to grazing and 19% to potentially arable land) (DAFF, 2010). Forestry, in comparison, occupies just 1.5% of the surface of the province and 'other' land uses – presumably including urban settlements – account for 3.5% of the 'land take'.

Impacts of floods on agricultural land use of floodplains, wetlands and rivers

Vineyards and orchards that extend to the banks of rivers, which are often fringed with dense stands of woody alien plants or choked with reeds, are a common sight in parts of the Western Cape. Farm tracks sometimes delineate the boundary between cultivated land and adjacent watercourse. In other places, channels and the adjacent floodplain have been ripped open by floods, exposing vast stretches of bleached boulders and gravel. It is common to see signs of in-channel bulldozing and deposits of excavated sediment along the top of river banks in farming areas adjacent to mountains.

As noted by King (2012a), riparian farmers along Western Cape rivers experience a variety of problems as a result of flooding and instability of rivers. These include:

- Loss of land with established vineyards, orchards and feed crops;
- Loss of access roads around vineyards and orchards, plus irrigation infrastructure such as pipes and valves that are often buried underneath these roads;
- Destruction of public roads and bridges that enable farmers to market their produce;
- Deposition of sediment in vineyards and orchards; and
- Blockage of surface and sub-surface drainage systems that can contribute to water-logging and increased soil salinity.

Other flood-related issues that farmers may have to contend with are damage to excavated irrigation sumps in river beds, clogging of sumps by flood debris, damage to causeways ('drifts') that can severely disrupt farming operations, and loss of buried electrical cables and irrigation pipes that are laid across river beds (De Villiers, 2011a). Formation of sand banks that are colonised by indigenous (especially fluitjiesriet *Phragmites australis*) and alien (such as various wattle species) plants poses a particular challenge to agencies that are responsible for managing and maintaining large-scale irrigation infrastructure such as diversion weirs and canal off-takes.

Some of these problems can develop gradually, over time (such as build-up of sediment and associated salinisation), whereas others (e.g. bank erosion and destruction of drifts) occur calamitously as a result of floods. Management responses are scheduled accordingly: clearing channels of sediment can take place every couple of years, but flood damage often demands an immediate response.

Farmers' responses to changed flow patterns, erosion and sedimentation

Agricultural responses to erosion and sedimentation can be broadly grouped in terms of the processes to which they are reacting or anticipating, i.e. flow patterns, or hydrogeomorphological changes:

Changes to flow patterns		Changes to hydrogeomorphology	
Floods	***Droughts***	***Erosion***	***Sedimentation***
Bulldozing of levees to prevent flood waters over-topping river bank and inundating cropland	Excavation of sumps in dry river beds to obtain access to sub-surface water	Bulldozing coarse alluvium to protect river banks against erosion	Clearing flood debris from pre-excavated irrigation sumps in the riverbed
Bulldozing levees to redirect flow away from cultivated portions of the floodplain		Packing rocks and tyres in eroded parts of the river bank	Clearing flood debris from culverts and bridges to prevent sediment build-up
Transverse bulldozing of river banks to 'open river' and accelerate flood run-off			Removal of 'islands' and indigenous riparian plants (e.g. palmiet) from channels
			Removal of finer sediments and reeds
			Allowing cattle to browse 'fluitjiesriet'
			Burning reed beds
			Treatment of reeds with herbicides

Information sourced from case studies for the Langtou (De Villiers, 2011a), Hex, Jan du Toits, Hartebees, Nonna, Nuy, Vink and Keisie rivers (De Villiers, 2011b), Nonna and Nuy (De Villiers, 2011c), Vier-en-Twintig (De Villiers, 2012), and Nuy, Upper Duiwenhoks and Bos (King, 2012a and 2012b) rivers.

This paper concentrates on the use of bulldozers in watercourses owing to the acute complexity that this widespread practice poses for environmental management in support of sustainable agricultural resource use.

The situation is complex for various reasons. Firstly, bulldozing in rivers clearly has deleterious environmental consequences. However, owing to historical patterns of cultivation in floodplains and riparian areas, the practice in widespread. Bulldozing in watercourses goes hand-in-hand with simplification of aquatic ecosystems, degradation to floodplains and catchments, and destabilisation of river channels. In turn, the close proximity of high-value cultivated land to increasingly flood-prone watercourses has meant that riparian landowners will take matters into their own hands to secure land against flood damage, or to repair such damage when it has occurred. Inasmuch as these practices may be construed as being undesirable from an environmental perspective, and even counter-productive in the long term, for the affected farmers they are viewed as being both essential and legitimate.

Unsurprisingly, this state of affairs results in considerable tension between regulation and established practices and values with regards to the use and management of agri-environmental resources.

The impacts of bulldozing on river stability

Attempts to stabilise channels and river banks represent one of the most prevalent forms of river maintenance in agricultural settings. As indicated above, these practices are aimed at preventing or repairing flood damage and clearing flood debris from bridges, drifts and irrigation sumps.

Bank and channel stabilisation can take various forms (King 2009 and 2012a). These include:

- The 'traditional' method of excavating and landscaping the river with bulldozers;
- Lining channels with concrete;
- Lining channels with rip-rap;
- Establishment of water detention ponds and sediment traps;
- Reducing flow velocities by widening the channel and constructing weirs; and
- Fixing the location of watercourses by means of groynes that also promote the recovery of eroded river banks through sediment deposition between the structures.

Only the first option – bulldozing – is considered here as all the others, besides constituting 'construction' that would trigger the requirement for environmental authorisation, are generally not available to farmers owing to the costs involved.

Bulldozers and other tracked earth-moving machinery are used widely to manipulate watercourses on farms in the Olifants, Berg, Breede and Gouritz water management areas in the Western Cape. Farmers typically attempt to 'straighten' rivers by removing bends and obstructions such as sandbanks and indigenous vegetation so that floodwater may pass quicker and leave their land as soon as possible. It is commonly believed that bulldozing creates flow space in a river, thereby directing floods away from cultivated lands. The effects of bulldozing do not, however, always match expectations.

In reality, the bulldozed profile of a river rarely remains intact after even a small flood. The reason for this is that the forces that drive sedimentation have not changed, and sediment usually gets deposited where it always was – with the result that after every flood the river has to be bulldozed again. Other hydraulic and erosion-related disadvantages of bulldozing rivers include:

- When the cross section of a watercourse is changed by being made deeper and narrower, the flow velocity and sediment movement during floods is greatly increased. Typically average flow velocities in undisturbed wetlands during floods are in the order of 2.5 or 3.0 m/s. In the Buffeljags River (near Swellendam, Western Cape) and Swartberg River (Ladismith, Western Cape), both of which are highly disturbed by bulldozing, flow velocities of up to 6 and 8 m/s respectively have been observed. In these rivers it is not uncommon to see rocks with a diameter of 300 mm and more being moved down the river.
- The increased flow velocities which occur once the river cross section has been altered by bulldozing result in increased erosion and transport of sediment – sediment which is deposited somewhere downstream when the flow velocity drops. This sediment forms islands which deflect the flow into river banks and initiate fresh erosion.
- Bulldozing destroys indigenous vegetation which has deep roots (such as palmiet *Prionium serratum*) and is adapted to holding back soil during floods. Newly-formed sediment islands and river beds that have been denuded by bulldozing are ideal locations for alien vegetation to flourish, which creates its own problems. The proliferation of opportunistic invasive alien plants promotes the capturing and build-up of sediment in the altered channel, which contributes to erosion and the destabilisation of affected watercourses.
- Bulldozing segregates large and small sediment particles. This disturbance of the mix of sediment and natural compaction increases the susceptibility of the sediment particles (large and small) to erosion.

The large-scale movement of sediment in channels, and mechanical manipulation of river banks, is a primary cause of hydraulic and geomorphological instability in numerous Western Cape rivers. In the short term, and at a localised scale, bulldozing can addresses instability and meet the direct needs of riparian managers and landowners. However, mechanical disturbance to the channel and banks triggers a domino effect whereby the drivers of channel and bank instability are transferred downstream, obliging other riparian landowners to take corrective measures that simply perpetuate and amplify the problems associated with a destabilised watercourse.

Ultimately, bulldozing to protect farmland against floods does not provide a solution because it has to be repeated after every flood, the river section becomes more and more altered and, as a result, unstable and increasingly difficult to manage. Bulldozing of rivers also translates into potentially severe ecological effects, which are discussed below.

‘RIVER MAINTENANCE’ ON FARMLAND: ECOLOGICAL IMPLICATIONS

The bulldozing activities described above are clearly of immense significance from an ecological perspective. The direct effects of bulldozing of river channels and the creation of bank armouring and/or flood protection levees are relatively self-evident and can have the following effects on biotic communities, their habitats and ecological processes:

- Reduced in-stream habitat diversity and impacts on faunal diversity;
- Impaired ecological relationships and processes; and
- Degradation of floodplain dynamics.

Each of these factors is discussed below.

Reduction of in-stream habitat diversity and impacts on faunal diversity

Channel simplification reduces natural in stream habitat diversity that, in these systems, would often comprise a complex mosaic of shallow riffles, runs, sandbars, pools and vegetated margins, each associated with different flow and microhabitat conditions, and suitable for colonisation by different macroinvertebrate communities. Such habitat diversity would also have played a role in fish diversity in many south western Cape rivers. Regular disturbance of riverine habitats by bulldozing thus changes habitats and has a destructive direct impact on riverine fauna. The extent of recolonisation of disturbed areas depends on the degree of upstream disturbance, the kinds of habitat that remain to support different taxa and the frequency of disturbance.

Impaired ecological relationships and processes

Changes in instream faunal community structure can have significant impacts on other aspects of river function and structure, such as changes in dominant fish species and ensuring knock-on effects on predator–prey relations or grazer abundance.

Although the effects of bulldozing may be transitory from a farmer’s perspective (albeit with re-deposition of rocks and finer sediments occurring after floods,) the ecological impacts can be permanent. Bulldozing and the ensuing down-cutting of channels sets in motion a cycle of increasing flow velocities, constriction of these flows, and further down-cutting. Over time, the effects of down-cutting include a lowering of the local water table, resulting in drying out of riverine vegetation, such as Palmiet *Prionium serratum*, which would have played a natural role in bank stabilisation.

Degradation of floodplain dynamics

Bulldozing of the channel is moreover often accompanied by berming of secondary flood channels, to protect agricultural areas that have been established in the floodplain. This exacerbates the concentration of flows through the main channel and ongoing down-cutting, itself leading to increasing separation of the channel from its floodplain. In many floodplain systems, access to floodplain wetlands / braided secondary channels and pools under flood conditions is an essential aspect of the life cycles of indigenous fish species. It is however not known to what extent the almost wholesale destruction of this element of floodplain function in the majority of floodplain rivers of the south-western Cape has affected natural fish populations, most of which have been highly impacted from their natural community structure.

The agri-ecological – systemic – effects of bulldozing in river channels

Unfortunately, in many of the rivers that have informed the present paper, discussions about the impacts of agricultural activities on natural fauna are meaningless, because a long history of ecologically destructive processes has eliminated or radically altered much of the natural aquatic community. However, there are also broader ecological issues that are affected by bulldozing and channel manipulation and that are of relevance to agriculture itself, if it is to be an economically sustainable activity in these areas.

In this regard, it is noted that this paper has talked so far of the separate effects of sedimentation, erosion, increased velocities in river channels and down-cutting and ongoing separation of the channel from its floodplains. In fact, the causes and processes themselves are all linked, and attempts to manage isolated problems, at the level of a single site or river reach, can result in amplification of a host of other problems, which have implications for landowners as much as for the struggling remnants of riverine and wetland ecosystems.

Attempts to analyse cause and effect at the scale of a site only may thus result in significant knock-on effects both up- and downstream in the system. In the Langtou catchment in the south of the Gourits Water Management Area, for example, alien encroachment into the floodplain of large vegetated valley bottom wetlands resulted in significant reduction in floodplain capacity in some areas, while cultivation of floodplains continued further downstream, including infilling of some areas and stabilisation of channel edges to support more agricultural areas, and infrastructure such as heavily bermed abstraction sumps were constructed within the open floodplains (Day, 2011). These impacts initially did not precipitate significant obvious changes in river morphology, and became entrenched farming practices.

However, over time, various advancements, such as the advent of electrical power to the catchment, and the potential for pumped irrigation that came with it, among other issues, increased the extent of agricultural development, particularly along hitherto undeveloped floodplains. Together, these effects resulted in a loss of floodplain capacity, and a decrease in natural ecosystem resilience, which had little impact under normal conditions, including the recurrence of minor floods, but had significant effects under conditions of large floods.

Large-scale floods (e.g. 1:50 year return interval events) re-occur, by their nature, relatively seldom. When large floods swept through the Langtou catchment, the dense band of alien vegetation in the upstream reaches prevented access to the floodplain, and the river cut down, eroding virtually all of the wetland from the channel. Subsequent floods passed through this cleared channel with increasing velocity, causing significant erosion of the cleared floodplains downstream, and resulting in loss of wetland vegetation in those reaches. Berms around sumps diverted flows into adjacent banks, exacerbating erosion, loss of land and infrastructure.

The necessity of an ecosystem approach to river management and maintenance

Clearly, the above example is an over-simplification of a cycle of destructive cause, hydrological effect and ecological response, exacerbated by reactive and pro-active, site specific activities by landowners.

It does highlight however the crucial importance of approaching river management and maintenance practices, be they from the perspective of ecological rehabilitation, or simply ensuring sustainable use of floodplains for agriculture, at a scale that encompasses the scale of system drivers and responses. That is, it is usually useless and often actively destructive to attempt to micro-manage major hydrological processes at single sites, without an understanding of the drivers of change and disturbance, and the likely chain of hydrological, geomorphological and ecological responses.

This point leads to the crucial importance, then of river maintenance activities being undertaken from within the ambit of a broader, ecosystem based level of understanding of catchment-scale processes. It is only in this context that the approval of long-term river management plans to agricultural (and other) land users can start to address the current ongoing wastage of financial, ecological and agricultural resources in floodplain systems.

As part of the dialogue that is required between agriculture and environmental proponents, there must be acceptance that floodplain agriculture needs to be managed with an anticipation of periodic flooding, and a focus on promoting ecosystem resilience, rather than with a view to avoiding altogether a process that is integral to the natural system. These considerations are equally apposite to the formulation of management plans for maintenance purposes in 'working rivers' in agricultural contexts. In short, local responses to changes in the riparian environment cannot be decoupled from broader, systemic, factors and dynamics: the two scales function indivisibly.

THE DESIRABILITY AND CHALLENGES OF AN ECOSYSTEM APPROACH

As already indicated, Activity 18 of Listing Notice 1 is effectively mute on the substance and environmental objectives of management plans that are drafted for maintenance purposes for approval by a Competent Authority. This naturally can contribute to great uncertainty and erratic proposals, and decisions, as to what ought to be captured in such a 'maintenance management plan', and to what end.

Having such a blank sheet, however, offers rare opportunity to formulate maintenance / management plans that in all salient respects are substantially consistent with the key elements of the ecosystem approach as promoted by the Convention on Biodiversity (CBD, 2001 and 2004; Smith and Maltby, 2001) and International Association for Impact Assessment in its best practice guideline for biodiversity in impact assessment ((IAIA, 2005).

The 'ecosystem approach' (see Box 5) is premised on 12 principles that have been synthesised into operational guidelines (CBD, 2004) for implementation of the ecosystem approach that are directly relevant to how we approach river maintenance in support of agri-ecological objectives:

- Focus on the functional relationships and processes within ecosystems;
- Enhance benefit-sharing;
- Use adaptive management practices;
- Carry out management actions at the scale appropriate for the issue being addressed, with decentralisation to lowest level, as appropriate; and
- Ensure inter-sectoral cooperation.

BOX 5: The Ecosystem Approach

Smith and Maltby (2003, p 4) define the CBD's 'ecosystem approach' as:

- Being designed to balance the three objectives of the CBD, i.e. conservation, sustainable use and equitable sharing of biodiversity and genetic resources;
- Putting people at the centre of biodiversity management;
- Extending biodiversity management beyond protected areas while recognising that they are vital for meeting the objectives of the CBD; and
- Engaging the wides range of sectoral interests

Viewed thus, effective river maintenance cannot be divorced from the factors that shape flow regimes, river morphology, and associated biodiversity pattern and process. A functional understanding of these systems will grasp that all their constituent elements are inter-related and that changes to any one facet will have an influence on others. There is also a point where aquatic ecosystems cannot any longer absorb external pressures and the impacts of channel and floodplain modification; this is where the cycle of instability sets in, and human intervention to stem the resulting damage itself serves a direct contributing factor to further destabilisation and degradation and, in response to this, even further interventions that seldom have the desired effects.

For environmental assessment practitioners who are appointed to draft maintenance management plans in the types of circumstances outlined above, two of the five pointers on practical application of the ecosystem approach are fully within their reach and essential to a defensible planning process – namely the fundamental necessity of taking a functional, ecosystem-scale view of matters, and couching inquiries and management responses at the appropriate hydrological, geomorphological, ecological and social scales. There are no shortcuts in this regard. Maintenance management plans that do not demonstrate a practical integration of these principles into their formulation must be treated as incomplete and inadequate for the tasks that they claim to be addressing.

Given the integrated, dynamic nature of aquatic ecosystems, and the cumulative effects of human interference with their condition and functioning, it is difficult to approach the development of river maintenance management plans without reference to questions of appropriate forms of resource governance, sectoral co-ordination and long-term strategic planning (De Villiers, 2010). And, because of the inevitable uncertainties and predictive weaknesses that assail the management of destabilised rivers, adaptive management becomes a crucial adjunct to planning for sustainable use. Overall, river management and maintenance-related activities, particularly in farming contexts, is cut out for a collaborative, strategic approach to ecosystem governance (Imperial, 1999) – a challenge to which neither current legislation nor administrative or professional practice seemed to be particularly well suited. Debate in this regard is both necessary and important.

The next section sketches a proposed planning protocol for drafting river maintenance plans for the movement of sediment for agricultural management purposes that is informed by the concerns and principles outlined above.[3]

PROPOSED PROTOCOL FOR DRAFTING RIVER MAINTENANCE PLANS

The following steps are recommended to ensure an inclusive, ecosystem-based approach to the formulation and adoption of river maintenance plans for farming areas:

1. Define the study domain, preferably from a whole-catchment perspective and, as a minimum, from a geomorphological reach perspective;
2. Identify an accountable, representative body that should take unbiased custodianship of the river maintenance plan and drive its implementation (working via a Water Users Association or farming association will facilitate ecosystem-scale planning and governance, and helps with the co-ordination and monitoring of maintenance);
3. Identify key stakeholders, starting with the users and custodians of the affected system;
4. Divide the river into useful management units, which can be based on reaches or property frontages;
5. Undertake a rapid baseline (Ecostatus) assessment, which should incorporate review of historical changes in land use and river morphology;

[3] This protocol is based on discussions with *inter alia* Jeanne Gouws, Donovan Kotze, Mark Rountree, Rudolph Röscher and Nik Wullschleger.

6. Identify major drivers of river disturbance and instability – human and natural, and their primary and secondary effects (this analysis would include identifying typical maintenance-related activities, such as channel clearance, removal of flood debris from in-stream sumps, or repairs to eroded river banks);
7. Identify conservation priorities and/or obligations within each management zone on the basis of the Ecostatus assessment and existing conservation plans and catchment management strategies;
8. Solicit input from stakeholders on their priorities and objectives (it is critical that riparian landowners and resource managers participate in this process);
9. Set management objectives based on need for ecological and economical sustainability (e.g. halt the loss of high priority wetlands, curb erosion and sedimentation that threatens agricultural resources, rehabilitate areas undergoing active ecological degradation that threatens agricultural resources, facilitate sustainable use of wetland resources while maintaining minimal essential levels of ecosystem function and services, etc);
10. Identify areas in different reaches where management or rehabilitation interventions are necessary and/or appropriate (this should be determined through consultation with key stakeholders);
11. Define best practice guidelines for implementing rehabilitation and maintenance (these measures would be drafted as method statements for rehabilitation and maintenance respectively);
12. Design a plan for ecological monitoring which is specifically linked to the stated objectives; and
13. Develop an implementation programme and review mechanism (implementation preferably should be linked to specific projects or programmes for which designated stakeholders take funding and/or management responsibility).

From this, it is apparent that the development of a river maintenance plan is a collaborative endeavour that potentially has broad geographical and institutional boundaries defined by the system at hand, the extent of environmental management priorities that need to be attended to, as well as the different interests and mandates that need to be co-ordinated to this end.

DISCUSSION

There are three fundamental considerations that need to be taken into account when formulating an environmentally appropriate response to maintenance plans in the context of the legislative framework of the day:

- Firstly, there will be constant friction between economic interests and environment objectives as long as farmers feel compelled to take measures to control the negative impacts of floods, erosion and sedimentation on land and infrastructure, and its productive use. This situation is directly attributable to the prevalent and apparently immutable occupation and utilisation of floodplains for intensive agricultural production.

- Secondly, maintenance plans may introduce some *ad hoc* regulatory relief to farming but will fall substantially short of contributing to the resolution of long-standing and complex environmental problems arising from a long history of human dependence on rivers and floodplains in the Western Cape.

- Thirdly, farming needs to be approached as a form of ecosystem management in which the maintenance and restoration of at least an accepted minimum level of riparian ‘ecological infrastructure’ in terms of explicit ecological thresholds is as much an agricultural goal as a conservation one. Posited thus, farms become the focus of strategically-guided adaptive management, rather than rural equivalents of construction sites in which management is *ad hoc*, reactive and divorced from the overall imperative of promoting the optimal use and resilience of the natural resource base.

There are no readily evident and affordable solutions to decreasing the chronic vulnerability of floodplain-based agriculture to floods, or the ecological degradation that results from established agricultural management practices in rivers.

A desired objective would be to gradually withdraw land out of production where it is at risk from flooding and erosion. Judicious engineering and recovery of land to allow lateral dispersal of high flows into reclaimed floodplains could represent a complementary strategy in support of flood mitigation and adaptation. However, such options would entail major economic costs for which calculations as to their affordability and desirability probably still need to be done. There are also attendant socio-economic and political ramifications. We need open debate on these questions which remain sorely under-researched.

The protection and maintenance of agricultural resources and infrastructure in rivers and floodplains cannot be divorced from the natural processes that drive these systems. Neither can we ignore the fact that these systems have been profoundly changed by human use, are highly unstable, and that their resilience and productivity are as a result severely compromised. Also, it needs to be squarely recognised that regulatory control has been dismally ineffectual in stemming the degradation of our aquatic ecosystems in rural areas, and that there is little prospect of this situation changing for the better if we remain fettered by current outlooks and practices. Ideally, therefore, we need to redefine our focus towards pursuing an agro-ecosystem approach that is premised on desirable environmental outcomes instead of mechanistic compliance with an inflexible, decontextualised and ultimately unhelpful system of environmental regulation.

RMPs that focus on restoring or maintaining functional relationships within ecosystems, using adaptive management and carrying out management actions at a scale that is relevant to the issues being addressed have much potential to promote efficient co-operative action in support of healthy, useful rivers on farms in the Western Cape and further afield.

RECOMMENDATIONS

Regulatory provisions for management plans in support of river maintenance are a relatively recent addition to the South African environmental rule book. The lack of substantive definition of such plans is viewed as a vital attribute that provides rare space to debate and share experiences across a wide front of stakeholders who have an interest in the productive use of aquatic ecosystems in support of sustainable agriculture and rural development.

The purpose of such debate *inter alia* would be to negotiate an informed consensus as to what, qualitatively, can reasonably be expected from such river maintenance plans, how best to achieve this, and to define a measure of best practice that gives practical effect to the principles of the ecosystem approach in one of the most neglected realms of environmental management in South Africa – the country’s farms.

The following proposals are offered for debate:

- Farming, maintenance and construction-related activities in floodplains and rivers need to be informed by strategic, ecosystem-based river management plans that are developed on the same lines as LandCare Area-Wide Plans as promoted by the Western Cape Department of Agriculture;
- River management and maintenance plans should be adopted on behalf of bodies that promote integrated and co-ordinated water resource management, such as Water User Associations or irrigation boards, and which undertake maintenance on behalf of their members;
- In the absence of strategic river management plans, maintenance plans submitted for approval in the Western Cape in terms of Activity 18 (LN 1, GN R. 544, 18-06-2010) need to be

explicitly informed by the C.A.P.E./CapeNature fine-scale planning guidelines (Job *et al.*, 2008) for managing aquatic ecosystems and the Ecostatus of the affected river or floodplain;
- River maintenance plans must specifically address and be designed according to interventions relating to river hydrology, erosion and sedimentation, and the conservation and restoration of riparian habitat and ecological connectivity;
- River maintenance must be based on the principles and practices of adaptive management;
- Rehabilitation of riparian and floodplain habitats must be considered as a legitimate form of mitigation and trade-off where maintenance cannot be effected without bulldozing or excavation;
- Maintenance plans must either include or be aligned with programmes to clear and manage riparian areas and floodplains infested with invasive alien plants;
- Agreement needs to be obtained from the Department of Water Affairs on the licensing and registration requirements of landowners or managers who conduct river maintenance in accordance with a formally approved maintenance management plan (could they, for example automatically come into contention for the exemptions provided by the General Authorisation[4] dealing with the impeding and diversion of flow, and altering the beds and banks of a watercourse?);
- There must be a single protocol, endorsed by CapeNature, for maintenance-related baseline ecological assessment, site characterisation and biomonitoring that applies throughout the province; and
- The availability of expertise to undertake ecological assessments and conduct biomonitoring in rural areas, and the affordability of these services, need to be addressed as a matter of urgency.

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