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Gawie du T de Villiers

The management of urban rivers

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This article addresses the problems involved in the management of urban rivers. These problems are identified as channel adjustments resulting from urbanisation, changes in water quality, solid waste disposal, and floods. Suggestions are made for alleviating these problems and establishing rivers which are assets to their urban environments.

Die bestuur van stedelike riviere

Die artikel fokus op die probleme verbonde aan die bestuur van stedelike riviere. Die probleme word geïdentifiseer as kanaalsverandering as gevolg van verstedeliking, waterkwaliteitveranderings, storting van vaste afval en vloede. Voorstelle word gemaak om die probleme te oorkom en om riviere te vestig wat 'n bate vir die stedelike omgewing is.

Prof G du T de Villiers, Research Associate, Dept of Geography, University of the Free State, P O Box 399, Bloemfontein 9300; E-mail: gabv@absamail.co.za

This article is the result of some thirty years' research and practical involvement in the management and conservation of urban rivers. It suggests that management problems in relation to urban river catchments can be classified into four categories: morphological adjustments of channels as a result of land use changes, water quality, solid waste and floods. These are interrelated problems and need to be approached as part of the framework of the whole catchment. However, river restoration and rehabilitation work often focus on specific problems, and are therefore *ad hoc* in nature. A detailed holistic catchment management plan, making provision for emergency action, is consequently an essential prerequisite for a healthy, aesthetically pleasing urban river. Such a plan should set out the required management practices and systems to address the issues. It must also have aims and objectives with a focus on a desired end state. Communication and co-operation with all interested and affected parties are essential. There must also be an accountable person, preferably a management committee with representatives from the whole spectrum of society.

The author was a member of such a committee in Durban for many years and found the urban river an exciting and challenging environment for restoration and management along the lines envisaged by Gregory & Chin (2002: 313).

The current ideal is to have as natural an urban catchment and stream as possible — one in which aquatic life can survive and indigenous vegetation is restored and protected. One should work with the river rather than against it (Montgomery 1997: 328). One should strive for a condition of dynamic equilibrium between the channel and the urban environment. Restoration, rehabilitation, naturalisation, stabilisation, mitigation and purification should be the aim. This has not always been the case, however. Urban rivers were often destroyed and abused by canalisation and pollution. Alternatives to canalisation, using restoration and renovation, were first advocated for urban streams a few decades ago by Keller (1976: 122) and Keller & Hoffman (1977: 238), among others. Restoration to as natural a condition as possible was proposed wherever feasible by De Villiers (1991: 18 & 1993: 104). Restoration always implies channel stability and acceptable water quality.

The four problem categories identified will now be discussed, along with potential solutions.

1. Morphological adjustments due to urbanisation

Morphological changes in the urban river take place because the natural runoff process is altered by urbanisation which disturbs the perceived dynamic equilibrium between the catchment and the channel. Increases in flow velocity result, leading to larger flood peaks and channel growth.[1] De Villiers & Schmitz (1992: 28) recorded flow velocity increases of around 25% and flood peak enlargements of about 200% in the lower Mbokodweni River. In a city, unabated channel growth can often not be tolerated because it endangers the urban fabric. Channel stabilisation may therefore be necessary, but only in carefully selected parts, where sinuosity and turbulence may cause problems. Although empirical and theoretical work on river meanders suggest that instability is an inherent aspect (Hooke 2003: 242), a stream could still oscillate in sinuosity and eventually maintain a self-organised state (Alabyan & Chalov 1998: 470). Schumm (1994: 133) has also pointed out that perturbations may appear persistent, but a new steady state will ultimately be reached. The implication of this is that concrete channelisation (Photo 1) is not an option. It not only destroys the river as a living organism, but often leads to the river environment as a whole being regarded as unattractive and therefore neglected, resulting in a variety of environmental and socio-economic problems.

Restoration and soft engineering methods offer solutions, including the use of gabion wire baskets filled with rock. These baskets, usually measuring a cubic metre, are stacked on a sound foundation in the channel where width growth and bank collapse may be a problem (Photo 2). A good foundation is important, otherwise riverbed erosion will undermine the gabions and the wall will collapse. Bidum cloth behind the baskets will prevent sub-surface erosion and further augment the stability of the bank. The baskets offer sound protection, and are stable and aesthetically pleasing, particularly if riverine vege-

1 Cf Harvey 1969: 84; Gregory 1976: 240; Hollis & Luckett 1976: 354; Neller 1988: 5; De Villiers & Schmitz 1992: 30; Chin & Gregory 2001: 599.

Photo 1: Concrete stabilisation of a channel

Photo 2: Gabions on a concrete foundation. Vegetation such as creepers could be used to soften the visual impact

Photo 3: Flexible concrete grids provide a stable channel in densely built-up areas

tation is used to enhance the restoration. The riverbed is often left in its natural state, which may be bedrock, boulders, sand or vegetation. Flexible concrete networks (Photo 3) with net apertures of about 0.25 m^2 are a more recent alternative for use in densely built-up areas. In this case, grass can also be used to give the appearance of a natural channel.

It is beyond the scope of this paper to discuss all the existing methods of stabilisation, which are documented elsewhere. New approaches, unique to the specific environment, should in any case always be considered. One good example is a wide-based stacked rock wall, without any binding material, which was noted in the Eerste River of Stellenbosch. However, the flood history of a river must always be considered prior to restoration. Such a wall would hardly withstand the flood peaks associated with the summer rainfall region of South Africa. The emphasis should, nevertheless, always be on creating a natural river that is an asset to the environment and to the residents.

2. Water quality

The Department of Water Affairs and Forestry (DWAF 1996: 3) uses the term water quality to describe the physical, chemical, biological and aesthetic properties of water. These determine the fitness of water for a variety of uses and for the protection of the health and integrity of aquatic ecosystems. From this it may be deduced that the water quality of an urban river should be such that it can sustain aquatic life and not negatively affect animals drinking from it or children playing in it. It follows that programmes to monitor the quality of water are essential, particularly on rivers subject to urban influences. Meticulous planning of such programmes is crucial. The positioning of the sampling points must be such as to obtain an overall picture of the catchment and at the same time pinpoint problem spots. The timing of the sampling is also of the utmost importance. A periodic cross-check of the analytical results by a second laboratory is a good idea.

Several extensive water quality sampling programmes were conducted by the author and associates in the Palmiet River in Pinetown near Durban[2] to provide the local authorities with the baseline values for the control of point and non-point pollution. Urban runoff, a form of non-point pollution, contributed significantly to the pollution of the river. In the study by Schmitz & De Villiers (1997: 42-54), where high flow events were sampled by means of an automatic sampler programmed to collect a sample whenever the stream level rose or fell by 5 cm, the non-point effect was clearly illustrated. For example, in one case suspended solids rose from 186 mg/l in the first sample to 1506 mg/l in the ninth, then dropped to 794 mg/l in the twelfth. Pretorius (2002: 5-26), with the author as an associate, found TDS values varying between 481 and 630 mg/l in the Fontein Spruit near Bloemfontein — four times the norm for African rivers. Among other things, she found very high values for PO4-P, resulting from human and animal waste in the catchment. Raw sewage entered the system at times.

2 Cf De Villiers & Malan 1985: 35-42; Du Preez & De Villiers 1987: 23-30; Schmitz & De Villiers 1997: 30-54.

The importance of a clean urban area should be obvious from these studies. Concerted efforts are required to achieve and maintain specific standards of management. This is possible with a water quality management plan (WQMP). The rationale of such a plan is to introduce management guidelines to assist both authorities and developers in the selection of the most appropriate methods for addressing water quality problems. Such guidelines must obviously include a component directed at residents within the catchment area. The key objective of such a WQMP is therefore the integration of the environmental, physical, social and economic issues relevant to the effective management of water quality. A detailed model of such a plan is in preparation for future publication.

3. Solid waste

The littering and dumping of solid waste can have an impact on urban rivers as it may be washed into the channel by surface runoff or, even worse, the river environment itself may be used as an informal dumping site. The Pinetown studies referred to earlier demonstrated this problem. The majority of visitors to the CBD in the catchment behaved in an unacceptable and undisciplined way, discarding urban refuse such as plastic bags. This resulted in the storm water system, and often the sanitation system as well, being blocked by solid waste, leading to overflows and disastrous environmental effects. A well-organised management system for solid waste is therefore a prerequisite for a healthy, aesthetically pleasing urban river. The problem is more acute in developing or informal areas, where proper management of solid waste is often lacking. To address the problem, communal skips may be considered. The skips (large open metal containers) should be located at various points throughout the informal sector, for the residents' household refuse. They should be regularly removed and emptied at the official landfill site by the local authority or agency responsible for waste management.

The transfer of household refuse from a dwelling to the skip may be the responsibility of the household but alternatively, a local contractor may be appointed to collect it from households and transfer it by hand, bicycle or cart. The appointed person should also be responsible for maintaining and cleaning the area around the skip. The factors crucial to the success of the system are:

- reliable and regular removal of skips;
- maintenance and cleaning of the area around skips;
- strategic distribution of skips, in close proximity to every household, and
- a desire on the part of the community to keep its area clean (Pretorius 2002).

The Tidy Town Programme, an initiative of the Keep South Africa Beautiful organisation may also be considered for implementation. The Tidy Town Programme offers a systematic community-driven education-and-awareness approach to changing the attitudes, perceptions and practices of communities in terms of the way they handle their waste. The key objectives are to encourage, educate and empower members of the community to participate in the effective handling of waste in their arrea. The programme makes optimal use of local resources and emphasises capacity building so that a community, in association with its local authority, will be enabled to raise environmental awareness levels in order to deal effectively with its local environmental problems by means of voluntary community participation (Nyamane 2000: 59).

4. Floods

The impact of floods on urban river channels has been well documented.[3] The most frequently cited effects are bed and bank erosion, the loss of riparian trees, and damage to riverbank structures. In this discussion, more attention will be paid to management in the urban floodplains, for which a floodplain management system is essential. Booysen (2001), with the author as an associate, investigated the theme. Elements of the floodplain management system include a floodplain management committee, flood studies, and floodplain management plans. The floodplain management committee should be in charge of

3 Cf Leopold 1973: 852; Graf 1975: 691; Gregory 1976: 238; Knight 1979: 184; Neller 1988: 4; Beven & Carling 1989: 126; De Villiers & Schmitz 1992: 26; Chin & Gregory 2001: 599.

the management process. It may consist of council members, industrialists, and members of the local population.

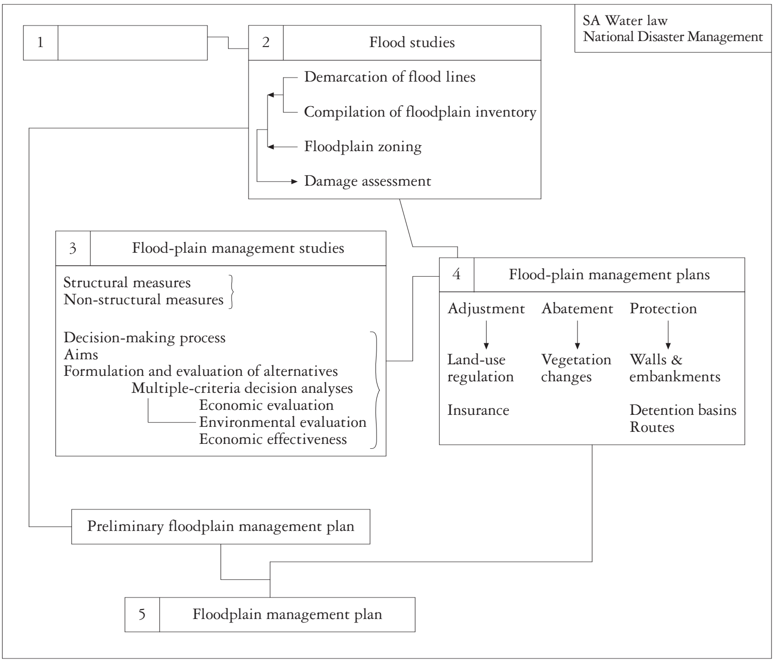
Flood studies are those activities that have to be executed in order to study the characteristics of floods. One of the first such investigations is the erection or establishment of flood lines to identify the flood plain and divide it into zones so that disaster managers can identify risk areas and plan emergency actions such as evacuations. Ground practices determine the potential for flood damage and thus the potential risk areas in the floodplain. Together with the flood line inventory, hydraulic and hydrological information can be utilised to compile risk analyses and flood risk charts. The final aspect of flood studies is the calculation of potential flood damage. This can serve as an indication of the impact of floods and can also be used to evaluate potential measures for the reduction of flood damage.

Floodplain management studies, the next step in the management system, are undertaken to identify appropriate structural or non-structural measures and to evaluate their effectiveness. The non-structural approach consists of activities planned to reduce the effect of floods without erecting structures to change the flow of the river. Structural (physical) measures to reduce flooding include temporarily storing flood water, building flood walls around risk areas, and developing floodways (Booysen 2001: 102).

Floodplain management plans combine various activities aimed at the reduction of flood damage in a package of measures. This starts with the decision-making process where goals, policies and/or strategies are developed. The next step is to identify the various measures that could be utilised to reduce flood damage. Several techniques exist for combining various projects into an optimal package of measures, or for evaluating different measures, as in the case of flood damage reduction. Two of these, namely Cost Benefit Analysis (CBA) and Multiple-Criteria Decision Analysis (MCDA) are discussed by Booysen (2001: 79-84).

The floodplain committee must supervise and monitor all the processes in the system (see Figure 1). Box 2 shows that flood lines have to be demarcated in order to identify land that will be submerged under certain conditions. Most local authorities in South Africa use the 1:50 year floodline as an indicator and do not permit development below this line. Notwithstanding this ruling, long-established urban areas may well lie below the line, and thus require protection. An inventory of the floodplain must then be compiled and used along with the hydrological and hydraulic information which is also an outcome of the assessment of flood lines and risk zones. The risk zones must be managed according to the risk characteristics. Measures for the reduction of flood damage are a further essential consideration (box 4). The gabion walls mentioned earlier can also be used for flood protection. Alternatively, detention basins can be very effective in reducing flood peaks. All alternatives must be evaluated by means of socio-economic techniques (box 3). The MCD procedure is recommended for this purpose.

Figure 1: A system for the management of urban floodplains in South Africa



5. Conclusion

An urban river should be an asset to residents of the arrea, not a liability or a problem. It should be an area where they can relax, with relatively good quality, controlled stream flow, lush vegetation and an attractive, stable channel. Bird watching and even fishing should be possible. However this is only the case with sound management and participation on the part of most individuals and groups. Once this scenario is achieved and maintained, it has many positive spin-offs in the form of increased land values, growth in business activities, visits to the city by tourists and, ultimately, a larger tax income. There are many examples of urban rivers which fall into this category, in South Africa as elsewhere, but unfortunately many rivers are little better than channelised sewage drains. The Bloem Spruit, running through the heart of Bloemfontein, is a typical example.

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