

**A RIVER REHABILITATION PLANNING PILOT TRIAL:
THE IHLANZA RIVER, EAST LONDON, SOUTH AFRICA
BASED ON THE AUSTRALIAN RIVER REHABILITATION
GUIDELINES**

AC Uys

WRC Report No. 1309/2/04



Water Research Commission



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THE IHLANZA RIVER, EAST LONDON, SOUTH AFRICA
Based on the Australian River Rehabilitation Guidelines**

**VOLUME 2
Parts 1 of 2: Text**

by

AC Uys
A Report to the Water Research Commission by
LAUGHING WATERS
Aquatic Research Consulting Media

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**A River Rehabilitation Planning Pilot Trial:
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Based on the Australian River Rehabilitation Guidelines

PROJECT K5/1309 VOLUME 1
Part 1 of 2: Text

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A Report to the Water Research Commission by
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EXECUTIVE SUMMARY & DOCUMENT STRUCTURE

VOLUME 1: REPORT ON THE PROCESS

Volume 1 documents the project in written form, and includes Introduction, Methods and Results chapters, as well as chapters on Natural and Present State and Future Attainable State and objectives for each segment. A chapter providing commentary, recommendations and conclusions completes the report.

CHAPTER 1: INTRODUCTION

Many streams and rivers around South Africa have been extensively degraded as a result of development and urbanisation. While guidelines for the rehabilitation of such rivers have been produced in a number of countries, there are as yet no formal guidelines available for this practice in South Africa. The purpose of this project was to trial the existing Australian Stream Rehabilitation Guidelines of Rutherford et al (2000) on a degraded urban river in South Africa. The intention was to plan the rehabilitation of the selected river, following planning Steps 1 to 9 of the 12 step Australian method. The Ihlanza River in East London was selected for this exercise. The river has a catchment size of less than 10km² and in its short length has been exposed to many typical urban impacts. Floods in August of 2002 caused enormous damage to a shopping centre which has been built over the main channel of this river.

CHAPTER 2: METHODS

The method adopted for the study is divided into twelve steps, each of which comprises a number of tasks. The first nine of these, as undertaken, are described and the relevant adaptations required for the present study are outlined.

The basic twelve steps are as follows:

- | | |
|----------|--|
| Step 1: | Develop a Vision and a Goal |
| Step 2: | Share the Vision and the Goal |
| Step 3: | Describe the stream condition |
| Step 4: | Identify the Assets and Problems |
| Step 5: | Set priorities |
| Step 6: | Identify strategies to protect assets and improve the stream |
| Step 7: | Set specific objectives |
| Step 8: | Check the feasibility of objectives |
| Step 9: | Detailed project design |
| Step 10: | Plan the evaluation |
| Step 11: | Schedule and supervise the works |

Step 12: Assess and maintain the project

The exact ordering of the steps and tasks should be iterative rather than linear. Certain of the steps are similar in approach to methods in use in South Africa at present. For example, Step 3 relies on methods also used in the Ecological Reserve Determination (DWAF 1999) process and in River Health Programme 'State of Environment' (RHP 2003) reporting.

CHAPTER 3: RESULTS

Step 1:

The Vision for the project is summarised as follows: *To restore the Ihlanza River to its pre-impact dynamic equilibrium state, in which water quality is impacted only by areas or periods of no-flow; the water table is raised; the channel is predominantly stable, with well vegetated banks and a somewhat meandering planform; the riparian area is vegetated with transitional coastal forest, such that most of the stream is shaded; and the biota shows a balance between diversity, abundance and sensitivity.*

Recognising this Vision to be unattainable, the more realistic Goal is summarised as follows: *To return the Ihlanza towards a healthy ecological and physical state, while recognising that it has a number of urban functions. To recognise and increase the stream's natural and amenity value to the community. To improve the instream and riparian biodiversity within the stream corridor, and to make it a safe, attractive and indigenous recreational green belt in the suburbs. To protect and enhance the estuary by including it as part of the Nahoon Nature Reserve.*

Step 2:

The Goal for the river was developed in consultation with a number of individuals who previously comprised the Ihlanza River Watch, a community project concerned with the upgrading and enhancement of the river. Other individuals identified as important roleplayers in the exercise include the Buffalo City Municipality, who have jurisdiction over the river; relevant Ward Councillors; representatives of organisations, commercial enterprises, and institutions in the catchment; and property owners in the catchment. Wherever possible these individuals were contacted, and meetings or discussions were held. A number of news articles were published to create public awareness of the project. National-level legislation and local-level regulations were examined. Means of increasing support for the goal included networking, creating awareness of rehabilitation benefits, and capacity building within the community.

Step 3:

The river was divided into 6 zones, 10 segments and 30 reaches for this study, on the basis of ecophysical, infrastructural and logistical criteria. Within each segment,

at least one reach was surveyed. Specialists representing the component disciplines of geomorphology, riparian vegetation, fish and invertebrates undertook to describe Natural (pre-impact) State, the Present Ecological State, and the Future Attainable State of the respective reaches, following standard techniques already in use in South Africa. Each of the 30 reaches of the river was then mapped using GIS (Geographical Information Systems) software.

In its natural state, this river would likely have been a wetland in its upper reaches, with an ill-defined channel. In its middle and lower reaches the channel would have had a similar planform to its present state, however with well-vegetated, sloping banks, and a riparian zone comprising coastal dune forest and scrub forest. Water quality would have been natural and hydrology typical of a small Eastern Cape coastal stream (i.e. probably perennial and relatively flashy, with low flows through the year). The instream biota would have included fish species such as *Barbus anoplus*, *Glossogobius callidus* and *Sandelia bairdii*, *Anguilla marmorata* eels, and a diverse macroinvertebrate community. The estuary condition would likely have been similar to present day, except for water quality.

The present state of most of the system reflects the degree of impact to which the system has been exposed, particularly in terms of water quality and quantity. Water quality is considered to be highly degraded, largely as a result of leakage and spillage of diluted sewage into the river, particularly during high flow events. Instream biota is disturbed. No fish were collected or observed in the freshwater section of the river, and poor invertebrate communities exist along the river. The riparian zone is highly invaded with exotic vegetation along much of the river. In several sections, bankside areas have been grassed and planted as parkland, with ornamental shrubs and trees.

Step 4:

The description of Assets (features of the river which have not changed since natural conditions) and Problems (features which threaten these Assets) was only done at those sites at which there were still natural features.

Step 5:

A number of different prioritisation exercises were undertaken, following the principles of prioritisation described in Rutherford et al. (2000). On the basis of this exercise, the estuary was prioritized most highly for protection of the relatively intact riparian forest, and conservation of the avian and mammalian fauna. Lower reaches of the river were prioritised next, on the basis of their local conservation value and the necessity to protect remaining natural features. The middle sections of the river are actively deteriorating, and were prioritised for arresting degradation and prevention of further deterioration. The upper-middle reaches, which are in relatively good overall condition (excepting water quality) were prioritised for expansion of remaining natural features. In the lower-middle reaches, where recovery should be occurring but is prevented by some problem, the priority is to address the present problems. Reaches which need immediate attention (associated with relatively high costs) were assigned a relatively low priority using this method. This is a concern as

the specialists' feeling was that these reaches had several limiting problems and should be addressed as a high priority, in terms of water quality at least.

Step 6:

Strategies were identified for i) the protection of environmental assets and/or the prevention of degradation; ii) the improvement of environmental assets; iii) fixing present problems. Where there were few or no assets for the Ithanza, the decision was taken to identify strategies for protection and improvement of the area.

Step 7:

Objectives were set in terms of what were considered to be 'attainable conditions' for the ecophysical condition of the five river zones. These were measurable only in that they specified a **range** of desired and achievable outcomes. For each of the ten segments, an additional series of objectives was drafted in each of three categories: Ecological, Infrastructural, and Social/Educational/Recreational. These categories reflect the likely implementation groups: natural scientists; engineers and local authorities; and communities, teachers and pupils respectively. Exact spatial scale was not defined for the objectives in most instances, as it was considered preferable to detail this during the design phase, once there was support for the objective and costings were available for the various different treatment options. The objectives were described in terms of an acceptable time period for rehabilitation, from the time of intervention. Objectives were typed chiefly in terms of **outcomes** rather than **outputs** (sensu Rutherford et al. 2000).

Step 8:

In checking affordability of objectives, the costs of planning and mobilising the project were taken into account early on in the project process. For the planning process, eight specialists (each charging R1500-plus per day) were budgeted for. Information and mapping costs also considered. The national laws investigated (Uys and Ruiters 2002), were considered inadequate to cover the activities required by rehabilitation, and the development of a legislative framework for this field was called for (Uys *in press*).

The assessment of confidence or assurance in the positive outcomes of the project, and the calculation of the chance (and extent) of possible perceived 'negative' effects or risks, would require specialist evaluation of final engineering designs, and was thus not possible for this project. The balancing of estimated costs, risks and outcomes in the project could not be addressed, as detailed costings for interventions were not undertaken.

Step 9:

Conceptual designs to meet the various objectives of the study were developed or accessed. It was considered premature to provide the detailed design called for in this step.

CHAPTER 4: PRESENT ECOLOGICAL STATE

In this chapter, each river segment is dealt with as a unit. The segment is described, followed by a description of likely Natural State, and Present Ecological State for each of the components investigated (geomorphology, vegetation, fish, invertebrates). Where appropriate, the Assets and Problems are presented. The maps and relevant plates for each reach of the segment are referred to, and are presented in Volume 2.

The Present Ecological State of each segment of the river, as described in terms of the interim Department of Water Affairs and Forestry Classification System (comprising categories A to F), is based on the categories assigned to each component, and is as follows:

Segment	Overall Present Ecological State	Future Attainable State
1	River buried	River buried
2	F	E
3	D/E	C/D
4	D/E	C/D
5	E	D
6	E	D
7	D/E	C/D
8	D/E	D
9	D to D/E	C or C/D
10	D	C

Where the descriptions of class are as follows:

Category	Broadest Description
A	Excellent (Unimpaired)
B	Very good (Minimally impaired)
C	Good (Moderately impaired)
D	Fair (Largely impaired)
E	Poor (Seriously impaired)
F	Very poor (Critically impaired)

The Present Ecological State of the river thus ranges from a class D to a class F, which both highlights the need for rehabilitation measures and provides an indication of the extent to which interventions would be required to improve the present state.

CHAPTER 5: FUTURE ATTAINABLE STATE AND OBJECTIVES

As with Present Ecological State, the river segment is the basic unit of measurement for the Objectives and the Recommended Rehabilitation Measures. The objectives take into account the priority of the segment, the infrastructural requirements and the social needs in the relevant part of the catchment.

Segment 2, where the river first daylight, is highlighted for water quality treatment and flood remediation. The placement of a flood detention and filtration system in Reach 2 is recommended. The detention basin would have the primary function of flood attenuation, and the additional important function of water quality remediation through biological filtration. The creation of a "closed catchment" area with the use of pigmented concrete palisade fencing is recommended, to limit access both for the protection of the detention structure and to limit access to downstream reaches via the Chamberlain Road culvert.

In Segment 3, remnant indigenous riparian vegetation is highlighted for protection. Various structural adjustments to the channel and banks are recommended to increase flood conveyance, and to address the high levels of bank disturbance and dumping of rubble and waste in this section. The modification of extant cross-channel sewer pipes – to increase flow through – is recommended.

Much of Segment 4 is bordered by the parkland of a retirement complex. Here interventions include adjustments to the channel to enhance hydraulic habitat, the stabilization of banks, maintenance of infrastructure and investigation into the functionality (and importance) of certain infrastructure, including river crossings and cross-channel fences. In the upper and middle sections of this segment, a boardwalk leading to a fragrant garden is the suggested design.

Segments 5, 6 and 7 are bordered by Public Open Space with high access, and as such have been prioritised as the key recreational area of the river. The ecological aim is to enhance ecophysical river health in this section, through various structural adjustments to the channel and the planting of indigenous marginal and riparian vegetation. Alongside this, the plan is to develop a walking and cycling path along the right bank of the river, and to augment this with various other recreational features, including a trim park and an 'environmentally friendly' skateboard park. Horse or foot patrols will be necessary to enhance security in this area which is presently poor.

In Segment 8, the river is again bordered by Public Open Space, however this is a low-access area. Riverside residents have already initiated a programme for the clearing of alien vegetation and replanting of indigenous riparian species on the banksides adjacent to their properties. The ecological aim for this segment is to address the channel sedimentation in the river and to reinstate a healthy riparian zone. This links well to the objective of interacting and encouraging the continuation of the homeowners' efforts in this area, and to address the maintenance and/or upgrading of the sewer system along the banks.

Remnant indigenous riparian vegetation is present on the banks and banksides of much of Segment 9. This is highlighted for vegetation control and replanting, and for protection and expansion of remaining natural features. The segment is largely surrounded by suburban properties and has a golf driving range along part of its right bank. It is recommended that it could border a natural reserve-type estuarine area, and remain a corridor for birds, fish and wildlife).

The estuary, Segment 10, is disturbed by poor water quality and urban infrastructure, including a sewerage pump station at the mouth and a sewer pipe bridge across the mouth of the estuary. This segment is prioritised for upgrading of this infrastructure; protection of remaining indigenous riparian vegetation; conservation of additional biodiversity (juvenile fish, frogs, birds, small mammals); and low-impact recreational use, for the purposes of access to the beach and increasing public awareness of estuarine ecology.

CHAPTER 6: COMMENTARY, RECOMMENDATION AND CONCLUSIONS

This exercise in trialling Steps 1 to 9 of the Australian Stream Rehabilitation guidelines has been beneficial in assessing the method, the financial, human and time resources required for a project of this nature, and the likelihood of achieving the objectives set. The rehabilitation plan will provide the local authority (Buffalo City Municipality) and the catchment community with adequate information on which to base final designs, costing, prioritisation and implementation. This is considered a satisfactory outcome, within the modest budget requested. It is, however, unlikely that such an exercise would be easily repeated unless the budget was significantly improved.

The Australian method provides an excellent and comprehensive toolkit for rehabilitation planners at all levels, and has implicit in it a series of 'checks and balances'. Recommendations for modifications to the ordering and general management of the process include:

- The appointment of an appropriate full or part-time paid coordinator for the project;
- Prior to addressing Step 1, the drafting of a budget and project plan to indicate the feasibility of the process, the information required; the costs of information, specialists and other inputs; and the scale at which the work should be undertaken;
- Prior to project initiation, informing the relevant authority of the project, to harness their support and to ensure a cooperative relationship;
- Initiating the GIS mapping of the river reaches in the early stages of the project, prior to Step 3, so that all mapping is electronic and all reach maps are standardised prior to the specialists' fieldwork.
- Running Steps 1 and 2 and Step 3 in parallel;

- Prioritising the creation of public awareness over the need for public participation, until such time as there is a sound scientific and technical information base to provide the public with material to comment on and make input to;
- Modifying Step 4 (Assets and Problems) for urban systems, to rather answer the question "What are the stream's ecophysical assets, and what threatens these?" (Where ecophysical assets are defined as those river features which contribute to the healthy functioning of the riverine and riparian ecosystem, and ecophysical threats are defined as those features or processes that threaten the assets.
- Between Step 4 and Step 5 (prioritisation), it is recommended that the Future Attainable State (FAS) be considered, on the basis of: the 'Natural (or Reference) State; the Present Ecological State; and the trajectory of change. The FAS provides a guideline for the setting of objectives.
- Augmenting the prioritisation process provided in the Manual with a procedure which takes into account, and appropriately weights, a number of criteria for consideration in the exercise.
- Bearing in mind the setting of objectives from the earliest stages of the project, and recording specialist, community or local authority ideas and desires at any time during the project process, so that they can be reassessed for their feasibility during the objective-setting process.
- To assess measures to meet the objectives need to be considered; conceptual designs considered, and broad-level costings supplied.
- Step 8 requires an answer to the question "are your objectives feasible?". This answer is likely to be based on the broad costings, conceptual designs, legal and other constraints, and other potential negative effects of the recommended rehabilitation measures
- Recognising that Step 9, the detailed project design, represents the beginning of a second project management plan, and requires the assistance of individuals with skills in this arena.

In conclusion, the rehabilitation planning exercise has built capacity in river rehabilitation practice in the project leader, specialist team, members of the catchment community, and officials in Buffalo City Municipality. It has helped to engender an awareness of the river as a continuum, an ecosystem which requires care and maintenance, and a corridor which could provide a great social asset rather than being an urban drain. It is hoped that one of the more lasting outcomes of the project will be the increase in coordinated focus it has provided for a number of groups who have previously been undertaking their actions in an uncoordinated and somewhat disparate fashion.

It should be noted that the level of detail in this report and maps was considered necessary and appropriate to a research project, however, for a similar, non-academic exercise in general rehabilitation planning, it is advised that the work be done at a far less intensive scale.

VOLUME 2: MAPS AND APPENDICES

Volume 2 is a supporting document for Volume 1. The intention of this was to enable the reader to refer to text and maps/photographs/designs simultaneously. Volume 2 contains all the maps which correspond to Present State analyses (Volume 1, Chapter 4), and to the Future Attainable State and Objectives (Volume 1, Chapter 5). All other Appendices, including photographic plates of the river reaches referred to in Chapter 4 (Volume 1), are also included in Volume 2.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Many streams and rivers in South Africa have been severely affected by the process of urbanisation and development. Impacts to these systems include:

- The alteration of natural hydrology due to an increase in impermeable surface in the catchment (e.g. roads, pavements, roofs), and resultant increase in runoff in the catchment during high rainfall events. The flashier, higher flows during these periods can alter channel form either through incision or widening.
- A lowering of the ground-water table, caused by the reduction in infiltration of rainfall and runoff.
- Loss of natural channel alignment through diversion, realignment, or straightening of the stream for the purposes of stormwater and flood management or development. This may be accompanied by the construction of trapezoidal, concrete-lined canals for stormwater management and flood prevention.
- The building of bridges or river crossings over the channel and the use of cylindrical or box culverts as conduits. These cause undercutting and incision on the downstream side, and can result in head-cuts on the upstream side (e.g. Riley 1998). Tree blockages in culverts are common and can increase flood risk.
- The burial of the former channel in box-culverts to facilitate development at the surface (i.e. for the purposes of land acquisition).
- The drainage of wetland areas with canals or pumps.
- The routing of sewer lines and stormwater drainage alongside stream courses.
- The alteration the natural aquatic microbial balance and the contamination of the river as a result of the inflow of treated or untreated sewage effluent, or leakage/surcharge of faulty sewerage systems.
- The alteration of natural water quality as a result of runoff and other urban point-source and diffuse pollution.
- The clearing of banks (and riparian vegetation) for the purposes of development, and the construction of levees on the floodplain.

The international science and practice of river rehabilitation has, in the past few decades, developed a suite of methods and approaches to address the deterioration of urban stream and river ecosystems (Riley 1998). Guideline documents and manuals have been developed in several countries to assist in the implementation of these methods.

In South Africa, the field is in its early stages of development. The term 'river rehabilitation' is often incorrectly used to describe projects which are in fact environmentally-sensitive stormwater management exercises, or the upgrading and landscaping of rivers adjacent to new developments (Uys, *in press*). If the practice is to develop in the direction of achieving international standards, it is necessary to instil an ethic of balancing two types of objectives:

- the improvement of eco-physical form and function of the system (with the end point in some cases being the return towards pre-impact or natural state), and
- the management of urban infrastructure, recreational assets, and aesthetics associated with the river (e.g. Rutherford et al. 2000).

This project represents an attempt to achieve this balance in a practical river rehabilitation planning exercise. As there are as yet no comprehensive South African guidelines available for this process, the Australian Stream Rehabilitation Manual of Rutherford et al. (2000) provided the method on which this trial was based. The intentions were to assess the transferability and appropriateness of these guidelines in a South African context; to evaluate the practicalities of attempting rehabilitation planning with ecological objectives in an urban setting; and to encourage an ethic of *sound planning* in future river rehabilitation projects.

For simplicity, the following terminology is used in this report:

The term 'restoration' implies a return to natural pre-impact state and is thus considered an aspiration, but seldom achievable (Rutherford et al. 2000).

- The term 'rehabilitation' focusses on achievable eco-physical objectives. The goal of rehabilitation is the improvement of important aspects of the stream environment with the aim of the system eventually resembling its pre-impact state (e.g. Rutherford et al. 2000).
- The term 'remediation' is appropriate in cases where it is not possible to rehabilitate due to a river system being irretrievably degraded, or where a system has been fundamentally altered in character but has, over time, adjusted and achieved a state of dynamic 'stability' or equilibrium (e.g. Drury 1966 cited by Riley 1998). This is often the case of a river channel downstream of a dam. The aim of remediation is to improve the ecological condition of the river *per se*, while not aiming for an end point resembling the pre-impact state.

1.2 OBJECTIVES

The objectives of the study were:

- To trial the planning stages of the Australian River Rehabilitation method (Steps 1-9 out of 12 steps) on a small degraded urban stream in East London, South Africa.
- To produce a plan for the rehabilitation of the river, with a view to:
 - returning a functional ecology and more natural physical form to sections of the river, while maintaining its urban functions (flood control, stormwater management);
 - establishing a safe, attractive urban green corridor and recreational area in the centre of East London; and
 - providing an example of how rehabilitation can work and be cost-effective on other urban rivers in the country with similar problems. The intention was not as much to assess the guidelines as to investigate their application within a limited budget, as this was considered to be the likely situation in which most community-based river rehabilitation projects would find themselves in this country.

1.3 THE SELECTION OF THE RIVER

The Ihlanza River in East London was selected for the rehabilitation planning exercise for the following reasons:

- The Project Leader had been involved with a community-based rehabilitation project on this river since 1998 (the Ihlanza River Watch or IRW). This project had achieved little due to a lack of funding.
- A number of the individuals involved in, or associated with IRW were interested in continuing with this project.
- In its length of < 6km, the Ihlanza has been exposed to the full suite of urban impacts already listed, and is as a result highly degraded and in need of attention. Water quality is a particular issue.
- The river flows through middle-to-upper income suburbs in East London, which was thought to improve the ease with which community involvement and participation could be harnessed. It also increased the likelihood of leveraging funding from local residents, schools and businesses for the future implementation of the plan.
- The river enters the sea on a famous surfing beach, Nahoon, in an area where many young surfers are trained. The historic and present levels of

coliform bacteria in the river water are well in excess of DWAF Water Quality Guidelines for both Recreation and for Aquatic Ecosystems (DWAF 1999). This was thought to require attention.

- The majority of the river is accessible for the purposes of survey and sampling.
- The river is under the jurisdiction of the local authority, Buffalo City Municipality (BCM). The Project Leader had established contact with many of the relevant individuals in the Municipality prior to initiating this project, which meant that a great deal of time and cost could be saved.

The major disadvantages of using this river for this study were:

- The lack of historical and current hydrological information on the system;
- The lack of comprehensive water quality data (only basic variables are tested on a regular basis by BCM at two sites on the river); and
- The paucity of previous biological or physical studies on the system (Harrison et al. 2000 did a once-off estuarine study on this river as part of a coast-wide estuary assessment).

1.4 THE IHLANZA RIVER CATCHMENT

The Ihlanza River is effectively a first order system for its entire length. The catchment size is less than 10km², and the total river length approximately 6km, of which almost 1.5km is buried in box culverts. Land-use in the catchment includes formal retail in the upper and middle areas; formal and home offices; institutions (schools, retirement homes); residential; dense residential; hotels, Bed and Breakfasts, Public Open Space (POS) and 'areas under construction' (Map 1.1, Volume 2).

The Ihlanza River rises as a spring close to Western Avenue in Vincent, East London (Map 1.1, Volume 2). Prior to urbanisation of this area, it is thought that the upper reaches of the river would have comprised largely wetland with an ill-defined channel. This section of the river is now buried in culverts that are routed beneath or alongside roads, houses and pavements, through the commercial and residential areas of Vincent.

The Vincent Park Shopping Centre (VPC) is built at the lowest point in the upper catchment. The main wing of the multi-story centre was built over a canalized section of the river. This had previously been routed through the wetland area, and was enclosed to form a box culvert. This runs beneath the main parking area and individual shops in the Centre. As the basement of VPC is situated below ground-level, in former wetland, it is necessary to pump seepage water continuously to avoid flooding. This water is returned to the river via the stormwater network (Koekemoer, pers.comm.).

The VPC has flooded several times in its history. During August 2002, a flood peak occurred in the early hours of the morning after two days of persistent rain, during which the maximum daily rainfall recorded was 317mm (SA Weather Bureau data). It is estimated that up to 300mm of rain fell in a period of less than half an hour (no data available to verify this estimate). Much of the runoff from the upper catchment was prevented from entering the stormwater drainage network due to surface debris blocking the entry grids. As a result, it flowed overland towards the closed basement entrance of Vincent Park Centre. The damming effect of the doors lasted briefly until the water broke through the doors, flowing into the basement level of the VPC, flooding the shops and businesses to a height of well over a metre. Tens of millions of Rands worth of damage was done to goods and property.

The 'river' first daylight into a concrete-lined canal downstream of a residential area in Neale Road, Vincent (Reach 1, Map 1.2). The canal continues through a steep-sided area which was formerly a quarry (Reach 2, Map 1.2, Volume 2). Water flows through the box culvert beneath Chamberlain Road river-crossing, and into natural channel in the grounds of the Berea Gardens Retirement Complex on the right bank, and Port Rex and Hudson Park High Schools on the left bank (Reaches 3-9, Map 1.2, Volume 2). The middle and areas of this segment are grassed and planted private parkland, and the lower areas are zoned as Public Open Space (POS).

Further downstream, the river is routed through a culvert under the North East Expressway and Old Transkei Road, and through a large energy dissipator (stilling well) downstream of the road crossings. From here and downstream (Reaches 10-27), the river banks and sections of adjacent floodplain are routed through a variable-width band of Public Open Space (POS) adjacent to middle and upper-income residential properties in Stirling and Nahoon. In the last 1-2 km of its length (Reaches 28-30), the river flows through relatively undisturbed Coastal Dune forest, and into an estuarine area which is largely undeveloped and relatively natural. The Ihlanza mouth is on Nahoon beach.

With the urbanization and commercialization of the catchment (and particularly the upper areas) has come an increase in the amount of hardened or impermeable surfaces such as roads, pavements, roofs, and parking lots. Water which would previously have recharged the groundwater must now be treated and managed as surface runoff. The stormwater drainage system in the upper catchment was designed for about 80% hardened surface, but is actually catering for almost 100% impermeability, with the result that problems have arisen in the catchment with stormwater management, particularly during flood events. The other physical consequence of reduced infiltration rates has been the lowering of the water table.

In the upper section of the river, upstream of the North East Expressway, the Ihlanza is particularly vulnerable to sewage spills during high rainfall events. This is because the area's main sewerage pipe (which is gravity fed) is routed alongside the river and stormwater drainage network. At various intervals along the pipe, there are manholes with steel covers designed to be 'pop' open under

upward pressure, allowing surcharge of diluted sewage directly into the river canal or channel. This is not strictly a municipal attributable to engineering or design flaw, but is commonly related to individual developers, builders or property owners discharging stormwater runoff into the sewerage system rather than the stormwater system. Regularly, during a high rainfall event, the capacity of the sewerage system is exceeded and diluted sewerage is surcharged into the river. In the upper sections, this results in the channel substrate being covered with sewage fungus, and no animal life being observed or collected during sampling.

CHAPTER 2

METHODS

2.1 THE AUSTRALIAN STREAM REHABILITATION PROCESS

The Australian stream rehabilitation planning process of Rutherford et al. (2000) is divided into 12 steps, each of which consists of a set of 'Tasks'. It is viewed as an iterative method rather than a linear one (i.e. the planner is likely to return to earlier steps and reassess them in the light of later steps). This is illustrated in Figure 2.1. A 'reality check' is built into each step, encouraging the planners to revisit previous steps. The procedure achieves a good balance between technical considerations and practical issues.

The method is detailed fully in Rutherford et al. (2000) and summarised in Uys (*in press*). For convenience and easy reference, this summary is reproduced in Appendix 1, and only the basic twelve steps and the modifications to them as required by the Ihlanza River Project are presented in this chapter.

NOTE: The interested practitioner is referred to the original manual of Rutherford et al. (2000) for the comprehensive guidelines.

2.2 THE APPROACH ADOPTED

While the Australian procedure was the basis of this planning exercise, the intention was also to allow the project to develop its own 'life' within the community, in the eyes of the local authority (Buffalo City Municipality or BCM) and from a more formal scientific perspective. It was considered important that this pilot trial should not be primarily an academic exercise, but that it should be focussed on establishing (and teaching others) 'how' to approach a rehabilitation exercise, in a way that would both create awareness and encourage the involvement of key role-players such as BCM, schools, and members of the catchment community. As such, extensive effort has gone into relationship-building during the project.

It was also an intention that the specialist team commissioned to assess the present and future-attainable state of the river should use methods already in use in other, linked, South African programmes, particularly those of the River Health Programme (RHP 2003), and those use in Department of Water Affairs and Forestry's (DWAF) Ecological Reserve Determination process (DWAF 1999). The intention behind this was to check the appropriateness of these methods in a rehabilitation context, and (in the longer term) to attempt to link rehabilitation planning to River Health programme activities and/or Environmental Flow Determination type projects, or at least to encourage sharing information where possible.

As discussed in Uys (*in press*, Chapter 5), there are many steps common to the rehabilitation planning process, the Environmental Flow Requirement process (or Ecological Reserve Determination), and the River Health Programme methods. For instance, all three procedures require a 'present state' analysis for all components (geomorphology, riparian vegetation, fish, invertebrates), and typically use the same methods to derive this. It would be logical to gradually align or link these processes between programmes, to facilitate information-sharing, improved application of information, and substantial cost-saving. This would also encourage integrated catchment-scale planning.



Figure 2.1. The 12-step rehabilitation procedure (from Rutherford et al. 2000)

2.3 THE METHOD AND MODIFICATIONS TO IT

Only the planning steps, i.e. Steps 1 to 9, were completed for this project. The intention behind this was that throughout this process, the catchment community and local authorities should be encouraged to take responsibility for the implementation of the plan. This would likely lead to more sustainable outcomes.

In this Section, the 9 step planning procedure is highly summarised, with individual tasks listed, and the modifications as required by the project are described.

2.3.1 STEP 1:

The definition of both a vision and a goal for the river is a slight adaptation of the method of Rutherford et al. (2000), who only require the definition of a vision. The rationale for this is provided in Appendix 1 (Step 1). In this case, the vision was to be based on a historic re-creation of the river, and would describe an ultimate, and probably unachievable, end point of the project: the return to the pre-impact, historic state. The goal would be calibrated against this vision, but would be developed on the basis of what was thought to be practically and realistically achievable (see Appendix 1).

2.3.2 STEP 2: SHARE THE VISION AND THE GOAL

The four tasks included under this step were considerations throughout the project. However, the emphasis of the initial planning stages was on the determination of present and future-attainable ecophysical state, rather than on interaction with the public. This was considered necessary within the limited project budget, as public participation processes can be the most time-consuming element of a project. The decision was to interact with a limited group of individuals during the initial planning stages, and to be in an informed position about the river before interacting with the general community. This is a different approach to that taken by Engelsman et al. (2002), who prefer to have the community integrally involved from the outset. Our approach was, in this sense, a trial in itself.

1. Identification of individuals with interests in the stream (including land-owners, water users, authorities, water supply agencies, etc.).

This task had been begun by the Ihlanza River Watch Committee, and is considered to be an ongoing process which to some extent determines the 'life' of the project.

2. Identification of individuals who support and oppose the rehabilitation goals. Identification of relevant legislation and local regulations.

This task was addressed in the early phases of the project. However, this was a small and non-threatening rehabilitation planning exercise and once the local authority (BCM) were involved and supportive, it was felt there would be few individuals opposing the rehabilitation goals. These individuals also became known to us during the planning process. As discussed, it had also been decided that, in principle, the general public would only be involved once the technical information regarding the river was available to them, to allow them to make informed decisions.

National-level legislation pertaining to the project was examined in Uys and Ruiters (2002). Local-level regulations proved more difficult to access and examine. The results of this process are presented in Chapter 3.

3. Identification of individuals with the power to help or hinder the attainment of the goal.

Catchment land-use maps, cadastral maps with erven numbers (which could be linked to home-owners), and knowledge of the area were used to identify those individuals likely to be in a position to help or hinder the attainment of the goal. It did, however, become apparent during the process who these individuals were. This again emphasized the need for relationship-building during the project.

4. Decision as to how to increase support for the goal.

As this was a research project rather than a community-driven project, decisions such as this were not often made collectively. The decisions were rather based on a combination of meeting with individuals, holding discussions with the specialist team, having ongoing interaction with the local authority, and reviewing the experience of other rehabilitation practitioners.

2.3.3 STEP 3: DESCRIBE THE STREAM CONDITION

1. Divide the stream into segments and reaches.

The Ihlanza River was divided into six zones, ten segments and 30 reaches, as shown in Table 2.1 and illustrated in the introductory maps in Volume 2. From a scientific perspective, these divisions should ideally be based on eco-physical criteria (see Appendix 1, Step 3). However, in planning the rehabilitation of an urban river, a balance must be sought between ecological, social and infrastructural requirements, and the process of dividing the stream in to smaller units should take this into account. For instance, in dividing the river, it was necessary to consider the most useful scale for a planning unit.

Table 2. 1. The units, scale and description of the river divisions for this project.

Unit	Scale	Description
Zones or Areas of Interest (6)	Kilometre	This is based on an original zonation done by BCM on the basis of the expected longitudinal zonation of a river, i.e. upper, middle and lower reaches, and estuary. This has been slightly modified for the purposes of this project, and provides six easily recognisable and large-scale units for use in planning and prioritisation.
Segments (10)	> 250m	The segments were delineated on the basis of both urban criteria (e.g. road crossings, areas bordered by Public Open Space) and ecophysical criteria (e.g. the relative homogeneity of the river channel, excepting in Segment 6). The likely size of a river unit that could be practically used for planning purposes was also considered.
Reaches (30)	< 250m	This was done initially at a desktop level, dividing the stream segments into what would appear to be relatively physically homogenous units of stream of up to 250m. At least one reach per segment was to be sampled or examined by specialists, so it was important that the individual reaches should be more-or-less representative of the segment as a whole. The Reach length was considered practical for sampling purposes, and useful in that final reach maps could be presented at a reasonable scale for visibility, and presented on an A4 landscape page. The initial divisions were then ground-truthed and adjusted on the basis of physical homogeneity and the meaningfulness of the reach as a planning unit.

2. Construct a template of what the stream should look like (ideally in its pre-impact state).

Available documentary information on the catchment in the form of maps, aerial photographs, satellite images, plans, GIS files, and documents were sourced from BCM Directorates of Development Planning and Engineering Services. For the most part, BCM assisted willingly, however this exercise was reasonably expensive. Costs would have been reduced by having the project declared a municipal project, however this is a lengthy undertaking and despite initiating it, would have taken too long in terms of the project planning.

The information available was examined at length by the specialist team in the further planning stages. All specialists were requested to examine the maps and aerial photographs in particular, and discussions were held regarding likely pre-impact (or natural) conditions.

3. Describe the present condition of the stream.

During the first two weeks of November 2002, a group of riverine specialists were contracted to this project to survey the river to gather information regarding the likely natural / pre-impact state, Present Ecological State (PES), and Future Attainable State (FAS) of each segment, based on sampling or surveying of at least one representative reach per segment. The specialists and their relevant study components are listed in Table 2.2. A number of other individuals closely associated with aquatic ecosystem rehabilitation-type work were requested to join the team for part, or the whole, of the field exercise, both to expose them to the project and to get their input on the rehabilitation planning exercise, and to consider linkages with the projects they represented. This added great value to the project team in terms of additional expertise. These individuals are also listed in Table 2.2.

An attempt was made to coordinate the surveys and sampling, such that there would be a number of specialists on site simultaneously in order to optimise information-sharing and discussion regarding river condition. The team gathered for discussion at a central venue each morning and at midday. This process was both practical, facilitated exchange of ideas, and was cost-effective. Feedback from the specialists regarding this approach to the fieldwork was good. The local newspaper were requested to run a short story on this field work and this was printed the following week (Appendix 2). Ms Debbie Reynhart, the vegetation specialist, also wrote in her weekly column about this survey (Appendix 2). There were a number of phonecalls in response to these articles, offering either information or future support.

The specialists had been briefed ahead of time to use sampling or survey methods consistent with those being used in the Reserve Determination process (modified from DWAF 1999) or in River Health Programme monitoring. The majority of specialists had experience of data collection for either one or both of these processes. On the basis of these methods, the specialists were required to provide a brief description of:

- Assumed Natural (Pre-impact) State on the basis of available information, professional experience of the region, and professional judgement;
- Present Ecological State categorisation of the river (using the DWAF categories of A to F as shown in Table 2.3);
- A description and categorisation of Future Attainable State, and
- Other relevant information pertaining to their specialist component (such as taxa collected).

Table 2.2. Specialist team and additional assistance for the study

SPECIALIST TEAM		
Specialist	Organisation	Study Component
Dr Andrew Birkhead	Streamflow Solutions cc Gauteng	Channel cross-sections at 5 sites
Dr Anton Bok	Anton Bok & Associates Port Elizabeth	Fish survey
Mr Greg Brett	East London Museum	Fish survey
Dr Lesley McGwynne	Private Consultant	Estuarine survey
Dr Emile Plumstead	University of Transkei	Estuarine survey
Ms Debbie Reynhart	Down 2 Earth East London	Riparian vegetation Landscape planning
Dr Mandy Uys	Laughing Waters	Project Management, Invertebrate survey, Planning and GIS Mapping, Reporting
Dr Roy Wadson	IWR Environmental	Geomorphological survey
ADDITIONAL ASSISTANCE		
Individual	Organisation	Discussion Assistance
Mr Japie Buckle	Technical Manager, Working for Water, Eastern Cape	Riparian invasion Links to Working for Water
Ms Mary Bursey	Specialist ecologist East London Museum	Freshwater molluscs Riparian vegetation
Dr GV Price	Terreco cc. Geotechnical and Environmental	Geotechnical advice on the feasibility of various structures.
Mr Johan Koekemoer	Manager: Wastewater BCM Directorate of Engineering	Discussion regarding a flood detention structure in Neale Road section
Dr Ed Thexton	Director: Riparian Australia. Full time coordinator for the an Urban Creek rehabilitation project in Victoria, Australia, for 10 years.	Advice on the rehabilitation project as a whole. Riparian vegetation specialist input.

Table 2.3 Broad-level categories for Present Ecological State (PES) and Future Attainable State (FAS) of the river. Each specialist component has their own methods, criteria and descriptions associated with these categories.

Category	Broadest Description
A	Excellent (Unimpaired)
B	Very good (Minimally impaired)
C	Good (Moderately impaired)
D	Fair (Largely impaired)
E	Poor (Seriously impaired)
F	Very poor (Critically impaired)

The individual methodologies used by each of the specialists in this process are described below.

Channel Cross Sections

Cross-sectional surveys were undertaken at five sites along the length of the river, in Reaches 8, 11, 21, 29 and 30 (Figures 4.1 - 4.5). Fixed bench marks (steel pegs in mortar) were installed at each of the sites for future referencing, and the surveys are relative to local datums. The surveys were performed using a Total Station. Sections 29 and 30 are in the estuary, approximately 160m apart, and are fixed relative to a common local datum.

The purpose of undertaking these surveys was to provide a baseline of channel shape in these sections, against which to gauge future changes. Unfortunately, as hydrological information was not available and flow was too low to measure at the time of survey, the cross-sectional information could not be used to develop hydraulic rating curves (stage-discharge relationships).

Geomorphology

The longitudinal zonation of South Africa rivers reflects regional geology, tectonic events and long-term fluvial action, which together have affected the shape of their long profiles. The classic concave long profile may be disrupted by a number of features including outcrops of more resistant rock, and rejuvenation due to tectonic uplift or a fall in sea-level. Rowntree and Wadson (1999) have developed a zonal classification system for South Africa based on work carried out on a number of different rivers around the country. This is presented in Table 2.4, and is used to type the different zones found within the river system.

Table 2.4. River zonal classification for South Africa (Rowntree and Wadeson, 1999)

Zone	Zone class	Gradient class	Characteristic channel features
A. Zonation associated with a 'normal' profile			
Source zone	S	not specified	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	A	> 0.1	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
Mountain stream	B	0.04 - 0.099	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool. Approximate equal distribution of 'vertical' and 'horizontal' flow components.
Transitional	C	0.02 - 0.039	Moderately steep stream dominated by bedrock or boulder. Reach types include plain-bed, pool-rapid or pool riffle. Confined or semi-confined valley floor with limited flood plain development.
Upper Foothills	D	0.005 - 0.019	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow flood plain of sand, gravel or cobble often present.
Lower Foothills	E	0.001 - 0.005	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Flood plain often present.
Lowland river	F	0.0001-0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.

Table 2.4. Continued.

B. Additional zones associated with a rejuvenated profile			
Rejuvenated bedrock fall / cascades	Ar Br Cr	>0.02	Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.
Zone	Zone class	Gradient class	Characteristic channel features
Rejuvenated foothills:	Dr Er	0.001 - 0.019	Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/ pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel activated only during infrequent flood events. A limited flood plain may be present between the active and macro-channel.
Upland flood plain	Fr	< 0.005	An upland low gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

2. Present Ecological State (PES) is assessed for each river segment, using Table 2.5 as a guideline to assign a PES class.

3. Longitudinal Profile: The longitudinal profile of the river is calculated on the basis of elevation of the river channel (in metres) at different chainages along the river. For the Ihlanza, flood-level maps (Ninham Shand 1992) were used to calculate this profile. It is presented in the Results section.

4. Future Attainable State (FAS): The FAS is an assessment which is largely based on expert opinion. The class for this State is derived from Table 2.5.

Table 2.5. Present Ecological State (PES) and Future Attainable State (FAS) classes and descriptors for geomorphology

CLASS	Geomorphological Change	Anthropogenic Indicators
A: unmodified, natural	No changes, erosion and deposition within reach are in balance.	No human impacts identified in the catchment
B: largely natural	Short-term changes that can be reset within the frequency of the "bankfull" flood	Human impact identified, but no clear evidence of channel response
C: moderately modified	Slow trajectory of change, can be reset within five to ten "bankfull" events by restoring natural flow/sediment regime and bank stability.	Significant human impacts, changes to bed structure evident, localised bank erosion and channel widening, or deposition and narrowing. Changes reversible in the short term.
D: largely modified	Well into the trajectory of change, may be difficult to restore natural conditions.	Major human impacts resulting in significant long term changes to channel geometry, pattern or reach type, but river is in the process of adjusting its form to the current sediment load and flow regime.
E: seriously modified	Engineering intervention required for rehabilitation.	Channel structure largely engineered, but bed perimeter includes some natural materials that can be worked by fluvial processes (includes gabions, engineered bank stabilisation, channel straightening or re-alignment, bulldozing).
F: critically modified	Major engineering intervention required for rehabilitation.	Totally engineered channel, no natural material in the channel perimeter.

Riparian Vegetation

The riparian vegetation of the Ihlanza River was assessed using the site-based method for the Riparian Vegetation Index (RVI, Kemper 2001). An initial site walkabout was undertaken to record species composition and familiarise the assessor with the site. Further information on various components of riparian vegetation was then recorded, such as site disturbances, extent of exotic invasive plants, extent and distribution of plant cover and evidence of recruitment. This information was scored and used as input to the RVI formula to produce a score out of 20 which was compatible with the six Ecological Reserve Determination assessment classes presented in Table 2.6.

Table 2.6. Scoring criteria and descriptions for different classes (PES and FAS), as they apply to the scores derived using the Riparian Vegetation Index of Kemper (2001).

SCORE	CLASS	DESCRIPTION
19-20	A	Unmodified, natural
17-18	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
13-16	C	Moderately modified, a loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged
9-12	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred
5-8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive
0-4	F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

In addition, a modified version of the Riparian Index for riparian vegetation assessment (Kotze and Steytler 1998) was used. This version took into account physical attributes such as the extent of erosion and alteration of streambank morphology, as well as percentage area altered by human impacts including litter, and alien plant invasion. This also produced a score compatible with the six Ecological Reserve Determination assessment classes.

Fish

From a fish distribution perspective, the division of the Ihlanza River into the six zones (A to F) was considered useful. Surveys were not carried out in Zone A (channel buried or concretised), but the other zones were either inspected visually or surveyed with an electro-fisher. Due to the narrow channel, shallow flow depths and clear water, large stretches of the river could be effectively "surveyed" for fish visually by walking along the banks or in the river bed. The deeper pools (up to 1.5 m) as well as areas that provided potential cover for fish (undercut banks, root wads, etc.) were sampled with the electro-fisher, which is normally very effective under these conditions. As the method for assigning a Present Ecological State and Future Attainable State class to the fish assemblage (Kleynhans 1999) relies on at least 5 species being present in the sample collection, and was thus not able to be used for the Ihlanza. Expert judgement was thus used to assign these classes.

Invertebrates

Invertebrates were surveyed using the South African Scoring System 5 (SASS5) method of Chutter (Dickens and Graham 2002). This is a biomonitoring tool used both in the Ecological Reserve Determination process (DWAF 1999) and in the SA River Health Programme (RHP 2003). It is based on the sensitivity of aquatic invertebrate fauna to organic pollution in the river, on a scale of 0-15, with lower numbers representing higher tolerances.

The method requires the sampling of any or all of the following habitats available in the reach: stones in current, stones out of current, marginal vegetation, gravel/sand/mud. Each of the habitats present is sampled using the appropriate technique and with a 0.5mm mesh hand-held sampling net. The animals collected are tipped into a tray of clean river water or tap water, and the specialist spends up to 15 minutes identifying and recording the animals collected in this habitat. Each habitat is then scored for Total Score (sum of all individual scores), Number of Taxa, and Average Score Per Taxon or ASPT (Total Score divided by Number of Taxa). This is then done for the full suite of habitats, and this final cumulative total represents the SASS5 score for the site.

Alongside this method, a habitat assessment methodology known as IHAS (Invertebrate Habitat Assessment Score, RHP 2003) was used. This assists interpretation of the SASS5 scores. The SASS5 and IHAS scores are generally used together to determine the classes for Present Ecological State and Future Attainable State of the river. As there are, as yet, no criteria available to assign classes to Eastern Cape Rivers on the basis of both SASS5 and IHAS scores, the criteria developed by Thirion (in prep.) (Tables 2.7a and b) for rivers in other ecoregions of the country were referred to, and expert knowledge of the rivers in the region was used to recommend a PES and FAS class per reach sampled.

Table 2.7 a. Description of SASS4 condition classes (Thirion, in prep.)

CLASS	BIOTIC MODIFICATION RELATIVE TO CURRENT BEST ATTAINABLE CONDITION	DESCRIPTION	SASS4 SCORE (% OF REF. CONDITION (Natural state))	ASPT VALUE (% OF REF. CONDITION (Natural State))
A	Unimpaired	Community structures and functions comparable to the best situation to be expected. Optimum community structure (composition and dominance) for stream size and habitat quality.	90 - 100 80 - 89	variable >90
B	Minimally impaired	Largely natural with few modifications. A small change in community structure may have taken place but ecosystem functions are essentially unchanged.	80 - 89 70 - 79 70 - 89	<75 >90 75 - 90
C	Moderately impaired	Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.	60 - 79 50 - 69 50 - 79	<60 >75 60 - 75
D	Largely impaired	Fewer families present than expected, due to loss of most intolerant forms. Basic ecosystem functions have changed.	50 - 59 40-49	<60 variable
E	Seriously impaired	Few aquatic families present, due to loss of most intolerant forms. An extensive loss of basic ecosystem functions has occurred.	20 - 39	variable
F	Critically impaired	Few aquatic families present. If high densities of organisms, then dominated by a few taxa. Only tolerant organisms present.	0 - 19	variable

TABLE 2.7b: SASS4 and ASPT values per ecoregion as an indication of biotic condition (Thirion in prep.). As these ranges are still in development for the Eastern Cape, this table served as a guideline alongside specialist knowledge.

SASS4	ASPT	CONDITION	CLASS
HIGHVELD			
>120	>6	Excellent	A
91-120	5-6	Very Good	B
71-90	4.5-5.5	Good	C
56-70	4.5-5.5	Fair	D
30-55	Variable	Poor	E
<30	Variable	very Poor	F
CENTRAL HIGHLANDS			
161-170	>7	Excellent	A
>170	>6		
121-160	>7	Very Good	B
141-170	5-7		
91-120	<7.5	Good	C
121-140	<7		
61-90	<6	Fair	D
30-60	Variable	Poor	E
<30	Variable	very Poor	F
BUSHVELD BASIN			
>180	>6	Excellent	A
141-180	6-7	Very Good	B
91-140	5-6.5	Good	C
61-90	<6	Fair	D
30-60	Variable	Poor	E
<30	Variable	very Poor	F
GREAT ESCARPMENT MOUNTAINS			
161-180	>7	Excellent	A
>180	>6		
141-160	>6	Very Good	B
161-180	6-7		
91-140	>5.5	Good	C
61-90	<6	Fair	D
30-60	Variable	Poor	E
<30	Variable	very Poor	F
LOWVELD & LEBOMBO UPLANDS			
141-160	>7	Excellent	A
>160	>5		
106-140	>7	Very Good	B
106-160	6-7		
131-160	5-6		
76-105	>5	Good	C
106-130	5-6		
61-75	4-6	Fair	D
30-60	Variable	Poor	E
<30	Variable	Very Poor	F

Estuary

The estuary was divided into four regions from the mouth to the upper reaches. Sampling stations were selected in each region such that the stations were approximately 150m apart. Samples were collected at low water of spring tide. At each station the water depth was recorded and samples of surface and bottom water taken for *in situ* measurements of temperature, salinity, pH, conductivity, transparency and dissolved oxygen. In addition, samples were collected for microbiological (total coliforms and *Escherichia coli*) and nutrient (total nitrogen (nitrates and nitrites), ammonium, silicate and soluble reactive phosphorus) analysis. The laboratories of the Buffalo City Council and the Botany Department at the University of Port Elizabeth respectively conducted these analyses according to standard scientific techniques.

Pelagic macrofauna was sampled at each station by drawing a 20m trek net (mesh size 5mm) through the water column for a distance of 5m from the water's edge. Organisms caught were identified and counted. Benthic macrofauna were recorded by noting the presence of burrows in the sediment of the banks and the shallows of the mouth region. Birds were identified and counted during two passages by boat along the length of the estuary; the vegetation dominating the estuary valley was recorded at the same time.

Ecological Health Class

In the Ecological Reserve Determination process, the Ecological Health Class of an estuary is a measure of its present condition or ecological status and gives an estimation of the extent to which an estuary differs from its pristine or reference condition. The process uses six Ecological Health Class (EHC) categories (these are equivalent to the classes used in the present DWAF classification).

Table 2.8 Derivation of the PES and FAS classes for an estuary

Ecological Health Class	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified
E	Highly degraded
F	Extremely degraded

Water Quality

A water quality specialist was not appointed to the team to undertake the sampling, as it was decided at the outset that the water quality sampling and analysis for an urban river was the responsibility of the local authority, in this case Buffalo City Municipality (BCM). The Directorate of Scientific Services of the BCM provided the project with data from their two weekly sampling points at Chamberlain and Galway Roads (upper and middle reaches; monitoring of basic variables, total coliform counts, and *E.coli* counts only). Unfortunately, the dataset does not provide adequate information on which to base an assessment of Present Ecological State class. This is a complex task, which – even with one year of comprehensive water quality data – would be considered low confidence (Scherman pers.comm.).

A once-off water quality sampling and analysis was done at eight sites along the river during October 2003, and analysed by Buffalo City Municipality Scientific Services. A water quality specialist, Dr Nikite Muller (Centre for Aquatic Toxicology, IWR, Grahamstown), was requested to compare these results, where possible, to guideline Target Water Quality Ranges (TWQRs) published in the South African Water Quality Guidelines for Recreational Use (Volume 2) and for Aquatic Ecosystems (Volume 7). These TWQRs are the "No Effect Ranges", based on both national and international literature, considered to be sufficiently protective of South Africa's water resources (DWAf, 1996a and b).

The criteria listed in the 'aquatic ecosystems' guidelines are the quality of surface water required to protect fresh water ecosystems, and were derived using test organisms from the major trophic groups found in aquatic ecosystems. A number of water quality constituents listed in DWAf (1996b) were, however, not assessed in the October 2003 survey. Recreational water users experience water quality problems which are related to human health, human safety, aesthetic and economic impacts (affecting equipment) and users range from full contact (swimming) to non-contact (hiking along a water body). Certain of the water quality constituents considered important for recreational use were not assessed in the October 2003 water quality survey: algae, clarity, floating matter and refuse, enterococci and coliphages. Chemical irritants were also not specified. The data set is thus too limited to base any Present Ecological State or Future Attainable State class assessments on it. Thus, only the deviations from the Target Water Quality Ranges are taken into account, and this is considered a first, broad-brush interpretation of water quality in the system. The constituents not assessed to date should be included in future water quality monitoring.

Water Quantity

A major gap in this study was the absence of up-to-date hydrological information. There are no official, functioning rain-gauges in the Ithanza catchment, and no flow gauges exist at present. Rainfall and runoff data for the catchment is

therefore not available, and the modelling of hydrology was outside of the scope of this project.

The only information available on the system hydrology, as far as is known, was the Ithanza River Stormwater Management report (Ninham Shand 1992), and the Ithanza River 1:50 year Floodline report (Ninham Shand 1992), copies of which were retrieved from archive in late October 2003, during the project write-up.

Since the time of these reports being written, there has been an increase in impermeable surface in the upper Ithanza River catchment. The reports therefore would need to be updated to take account of changes in the catchment characteristics. Certain recommendations made in the reports regarding flood control and mitigation are presented in Chapter 4 (Results).

3a. Describe or assess a class for the Future Attainable State. (This step has been added to the method for the purposes of this study).

This step is absent from the Australian guideline, but was added to the method for this project, in order to align the full process with that of the Ecological Reserve Determination process. It was also felt that this information would provide a basis from which objectives could be realistically developed and scoped.

4. Produce a variety of annotated maps.

The river was mapped using Geographical Information System (GIS) software (Arcview 8.3). The actual course of the river was estimated by taking Global Positioning System (GPS) localities at 5-10m intervals along the entire river length, and geo-referencing these to a series of GIS map layers including the 1:50 000 map of the area, satellite imagery of the river with 1m contour intervals, and 1:50 year floodline drawings (Ninham Shand 1992). The difficulty with working with these different sources of information relates both to the fact that the contour intervals were digitally derived from ortho-photos (i.e. not surveyed points), and that river course has been somewhat altered in sections since the production of these reference maps and drawings. The mapping of the course was thus subject to error due to the limits of resolution of the information available, and the GPS technology (resolution of 5-10m). However, the final map has been ground-truthed and is felt to be sufficiently accurate for the purposes of the report.

For the 'Present Ecological State (PES)' series of maps (Chapter 4), riparian vegetation, instream substrata, bank condition, and flow conditions per river reach were overlaid onto the plan-form maps in the field, and later digitised using GIS software. This was done by visual observation and hand-mapping, the latter with the use of a tape measure. This was not an attempt at habitat mapping (which would have been done at a far finer scale), as the latter is appropriate to more detailed scientific investigations and monitoring. It is acknowledged that this information is somewhat low-resolution, however, it is felt to be more than adequate for the project needs, and serves to provide a clearer picture of

conditions and habitable area within the reach, and also provides a template for the river at a point in time.

For the 'Rehabilitation Objectives' series of maps (Chapter 5), the present indigenous riparian vegetation is shown, together with planned areas for clearing of alien vegetation and future riparian vegetation planting. Proposed pathways and recreational areas are illustrated. Areas requiring in-stream treatments or bank stabilisation are marked on the maps. Additional recommendations for management or maintenance of, or alterations to infrastructure impacting on the river, are shown as symbols linked to the relevant locality.

2.3.4 STEP 4. IDENTIFY THE ASSETS AND PROBLEMS

1. Identify environmental assets. (*Wherever there is accordance between the present state and the 'natural state' template, that ecological or physical component of the river is termed an 'asset', referring to an environmental asset.*) This was considered by the specialists to be a difficult task to complete meaningfully, likely due to this river being a highly impacted urban system, with little accordance between present and natural states in terms of planform, channel cross-sections, and expected biota.

2. Identify present problems. (*'Problems' are those processes or activities that are threatening or impacting on present assets. This is the equivalent of identifying the causes of current degradation of assets.*) As problems are defined as impacting on assets, and few assets were considered to be present, this step was again difficult to address meaningfully. However, an attempt was made to identify, in general, the sources of degradation of the reach.

3. Determine the trajectory.

Trajectory of change was assessed on the basis of the Present Ecological State results. This was evaluated assuming maintenance of the 'status quo', i.e. no change in current conditions (no further development, no improvement). Reaches considered to be degrading had a negative trajectory, while reaches considered to be stable (i.e. having reached some sort of equilibrium state despite being altered from natural) had a zero trajectory, and reaches considered to be improving had a positive trajectory.

2.3.5 STEP 5. SET PRIORITIES

1. Assign reaches to one of the nine categories presented in Table 2.9.

The four criteria guiding the prioritisation and ranking of reaches in this methodology are:

- **Rarity** (rare reaches have higher priority than common ones);
- **Condition** (reaches in good condition are easier to fix than those in bad condition);
- **Trajectory of change** (deteriorating reaches should be stabilised before action is taken on reaches which are improving without any intervention);
- **Ease** (attend to those reaches which are easy to fix, before those that are difficult).

This was done as follows:

- at the scale of the reach, problems within the reach were identified and ranked in the order of importance of addressing them (see Chapter 5: Objectives);
- a prioritisation exercise was then undertaken for the six zones, ten segments and 30 reaches, on the basis of the aforementioned criteria and the guidelines provided in Table 2.9. The stepwise process followed is further described in Table 3.1 (Results).

2. Rank reaches that are in the same category.

Where more than one segment had the same priority, these required further ranking, based on the same principles as those followed in Task 1.

3. Query and check the reach priority rankings.

Here, reasons other than ecological value were factored into the prioritisation process. Rankings could be changed on the basis of the importance of a particular reach in terms of its place in the life of the catchment community, its proximity to other urban features, or the presence of an animal with great public appeal (e.g. the Cape Otter and Water Mongoose in the lower reaches).

Table 2.9 Guidelines for the prioritisation of river reaches or segments (from Rutherford et al. 2000).

NO.	DESCRIPTION	ACTIONS REQUIRED	PROTECTION OF ASSETS
0	Reaches in good condition throughout, that are already protected.	Nothing needs to be done to these reaches, but to monitor for development of any threats.	
1	Reaches with important regional conservation assets and/or value.	Protect these for their rarity value. This includes identifying and fixing threatening problems that come from other reaches.	
2	Reaches with local conservation value.	These include surviving remnant sections of original streams. They may be common in the area, but rare in the catchment. Prevent these from deteriorating. This involves treating all threats to the reach, including those from outside the reach.	
3	Actively deteriorating reaches.	Arrest present deterioration and prevent further deterioration.	
Important assets should by this stage have been listed for protection. The focus now turns to the improvement of the stream's structure and ecological function.			
4	Reaches in good condition.	Expand these areas. The value of quality assets is greatest when combined with other assets to form a complete stream community. Work should be prioritised. Work on (i) reaches with some high quality assets and some degraded assets, (ii) poor quality reaches that link two asset-rich reaches; (ii) poor quality reaches with asset-rich reaches at one end.	IMPROVEMENT OF ASSETS
5	Reaches with impeded recovery, degraded but in stable condition.	Where natural recovery should be occurring but is prevented by a particular stream problem. Identification and rectifying that problem facilitates natural recovery.	
6	Moderately damaged reaches.	These are reaches with good potential to improve at reasonable cost. These need several interventions rather than just one (as in Category 5).	
7	Basket-case reaches (in very poor condition; not threatening to other reaches, and with little chance of self-recovery over time).	These are considered to have serious problems and need intervention to recover.	
8	Basket case reaches with hope (in very poor condition; not threatening to other reaches; and with some chance of self-recovery over time).	If the instability of this stream threatens downstream reaches these should be pushed up the priority list.	

4. Setting problem priorities.

This task was undertaken as a generic task for the river, rather than per reach or per segment. Causes of degradation in the Ithanza River were categorised from **fatal** problems (which may exclude fauna or flora from a reach) to **limiting** problems (which stress or alter the expected species distribution) to **nuisance** problems (which have a minor effect on the biotic community).

5. Check for other limiting problems

The problem/s most severely affecting assets were identified on the basis of specialist reports, discussions with specialists and BCM officials, and knowledge of the system.

6. Deciding where there are exceptions to the problems (cost limitation)

Here the prioritisation of problems not considered fatal or limiting was considered, as this could result in improved value for money. In the case of the Ithanza, consideration was given to:

- The fixing of longer reaches (segments) of stream rather than shorter ones and site-specific works.
- The initiation of longer-term ecosystem recovery process through certain actions (e.g. replanting of indigenous vegetation and protection of the root zones of large bankside trees).
- Attachment of a higher priority to reaches in which the influence would be good for the community and for educational purposes, and would improve the visibility of the stream area.

7. Check if some reaches/segments should have more than one rank.

In the case of river segments with multiple problems and/or several assets to protect, the recommendation was to protect the assets in this segment and then to protect those of other segments before attending to the degradation in the first segment. This first segment can be then have initially one priority, e.g. Category 1 (Regional Conservation Value) and, following remedial actions, may be assigned a Category 4 (Expand Good Reaches).

2.3.6 STEP 6. IDENTIFY STRATEGIES TO PROTECT ASSETS AND IMPROVE THE STREAM

Here strategies were identified for i) the protection of environmental assets and/or the prevention of degradation; ii) the improvement of environmental assets; iii) fixing present problems. As there were few assets for the Ithanza, however, the decision was taken to identify strategies for protection and improvement of those areas demonstrating the greatest ecological integrity, and to attend to the prevention of degradation and fixing of present problems.

Strategies for changing human behaviours included interaction with school groups, municipal officials, Ward Councillors and residents, in an attempt to raise awareness regarding river degradation; impacts from individuals and homeowners; how to clear alien vegetation; what to plant in the riparian zone; and how to reduce urban impacts on streams.

2.3.7 STEP 7: SET SPECIFIC OBJECTIVES

In the case of the Ithanza, confidence in the information available was relatively low. In the absence of extensive data on present or natural state, the setting of measurable objectives was considered to be conjecture. The approach was thus to set objectives in terms of what were considered to be 'attainable conditions' for the ecophysical condition of the five river zones. These were measurable only in that they specified a **range** of desired and achievable outcomes. The scale of the zone was used, as 'attainable conditions' did not vary greatly within a zone. For each of the ten segments, an additional series of objectives was drafted in each of three categories: Ecological, Infrastructural, and Social/Educational/Recreational. These categories reflect the likely implementation groups: natural scientists; engineers and local authorities; and communities, teachers and pupils respectively. The reason for categorising the objectives in this way was to cater for the possibility that the meeting of objectives may be tackled by different organisations or institutions, and this method simply clarified which objectives each different group should be addressing. Practical 'actions' required to fulfil the objectives were also listed. These are all presented in Chapter 5.

1. Define the extent of change desired.

The intention in this task was to clarify what the project was aiming to achieve, in terms of a range of acceptable outcomes, where one end of the range represented the best possible outcome, and the other end the smallest useful improvement (e.g. 'sewage discharges into the river to be reduced by a minimum of 20% and a maximum of 75% within five years'). As discussed, this type of objective was considered the only option for the Ithanza, particularly as addressing most of the problems would require the cooperation of a local authority. This project was also

designed to address the rehabilitation planning only, and not implementation or evaluation. Objectives were also set for maintenance or protection of natural features.

2. Define the spatial scope of the objective.

The spatial scope of the objective should be defined on the basis of the type of problem being treated, the cost of the treatment, and the length of river requiring treatment in order to get a response. For the Ithanza project, exact spatial scope was not defined in most instances, as it was considered preferable to detail this during the design phase, once there was support for the objective, and costings were available for the various different treatment options.

3. Set the time frame.

This task required that the balance be found between allocating sufficient time for the river to respond to the rehabilitation actions, and setting a short enough time frame to maintain the interest of those involved in the project. Rutherford et al. (2000) suggested that two time frames be considered – a short-term objective for the completion of the rehabilitation action (**output**), and a longer-term objective (in the order of years) for the evaluation of the effect of the treatment (**outcomes**). These two time frames were linked to the generic objectives for each of the six zones of the Ithanza, and were described in terms of an acceptable time period from the time of intervention. Actual dates and times could not be provided as scheduling of rehabilitation interventions was not included in this project.

4. Determine the type of objective.

Objectives for the Ithanza were typed chiefly in terms of **outcomes** rather than **outputs** (see Types listed below). The reason for this was that **output**-type objectives are only relevant once associated with particular treatments and their longevity, and the final choice of treatments and timing for their implementation was outside of the scope of the current project.

Output/outcome

Output
Output
Outcome
Outcome
Outcome

Type of objective

Execution of the project and treatment/s
Survival of the project and treatment/s
Aesthetics of the stream
Physical condition of the stream
Improvement or maintenance of ecological function and processes

2.3.8 STEP 8: CHECK THE FEASIBILITY OF OBJECTIVES

1. Check affordability

This step was one of the first to consider when budgeting for the proposed rehabilitation project. As Rutherford et al. (2000) point out, the issue to consider

here are the costs of planning and mobilising a stream rehabilitation project, which may be overlooked while attention is focussed on the cost of implementation of management actions. Mobilisation and planning of the project included:

<i>Planning Costs:</i>	In order to get the information and assistance required in the early part of the project, specialists were required during the planning stages. Consultancy fees in South Africa are estimated at between R2000 and R2500 per day (2003/4). For this project, consultants were paid somewhat less, at WRC hourly rates.
<i>Information Costs:</i>	The cost of items required in the early phases of the project, e.g. aerial photographs, maps, etc. was considered. Some information was provided by BCM, and additional information was purchased from them.
<i>Mapping Costs:</i>	The costs of producing GIS maps of the entire river both for Present Ecological State and for Future Attainable State were estimated at the outset of the project.

2. Check legality and legislative and administrative constraints

It was necessary to be aware of the numerous laws and regulations controlling what could and could not legitimately be done in and around the river. Rutherford et al. (2000) recommended that a database or report of the relevant controls be compiled, particularly in the urban context, where several authorities or service providers may have intersecting jurisdictions (e.g. roads, planning, stormwater control). The national laws considered for this project were investigated at length, and described in Uys and Ruiters (2002). This is however not considered a comprehensive treatment of this subject, and a full review of legislation pertaining to river rehabilitation – and a development of an appropriate legislative framework for this field – is called for (Uys *in press*). As the Ihlanza River falls within a municipal area, it is under the jurisdiction of the local authority, and the laws and regulations relevant to the project were also investigated through review, meetings and discussions with relevant BCM officials and local attorneys.

3. Check whether it is worthwhile doing (i.e. do the negative effects outweigh the positive ones?)

This task is considered critical during or directly following the design phase. It was however, premature to provide levels of assurance regarding the positive effects of the project relative to the negative ones without having detailed designs in place.

The assessment of confidence or assurance in the positive outcomes of the project, and the calculation of the chance (and extent) of possible perceived 'negative' effects or risks, would require specialist evaluation of engineering designs. Nonetheless, in recommending conceptual designs to fulfil certain of the objectives, these key questions posed by Rutherford et al. (2000) were borne in mind:

- whether the intended treatments would cause erosion or deposition;

- whether actions may influence flood height or duration;
- whether the option would affect the performance of hydraulic structures (for example, the installation of a fish ladder could compromise the performance of a weir); if so in what way, and how does one compensate for this;
- whether the option would affect the current practices of riparian landholders;
- whether and in what way/s the option affects the recreational uses of the stream;
- whether the option will affect other uses of the stream (e.g. water use, use as a drain or sewer) and how to compensate for this.

4. Assess confidence in the objectives

The balancing of estimated costs, risks and outcomes in the project could not be addressed in the consideration of objectives for the river, as detailed costings for interventions were not undertaken in this project. This balance would, therefore, however have to be properly assessed once decisions were taken as to which objectives to address in each segment, how to address them, and what the costs of this would be.

5. Weigh up the feasibility on the basis of Tasks 1-4

The issues already addressed in Step 8 should have determined the cost-effectiveness, cost-benefit relationship, and any legal constraints on the project, as well as the affordability of attaining objectives. This was not entirely true of this project, as costs were not comprehensively estimated for various interventions, as already discussed. This step will have to be revisited once this information became available.

2.3.9 STEP 9: DETAILED PROJECT DESIGN

In the Australian river rehabilitation process, this step involves providing detailed designs for structures to be built or actions to be taken. In this project, however, detailed design would have been costly and premature without the guarantee that any of these would be funded or implemented. The decision was taken to present only conceptual designs until either the local authority or the local businesses, schools or communities provided sufficient funding or commitment to proceed with more analytical design, assessment of design, implementation and evaluation. The principles as listed in Step 9 (see Appendix 1) were considered relevant in this step, and were taken into account in the choice of the conceptual designs.

CHAPTER 3

RESULTS

3.1 THE 12 STEP PROCESS

3.1.1 STEP 1. DEVELOPMENT OF A VISION AND GOAL

The vision for the project is based on the specialists' understanding of the pre-impact condition of the river, as described per river segment in Chapter 4. The vision describes an unrealistic return to this natural state.

The Vision for the river is: *To restore the Ihlanza River to its pre-impact dynamic equilibrium state, in which water quality is impacted only by areas or periods of no-flow; the water table is raised; the channel is predominantly stable, with well vegetated banks and a somewhat meandering planform; and the riparian area is vegetated with transitional coastal forest, such that most of the stream is shaded. The runoff pattern should mimic that of the uncleared catchment, and infiltration to groundwater should be natural. The instream biota should include Barbus anoplus, Glossogobius callidus and Sandelia bainsii fish, and Anguilla marmorata eels, with a diverse macroinvertebrate community, a SASS5 score of over 120 and an ASPT of 5.5 to 7.*

In this step it is recognised that this Vision is not attainable and merely serves as a template of natural conditions. A realistic and attainable goal is thus set, relative to it. The goal set for the river by the Ihlanza River Watch Committee in 2000 was included in this process. This goal therefore to some extent represents community ideals, values and choices.

The Goal is: *To return the Ihlanza towards a healthy ecological and physical state, while recognising that it has a number of urban functions. To recognise and increase the stream's natural and amenity value to the community. To improve the instream and riparian biodiversity within the stream corridor, and to make it a safe, attractive and indigenous recreational green belt in the suburbs. To protect and enhance the estuary by including it as part of the Nahoon Nature Reserve. Within ten years of commencing the rehabilitation exercise, people should be safe to swim in the river and the estuary.*

3.1.2 STEP 2. SHARING THE VISION AND THE GOAL

1. Identification of individuals with interests in the stream (this will include land-owners, water users, authorities, water supply agencies, etc.).

It was felt that the most important individuals initially were those in the BCM, as this local authority has jurisdiction over the river. Several meetings were set up to give presentations to relevant officials regarding the project aims, points of possible linkage with the IDP (Integrated Development Plan) for the city, and areas where BCM assistance may be required in the future. Where possible,

ongoing contact has been maintained with BCM, concerns have been discussed with relevant individuals, and their involvement has been sought on issues of concern. It was important to develop this relationship of mutual trust with BCM in order to be working 'in the same direction'. By the end of the project, officials were phoning the project team to inform them about intended actions on the river – many of which included clearing of alien vegetation.

Unfortunately, but typically, different Directorates within the municipality operate separately, with little apparent internal communication between engineers, planners, disaster managers and environmentalists. This necessitated several repetitive meetings with different officials, with the somewhat frustrating sense that to achieve anything in a holistic sense regarding river improvement, far greater synergy would be required between these different divisions. Others with interests in the stream included upper catchment businesses, schools, churches, residents, and land-owners. As this represents several hundred individuals, and time and budget were limited, it was decided that the media should form the major conduit for relaying information about the project to these groups. The media articles and the newsletter sent to interested parties nationally and internationally are presented in Appendix 2.

These reports were an excellent form of public relations, and gathered a small group of supporters. As the work gathered momentum, a number of individuals volunteered their assistance or time. One group of home-owners (one of whom had been previously involved with the Ihlanza River Watch) initiated an alien-clearing exercise with a number of neighbours, in an attempt to transform a highly disturbed landscape adjacent to their properties (and in POS) into an attractive, safe indigenous riparian zone. This exercise has been very successful and has a life of its own, with links to this more formal planning process. It is likely to increase property values in the area (e.g. Riley 1998).

2. Identification of individuals who support and oppose the rehabilitation goals. Identification of relevant legislation and local regulations.

This task was addressed within the early phases of the project, with residents and BCM officials. Aside from possible issues with developers in the area, this was felt to be a non-threatening rehabilitation planning exercise, and was unlikely to attract opposition. Many individuals within BCM were supportive of the project and assisted willingly with information. However, until such time as this becomes a municipal project, it is unlikely that there will be any actual 'buy-in' from BCM, which is a cash-strapped local authority in a traditionally 'poor' region. The IDP (Internal Development Plan) offices of BCM were also supportive and agreed that elements of the rehabilitation exercise could be incorporated as IDP Projects. The Buffalo City Environmental Trust adopted this as one of their key projects. The Trust will attempt to source funds to assist with the project's continuance.

Support would be most likely to come for the project as action was taken and people could see visible results and it was felt that once the BCM were

involved and supportive, there would be few individuals opposing the rehabilitation goals. These people would become known to us during the planning process, and indeed have. It was decided that, in principle, the general public should be consulted once the technical information on the Present State and the Future Attainable State was available from the specialist team.

Regarding legislation, the national-level legislation was examined in Uys and Ruiters (2002). However, the practical adequacy of this legislation is questionable in an area under the jurisdiction of a local authority with its own regulations. This is a subject of concern raised in Uys and Ruiters (2002).

One of the chief concerns for rehabilitation practitioners is developments on the floodplain. In the Ihlanza, for example, permission has been granted to a developer by the local authority to clear and build adjacent to the river bank in Reach 15, with the condition that the building is above the 1:50 year floodline. This naturally poses a hazard both to the imminent development, and to the properties on the opposite bank.

The National Water Act No. 36 of 1998 (Chapter 14 Part 3 Sections 144, 145) requires that certain information relating to flood and potential risks be made available to the public, and that township layout plans indicate a specific 1:100 year floodline. The Act does not, however, stipulate that there may be no development below the 1:50 or 1:100 year floodline. However, according to Hinsch (pers. comm. May 2003), it is Department of Water Affairs and Forestry's (DWAF) unstated 'policy' to follow a guideline of allowing no significant development below the 1:100 year floodline.

The only municipal-level regulatory requirement regarding construction relative to floodlines enforced in East London is as follows: *'Councils may not approve any development below the 1:50 year floodline unless an approved structure plan exists for the relevant area, and applications in this category must be submitted to the Administrator (now to the Premier's office) for consideration'* (Land-use Planning Ordinance 1985 Circular GOK/LDC.9/1998).

The lack of any firm regulations in this regard is a problem that local and regional authorities need to address. The City of Cape Town, in their 'Policy for Development Control near Watercourses' (2002), divides areas directly adjacent to a watercourse into zones, based on risk of flooding or environmental sensitivity for the purposes of controlling development. The document describes the floodplain as the area susceptible to inundation by the 1:50 year recurrence flood. It states that *'Even if (the flow is) partially obstructed, significant redistribution of flow may be expected thereby adversely affecting flood hazards in other parts of the floodplain. The permissible extent and nature of development within the floodplain should be subject to stringent evaluation and control. In particular, potential obstruction to free flow of water below the 1:20 year recurrence flood level should be avoided'*. The City of Cape Town has determined environmental buffers for all the major natural watercourses within their jurisdiction. These are areas adjacent to river channels that are considered sensitive and requiring

protection and management. They vary in width between 20m and 60m from the watercourse centreline.

3. Identification of individuals with the power to help or hinder the attainment of the goal.

While it is necessary to formally address this step, it also becomes apparent during the process who these individuals are. In the case of the Ihlanza, those who could help included:

- Relevant Ward Councillors
- Senior BCM officials
- Schools and other institutions in the catchment
- Local newspapers
- Willing residents
- The Golf Driving-Range Lessors (Reaches 26-27)
- Local businesses
- Local engineers and environmentalists.

Those who could hinder the goals were few and far between and included:

- Unwilling residents
- Developers with development rights below the 1:50 year flood line.

With both those who could help and those who could hinder, good relationship-building was considered essential during the project. This, however, was time-consuming and did highlight the need for either (or both) a full-time coordinator for this type of project, or a community-based committee of volunteers, with good understanding of the project concepts and strong leadership.

4. Decision as to how to increase support for the goal.

As this was not a community-driven project, decisions were seldom made collectively. Ideas as to how to increase support for the goal came rather through meetings with individuals and discussions with the specialist team and outside assistants, and review of projects already undertaken.

Means of increasing support for the goal included:

- Publicising the project, the rationale behind it, and its goals, in local newspapers and in newsletters (Appendix 2).
- Creating awareness of the beneficial effects of rehabilitation (e.g. increased indigenous vegetation, increased fish stocks, improved water quality, reduced odours).
- Networking wherever possible with community members, schools and other institutions.

- Increasing (over the longer term) the capacity of catchment members to undertake monitoring of the river. Riley (1998) writes that "the attitudes of scientists and agency personnel in the US evolved quickly from concern that volunteer-collected data could be inaccurate to enthusiasm for this 1980s and 1990s phenomenon as a critical component of many programs". This initiative had already gathered sufficient momentum a decade ago for the EPA to have published several editions of a National Directory of Volunteer Environmental Monitoring Programs (EPA 1994).
- Holding discussions with relevant senior municipal officials (Engineering, Social Services, Environmental, Scientific Services, Disaster Management and Planners) to inform them about the project progress.

As Rutherford et al. (2000) point out, in order to convey the rehabilitation goals convincingly, one must be well-informed, passionate in one's commitment, and yet, one must remain capable of seeing the interests and perspectives of other users of the stream.

3.1.3 STEP 3: DESCRIPTION OF THE STREAM CONDITION

1. Division of the river into segments and reaches.

The divisions of the river was described in Methods (Chapter 2) and illustrated in Maps 2.1 and 2.2. Each river reach is mapped individually, both for Present State and for Objectives, in Volume 2. The approach to the mapping is described in Task 4.

2. Construction of a template of what the stream should look like (ideally in its pre-impact state).

In South Africa, this step would more commonly be referred to as a description of Natural or Reference State of the river. This information is captured, per river segment, in the form of a brief description of 'Natural State' for geomorphology, riparian vegetation, fish, and invertebrates, in Chapter 4, and on maps in Volume 2. It is assumed that for all components, the river condition would be described as class 'A' in its natural state.

In describing the likely Natural State per segment and per component, a similar procedure was followed to that used in the Ecological Reserve Determination. Aerial maps, ortho-photos, 1:50 000 maps, and other information dating back to 1935 were consulted by specialists. As there was no information available on the pre-impact state of the river, specialists were forced to rely on their experience of Eastern Cape rivers and on their professional judgement in compiling their descriptions.

The Natural State for water quality was not described for this report. As already discussed, even a low-confidence assessment for water quality would require a

minimum of one year of water quality data (Scherman, pers.comm.). The only long-term data available for this river are the basic variables (pH, Electrical Conductivity, Ammonium Nitrate, Permanganate value as Oxygen, Orthophosphate, Heterotrophic Plate Count, Total Coliforms, *E.coli*), which are considered an inadequate basis for any assessment of present or natural water quality state.

Natural State: Riparian Vegetation along the Ihlanza

The likely natural state of the riparian zone for the entire river is described here. It is further described per river segment in Chapter 4.

Based on historical information, investigation of remnant features and comparison with vegetation on similar streams in the region, indications are that the riparian vegetation along the Ihlanza River was dominated by coastal transitional forest in the upper reaches, and dune forest from the ebb and flow to the estuary mouth. Inspection of the earliest available aerial photographs of the area (1935) indicates an area covered largely by grassland pastures, with a narrow strip of forest vegetation along the stream banks in sections. Large areas appeared to already be denuded of trees and shrubs, due to overgrazing and removal of timber and rock for building materials.

More recent aerial photographs indicate more extensive forested sections. This subsequent, relatively rapid reforestation due to removal of grazing impacts, along with the presence of remnant patches of relatively good coastal forest vegetation (particularly in Reaches 3 and 26-30) suggests that the area was originally entirely vegetated with transitional coastal forest in its natural state. Historical anecdotal evidence further supports this (Mostert 1993), as does research (Acocks 1998).

A representative cross-section of flora that one could expect to find along the Ihlanza River would include a combination of coastal dune forest and scrub forest. This would be typified in the upper and middle reaches by large woody trees such as *Protorhus longifolia*, *Harpephyllum caffra*, *Afrocarpus falcatus* and *Schotia latifolia*, as well as climbing or shrub-type growth such as *Dalbergia obovata*, *Turrea obtusifolia*, *Carissa* sp. and *Anisodonteia* sp. It is likely that an abundance of geophytic plants such as *Scadoxus*, *Sansevieria*, *Crinum*, *Drimiopsis*, *Clivia*, *Dietes* and *Aibica* spp. would also be present. Epiphytic orchids such as *Mystacidium capense*, *Cyrtorchis arcuata* and *Polystachia pubescens* would also probably be typical.

3. Describe the Present Ecological State (PES) of the river.

3a. Describe and classify the Future Attainable State (*this step is not explicit in the Australian method*).

The PES of at least one river reach per segment was described for the geomorphology, riparian vegetation, fish and invertebrates. This information is presented in Chapter 4 of this report. 'Present State' maps of the individual reaches are presented in Volume 2 (Maps 4.1 – 4.30). Photographs illustrating various river sections are labelled on the maps and are presented in Appendix 4.

In addition, generic results and comments relating to fish, riparian vegetation and water quality (for the whole river) and to the estuary are presented hereinafter.

In Chapter 5, the description of Future Attainable State is presented, followed by a series of Objectives and Recommended Actions. Wherever possible these are illustrated per reach on the 'Objective' Maps in Volume 2. Relevant conceptual designs are provided in Volume 2, Appendix 5.

PES and FAS classes for water quality could not be accurately assessed for the purposes this report, for reasons already discussed.

Channel Cross-Sections

The channel cross-sections are presented in Chapter 4 (Figures 4.1-4.5), alongside the descriptions of Present State.

Present State: Fish

No fish were caught in the freshwater reaches of the Ihlanza River. This was in spite of the fact that the physical habitats in Zones C, D, E and F all appeared suitable for fish life. Comprehensive water quality data were not available for periods prior to or at the time of the survey. However, the presence of sewage fungus and foul-smelling anoxic sediments in Zones A and C (the latter to a lesser extent) indicated that water quality was very likely the limiting factor for fish life in these reaches. In addition, during dry spells or low-flows, not only will water quality deteriorate further, but sufficient surface water is probably not available to support fish in most reaches.

Present State: Riparian Vegetation

A total of 144 different species of mainly-woody plants were recorded in the reaches of the river sampled. Because these included mostly woody tree and shrub species with only selected significant bulbous perennials and grasses, it is likely that the number is closer to about 200 species.

It is nevertheless evident that there is a significant loss in biodiversity in riparian areas upstream of the estuary, as well as a decrease in the relative abundance of species that would naturally be more common. For the length of the river which runs above ground (i.e. downstream of the buried upper section), alien plant invasion is a problem, due to unchecked clearing for development or servitude

creation, or due to work on the sewer pipeline. This alien vegetation is significant competition for the indigenous riparian vegetation and, in parts, has entirely replaced indigenous forest. Sedges and mesic forbs are noticeably absent from many of the reaches where they should occur, both instream and along the channel banks. This is due to clearing or alteration of channel shape as a result of development and subsequent erosion, which is exacerbated by unnaturally elevated flows during high flows and floods.

Although comparison with early aerial photographs (1935) indicates a recent recovery with regard to reforestation in some areas, new threats exist. These include the increased frequency and magnitude of high-flow events and the general increase in catchment runoff due to extensive areas of hardened surfaces in the upper catchment area. This additional runoff results in increased gully erosion, and channel incision, both of which cause bank steepening and create a hostile environment for riparian plants. The unchecked alien plant invasion is also a major threat to the intact indigenous vegetation on this river.

Natural State: Estuary

The formal classification of an estuary into an Estuarine Health Class (EHC) is a process requiring experienced opinions of specialists in the fields of hydrodynamics, water chemistry and estuarine flora and fauna. The input of such expertise was beyond the scope of the Ihlanza River study.

However, based on the initial study presented in this report, the Ihlanza is likely to meet the criteria of EHC category C (moderately modified). It is unlikely to achieve a higher status because of the permanent modification of its catchment by urban development and the influence of infrastructure and human activities on the hydrodynamics and water chemistry.

The Natural State and PES for the estuary are described in Chapter 4 and partially illustrated on Maps 4.29 and 4.30 (Volume 2). The Future Attainable State is described and illustrated in Chapter 5 and Maps 5.29 and 5.30 (Volume 2).

Present State: Water Quality

Available water quality data, and information on Target Water Quality Ranges are provided in Appendix 3. As is evident from this information, the majority of constituents exceed the Target Water Quality Ranges listed in Department of Water Affairs and Forestry's (DWAF) Water Quality Guidelines for Recreation, and the same guidelines for Aquatic Ecosystems (DWAF 1999a,b). This is considered undesirable, and needs to be addressed. Total coliforms and *E. coli* also exceed the TWQR as listed in DWAF (1999a).

It is difficult to provide an adequate assessment of the present water quality state of the Ihlanza River from a single water sample, particularly for those constituents where it is important to know the background variability of a constituent (e.g. pH,

TSS and Fe). The TWQRs for some water quality constituents are dependent on water hardness: this measure was not provided and an adequate assessment of these constituents could therefore not be undertaken (e.g. Pb). It is obvious that there is variation in water quality between different sites, and potential sources of pollution (whether point-sources or diffuse sources) that need to be identified and addressed.

4. Produce a variety of annotated maps of the river

Natural and Present State are described per river segment in Chapter 4, and Future Attainable State and Objectives are described per river segment in Chapter 5. Maps to illustrate this information are presented in a separate document (Volume 2) for ease of access, and are numbered as follows:

- Maps 4.1 to 4.30: Illustrating the information presented in Chapter 4. Map 4.1 is Reach 1, Map 4.2 is Reach 2, etc.
- Maps 5.1 to 5.30: Illustrating the information presented in Chapter 5. Map 5.1 is Reach 1, Map 5.2 is Reach 2, etc.

The maps are not extensively annotated, as line detail is easily lost when overlaid with text. The approach was rather to convert as much information as possible to graphic form. Thus, only road names, even numbers, land-use on the banksides and 5m contour intervals are labeled. The channel course itself proved challenging to map, as no surveys of the river existed and even floodline information had been derived from 1:1000 orthophotos. A combination of available information and GPS mapping was used to position the channel, but some degree of error should be allowed for. Channel substrate and typical base-flow types along the channel are broadly illustrated. Bank erosion, channel incision and areas of scour are illustrated with line symbols. Important indigenous riparian vegetation is illustrated at species level by symbols (the legend for which is presented at the beginning of Volume 2). The relevant sewerage and storm-water drainage systems are overlaid on the reach maps, per kind favour of Buffalo City Municipality.

3.1.4 IDENTIFICATION OF ASSETS AND PROBLEMS

1. **Identification of environmental assets.** (Wherever there is accordance between the present state and the 'natural state' template, that ecological or physical component of the river is termed an 'asset', referring to an environmental asset).
2. **Identification of present problems.** ('Problems' are those processes or activities that are threatening or impacting on present assets. This is the equivalent of identifying the causes of current degradation of assets.)
3. **Determination of the trajectory of change.**

Tasks 1 and 2 of this step were considered difficult to complete meaningfully, as already discussed (Chapter 2, Step 4). Wherever valid, however, assets and problems are tabulated per river segment, together with present state information in Chapter 4. The Trajectory of Change was also considered problematic for specialists to assess with confidence on the basis of only one field visit and little reference information. This is however considered important and would be possible to assess with greater exposure to the river (e.g. more fieldwork). It was however excluded for this exercise, and replaced by an assessment of Future Attainable State.

3.1.5 SETTING OF PRIORITIES

1. **Assign reaches to one of the nine categories presented in Table 2.9, based on the principles presented in the Methods (see Chapter 2, Step 5).**
2. **Rank reaches that are in the same category.**
3. **Query and check the reach priority rankings.**

A number of different prioritisation exercises were undertaken, at different scales. The process (Steps 1-7) and the results are presented in Table 3.1.

- | | |
|---------|---|
| Step 1: | The river reaches matching the description provided in the prioritisation guideline (Table 2.9) were entered into this column. |
| Step 2: | The relevant river segments matching the reach numbers (entered in Step 1) were entered into this column. |
| Step 3: | On the basis of the position of the entries in Step 2, priority rankings from 0 to 10 were assigned to each river segment. These differed slightly from those presented in the first column of the table, but were still linked to the relevant descriptions, as is evident on Table 3.1. |
| Step 4: | The numbers of reaches within each segment prioritised in Step 3 were entered into a new column, this time individually. |
| Step 5: | Priority rankings from 1 to 30 were assigned to each of these reaches listed in Step 4. |
| Step 6: | Appropriate zone numbers were now entered into a new column to match up with the segments and reaches already listed in previous steps. |
| Step 7: | Priority rankings from 1 to 9 were assigned to the zones. Although there are 6 zones, nine rankings were assigned, as some of the zones were divided into 'upper' and a 'lower' sections. |

Table 3.1 Process followed (Steps 1-7) and results of the prioritisation process, as based on the guideline table of Rutherford et al (2000) in Table 2.9.

NO	DESCRIPTION	Reaches matching this description	Segments matching this description	Segment Priority	Reach No.	Reach Priority	Zone No.	Zone Priority	ACTIONS REQUIRED
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	
0	Reaches in good condition throughout, that are already protected			0		0		0	Nothing needs to be done to these reaches, but to monitor for development of any threats.
1	Reaches with important regional conservation assets and/or value	26, 27, 28, 29, 30	Lower 9, 10	1	26, 29	1	F	1	Protect these for their rarity value. This includes identifying and fixing threatening problems that come from other reaches.
					30	2			
					26	3			
					27	4			
2	Reaches with local conservation value	25	9	2	25	5	E	2	These include surviving remnant sections of original streambeds. They may be common in the area, but are rare in the catchment. Prevent these from deteriorating. This involves treating all threats to the reach, including those from outside the reach.
		3	3	3	3	8	B (upper)	3	
3	Actively deteriorating reaches	10, 11, 12, 13, 14	5, 6	4, 5	10, 11, 12, 13, 14	9, 10, 11, 12, 13	C	4	Arrest present deterioration and prevent further deterioration.
		21, 22, 23, 24	8 (lower)	6	21	14	D	5	
					22	15			
					23	16			
					24	17			

Table 3.1. continued.

NO	DESCRIPTION	Reaches matching this description	Segments matching this description	Segment Priority	Reach No.	Reach Priority	Zone No.	Zone Priority	ACTIONS REQUIRED
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	
4	Reaches in good condition	15, 16, 17	7	7	15, 17	18	C (lower)	6	Expand these areas. The value of quality assets is greatest when combined with other assets to form a complete stream community. Work on (i) reaches with some high quality assets and some degraded assets, (ii) poor quality reaches that link two asset-rich reaches, (iii) poor quality reaches with asset-rich reaches at one end.
5	Reaches with impeded recovery, degraded but in stable condition	15, 16	7	8	15	19	B (upper)	7	Where natural recovery should be occurring but is prevented by a particular stream problem. Identification and rectifying that problem facilitates natural recovery.
		6, 7, 8	4	9	16	20			
					6	21			
					7	22			
					8	23			
6	Moderately damaged reaches	4, 5	3	10	4	24	B (mid)	8	These are reaches with good potential to improve at reasonable cost. These need several interventions, rather than just one (as in Category 5).
		18, 19, 20	8 (upper)	11	18	26	D (upper)	9	
					19	27			
					20	28			

Table 3.1, continued.

NO	DESCRIPTION	Reaches matching this description	Segments matching this description	Segment Priority	Reach No	Reach Priority	Zone No.	Zone Priority	ACTIONS REQUIRED
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	
7	Basket case reaches (in very poor condition; not threatening to other reaches; and with little chance of self-recovery over time)	2	2	12	2	20	A	10	These are considered to have serious problems and need intervention to recover
8	Basket case reaches with hope (in very poor condition; not threatening to other reaches; and with some chance of self-recovery over time)	3	3		3	31			If the instability of this stream threatens downstream reaches these should be pushed up the priority list

Table 3.2 Priorities for protection and/or rehabilitation of Segments, Zones and Reaches in the Ihlanza, based on the prioritisation exercise shown in the previous table.

No.	Zone	Segment	Reaches
0	Descriptions not applicable to any part of the river		
1	F (Estuary)	9,10	27,28,29,30
2	E (River-Estuary transition)	9 upper	25,26
3	B (Upper Reaches)	3 upper	3
4	C upper (Middle Reaches)	4 upper	10-14
5	D (Lower Reaches)	8 lower	21-24
6	C lower (Middle Reaches)	7	15,16,17
7	C (Middle reaches)	4 lower	6,7,8,9
8	B upper (Upper reaches)	3 lower	4,5
9	D upper (Lower reaches)	8 upper	18-20
10	A (Upper catchment)	2	2

4. Set problem priorities.

This task was undertaken as a generic task for the river, rather than per reach or per segment. Causes of degradation in the Ihlanza River were categorised from **fatal** problems (which may exclude fauna or flora from a reach) to **limiting** problems (which stress or alter the expected species distribution) to **nuisance** problems (which have a minor effect on the biotic community), as shown in Table 3.3. Water quality deterioration was considered to be a fatal problem. This is an issue throughout the river, but is most serious in Reaches 2 to 4 where there is dense growth of sewage fungus in the channel. The water quality is the likely cause of the absence of instream biota from all samples taken in this area.

Table 3.3 Fatal, limiting and nuisance problems identified for the Ihlanza River.

FATAL PROBLEMS		
Symptom	Major Contributing Cause	Affected Reaches
Water quality deterioration	Surcharge of sewage through manholes during high flow events. Poorly maintained sewerage system leaking into the river. Urban runoff entering the river.	All
LIMITING PROBLEMS		
Symptom	Major Contributing Cause	Affected Reaches
Sewage fungus in channel in upper reaches	Sewage surcharge into the channel.	2,3,4 (extreme)
Alien vegetation invasion	Urbanisation, clearing of land for development and for sewerage line, poor vegetation management.	All but 26, 27
NUISANCE PROBLEMS		
Symptom	Major Contributing Cause	Affected Reaches
Channel alteration through incision, sedimentation, or bank instability.	Urban hydrology: increase in runoff during rainfall and storm events. Stormwater inputs to river mostly routed through eroded earth channels. Increase in frequency of smaller floods ('flashier' hydrology).	Majority

The problem most severely affecting natural features of the stream (or assets) was considered to be water quality deterioration. Establishing an appropriate flow regime and geomorphology the river would do little to ensure a healthy system if the physical and chemical characteristics of the river remained inappropriate (e.g. FISRWG 2000). The deterioration of habitat quality was seen to result in part from water quality problems.

5. Check for other limiting problems

Other limiting problems were recorded as:

- Water quantity: base flows are extremely low; the groundwater level has dropped, reducing both the buffering of the system and the connectivity between channel and floodplain; and high flows have been increased in magnitude, frequency and duration as a result of urbanisation;
- Sedimentation: resulting both from bank instability or collapse, and erosion of stormwater drainage channels which intersect with the river. Fine sediments ('fines') can severely alter aquatic communities through clogging and abrasion of fish gills and suffocation of eggs and benthic aquatic insect larvae. It also affects water clarity and habitat quality (FISRWG 2000).

6. Decision as to where there are exceptions to the problems

The intention here was to consider prioritising problems that were not thought to be fatal or limiting, as this may improve the value for money or cost-effectiveness of the rehabilitation exercise.

One such problem was considered to be the encroachment of alien vegetation in the catchment. This is a concern in most reaches, but also threatens the protection and conservation of the sensitive and relatively natural riparian vegetation in Reaches 3 and 26 to 30.

This problem can be addressed both at a local scale by property-owners, and at a larger scale (e.g. conferring Protected Area status on the lower reaches), with relatively rapid and effective results. The clearing of aliens, replanting with indigenous flora, and protection and expansion of indigenous riparian vegetation in the river is considered a pragmatic, attainable rehabilitation target, and is assigned a high priority (e.g. Reaches 3, 25, 26 are high priority areas and the reason for this is chiefly alien clearing, replanting and maintenance).

Even in the absence of improved water quality, the state of the riparian buffer (30-50m from the channel edge) can be addressed with sustainable outcomes. One part of this exercise would be increasing the stream shading by planting appropriate bankside trees (which also improve bank stability). In shallow systems such as the Ihlanza, the clearing of stream sites can have a marked effect on stream temperature and increase the range of temperature fluctuations. Stream temperature can directly influence the growth and development of aquatic fauna and flora (e.g. Bunn et al. 1999).

Another part of the exercise would be the establishment of patches of marginal vegetation habitat, which should increase invertebrate abundances, assist in remediating water quality, and protect the stream from erosion (Rutherford et al. 1999).

The benefits of addressing longer reaches of the river rather than attending to smaller scale, site-specific works were also considered. This would generally be the preferred approach, and is applied to two priority zones of the river, Zone C (between NE-Expressway and Galway Road) and Zone F (estuary and mouth). However, certain small-scale actions are considered necessary to support the larger-scale measures. For example in Zone C, there is little point in attempting the gradual reinstatement of an indigenous river morphology and riparian biota, if the river is still disconnected from its floodplain and the channel and banks are incised so steeply that they are not visible from the recreational area. The key here seems to be to achieve a satisfactory balance between one's several objectives, and the two spatial scales, with the consensus of role-players.

Similarly, in considering the time-scales of the project, one is encouraged to initiate the recovery process in damaged reaches sooner rather than later. This would be the option for Reaches 2 and 10 to 12 for example (see Chapters 4 and 5, relevant reaches). However, these intentions are driven by this project, and the actualisation of them is entirely dependent on where the implementation funding is sourced, and the needs and priorities of funders and practitioners.

As the river runs largely through residential areas, the issue of community support is critical in the project process. The specialist team and others consulted felt, from early in the rehabilitation process, that the zone of the river which had the best public accessibility should be prioritised more highly than zones in which access was restricted or somewhat exclusive. Despite the fact that the majority of the length of the river is bounded by land zoned as Public Open Space (POS) on one or other bank, the only area in which there is truly open public access is Zone C (Reaches 10-17), between North East Expressway and Galway Road. This area is home to many families and there appears to be support for the idea of creating a 'River Health Park' – which would comprise a fitness park, natural areas, recreational amenities, and an urban walking path and cycle trail through this section of river corridor (as detailed in Chapter 5, Segments 5 to 7).

7. Check if some reaches/segments should have more than one rank.

This was a useful exercise, having completed the earlier prioritisation exercise (Table 3.1). Certain segments or reaches, such as Reach 3 of the Ihlanza, need both protection and rehabilitation (see Chapters 4 and 5 for details). The advice of Rutherford et al. (2000) in this case would be to protect the assets in these segments and then to protect assets in other segments before attending to the degradation in the first segments. This first segment could then have initially one priority, e.g. Category 1 (Regional Conservation Value) and, following remedial actions, would be assigned a Category 4 (Expand Good Reaches). This thinking would be applied to Reaches 3, 7, 8 and 25 to 30.

3.1.6 STEP 6. CONSIDERATION OF STRATEGIES TO PROTECT ASSETS AND IMPROVE THE STREAM

Strategies for the protection of environmental assets and/or the prevention of degradation.

The environmental 'assets' of this stream, as defined by Rutherford et al. (2000) are restricted to those areas of the river where there the instream habitat, flow diversity, and/or riparian zone are similar to what would be expected under natural conditions. Instream habitat features cannot be protected without being stabilised in some way, as the river is highly dynamic, and in high flow or flood events, coarse substrates are transported downstream (as noted during the 2002 floods). Thus, areas which are at present cobble/boulder could lose extensive bed material to downstream reaches during a flood of sufficient magnitude.

A strategy for the protection of existing riparian vegetation is thus considered more pragmatic and sustainable. Protection of indigenous vegetation is best achieved by conferring formal protected status to the area concerned. This is one of the objectives for Reaches 26 to 30 (see Chapter 5, relevant reach pages).

However, in the experience of this project, once individuals with some vested interest in the area (e.g. property owners along the river banks) become enthusiastic about riparian rehabilitation, significant positive change can occur within a short period. The Galway Road resident group, who own houses in Zone D for example, have cleared alien-invaded bank areas (much of which is in Public Open Space adjacent to their properties) under specialists supervision, and have replanted appropriate indigenous vegetation at their own cost. There is a clear awareness among this group of volunteers that this exercise has several positive outcomes, including improved aesthetics, safety, and river health; and increased property values. The associated rise in plant and animal biodiversity will add natural value to these residents' lifestyles.

A 'spinoff' strategy would be to encourage other nearby residents to form similar groups along their own stretches of the river. This would have the added benefit of enhancing community life and spirit.

Strategies for the improvement of environmental assets

Here, the strategy would be to raise awareness and enthusiasm for both the need for ecophysical improvements to the river, and the benefits that would result. Once there is interest, the relevant parties should gradually be encouraged to commit to a recommended course of action. The individuals to target initially would be either those in a position to make and implement relevant decisions (e.g. senior officials in the local authority; Ward Councillors), or those able to influence decision makers (e.g. businesses, educators, residents).

This could be achieved in many ways, firstly by direct contact with the individuals, and secondly by exposing them, either on-site or with the assistance of a presentation, to the story of the river, why it is degraded, why it should be rehabilitated, and how to go about it. When dealing with individuals, the initial emphasis should be both on *"how this will benefit the individual or group"* and *"how this will improve the river"*.

These individuals could ultimately assist with, or fund, the actual interventions and improvements of natural features of the river if they chose to, or were encouraged to by stakeholder groups.

Strategies for fixing present problems.

This is possibly the most difficult strategy to consider. In this project, as in many urban projects, addressing the priority problems (water quality, water quantity) will be costly and complex. The Ihlanza River is situated in a middle-to-upper income area and is unlikely to be prioritised for upgrading by BCM, who have many worse areas to attend to. There are however a number of other possibilities:

- A public-private partnership could be considered for the upgrading and maintenance of the sewerage system along the river, or this exercise could be incorporated in the Buffalo City IDP (Internal Development Plan) project list under the present ProjectTheme of *"Upgrading and maintenance of infrastructure"* (IDP 2002). The benefits of the upgrading process would have to be quantified in economic, environmental and social terms.
- The Working for Water Programme has already been involved in this project (see Table 2.1). This organisation could be approached to assist with alien clearing and replanting.
- Local businesses should be approached to fund the development of the River Health Park (Chapter 5, Reaches 10 to 17).

Translating this from a strategy into action would be a time-consuming task, best undertaken by a group or an elected River Conservation coordinator.

Strategies for improving human behaviour.

At this level, strategies should include the development of a framework for communication, education and public awareness (CEPA). This can be translated into many different activities, including public presentations, media, liaison with schoolgroups, and community 'river meets'. The intention is to develop a level of awareness which will prevent individuals, developers or authorities from causing further damage to the system and loss of biodiversity in streams.

In the Ithanza, the greatest immediate need is for increased awareness regarding the illegal drainage of stormwater into the sewerage system. This activity causes the capacity of the sewerage system to be exceeded during high rainfall events, resulting in sewage surcharge, spillage of diluted sewage directly into the water, and resulting water quality deterioration.

Another strategy would be to argue for the revision and implementation of new municipal regulations to address this and other issues, including

- development within the 100 year floodline
- interventions in the channel or on the banks
- diversion of flow or of the channel, and
- discharge of wastewater into rivers.

Controls regarding invasive alien vegetation, and education about how to remove encroaching species and what to plant in their place is another strategy that is likely to garner community support.

3.1.7 SETTING OF GENERIC AND SPECIFIC OBJECTIVES

Prior to setting objectives, this study considered, for each component (i.e. geomorphology, riparian vegetation, invertebrates, fish) the Future Attainable State (FAS) of the river, based on the perceived Natural State and the derived Present Ecological State classes (both of which were discussed in Step 3, and are presented per river segment in Chapter 4). The FAS is described as a class from A to F, as illustrated in Table 2.2, and is defined on the basis of a different set of criteria per component.

1. Definition of the extent of change desired.
2. Define the spatial scope of the objective.
3. Set the time frame.

Following the setting of FAS, a set of ten key objectives for the ecophysical rehabilitation and protection of the river were set at a generic level for the river, as the principles of what is required and what is considered attainable do not vary greatly along the length of the system. The spatial and temporal scaling of these objectives is thus purposefully generalist. Where possible and valid, these objectives are expressed in terms of an (approximate) acceptable range of time from the time of intervention. Actual dates and timelines cannot be provided as scheduling of interventions is excluded from this project. These are presented in Table 3.3.

Table 3.3 Generic Objectives (regular print) and recommended rehabilitation measures (italicized) for the rehabilitation of the Ithanza River.

VEGETATION
Overall, the vegetation within the riparian buffer strip (average 30 - 50m from the channel edge) in Reaches 25 to 30 should be 70 - 80% indigenous, and in Reaches 1 to 25 should be at least 40 - 50% indigenous, within 5 years of commencement of replanting and rehabilitation actions.
<i>This could be achieved by the development of a vegetation management programme to clear and control alien vegetation within the riparian buffer strip and to replant this strip with appropriate indigenous species. Funding is likely to be required.</i>
Protect existing intact areas of indigenous riparian vegetation.
<i>This requires the lower reaches of the river and its riparian area to be declared a protected area, with controlled access.</i>
Protect the root zones of the numerous exposed and threatened <i>Erythrina caffra</i> (coral trees) and <i>Ficus</i> spp. (fig species) along the river course.
<i>This requires intervention in the form of artificial root protection. For example coarse substrates such as cobbles packed around the roots, covered with a biodegradable material such as 'Biomac' and bound in place with the use of hexagonal double-twist wire mesh, to form a 'sack' gabion around the root zones. This would ideally be keyed or stapled into the bank. These structures should be designed professionally so as to prevent upstream or downstream bank scour. The added benefit would be the creation of additional invertebrate and/or plant habitat.</i>

Table 3.3 Cont. Generic Objectives (regular print) and recommended rehabilitation measures (*italicized*) for the rehabilitation of the Ihlanza River.

FISH
Increase fish diversity in the lower and middle reaches. Within 5 years of commencement of the rehabilitation actions, the following species could be expected to occur: <i>Barbus anoplus</i>, at least 2 species of freshwater eels (<i>Anguilla mossambica</i>, <i>A. marmorata</i>) and <i>Glossogobius callidus</i>. The stocking of the threatened East Cape Rocky (<i>Sandelia bainsii</i>) in the lower reaches should be under consideration. <i>This requires a significant improvement in water quality, the creation of additional instream habitat for these species, and the assurance of unrestricted fish passage along the river.</i>
INVERTEBRATES
Increase invertebrate diversity and abundance. As a cautious estimate, SASS5 total scores at a site should improve to 80-100, with an Average Score Per Taxon (ASPT) of >5 (approximately 16 taxa), within 5 years of commencement of water quality remediation measures. Details of expected taxa are provided in Chapter 5. <i>This requires a significant improvement in water quality, the improvement of physical and hydraulic habitat diversity, and the creation of additional physical and hydraulic instream and marginal habitat (including marginal vegetation).</i>
ESTUARY
Improve the quality of water entering the sea from the Ihlanza such that it meets with DWAF recreational water quality standards (DWAF 1999a) for 80% of the time by the year 2010, and aquatic ecosystem quality standards (DWAF 1999b) for at least 50% of the time by 2010. Protect this estuary as an example of an almost natural, undeveloped indigenous area, and use this to create public awareness of estuarine ecosystems and the important roles they play (e.g. connecting rivers to the sea, providing nursery areas for juvenile fish; transport and distribution of indigenous seeds, etc). <i>The first requirement would be similar to that for Water Quality. The building of a boardwalk, as recommended in the Objectives (Chapter 5), would go some way towards achieving the second objective.</i>

Table 3.3 Cont. Generic Objectives (regular print) and recommended rehabilitation measures (*italicized*) for the rehabilitation of the Ihlanza River.

WATER QUALITY
Reduce the levels of point- and diffuse-source pollution entering the river. Point-source pollution in this catchment is invariably the result of surcharge or leakage of sewage directly into the channel, and of stormwater inputs. Diffuse-source pollution includes road-runoff, the use of cleaning materials and fertilizers in domestic and garden maintenance, and general litter. The five year goal would be to reduce the present levels of water pollution such that water quality meets with DWAF recreational water quality standards (DWAF 1999a) for 80% of the time by the year 2010, and aquatic ecosystem quality standards (DWAF 1999b) for at least 50% of the time by 2010. <i>There are three major requirements. The first is the upgrading and maintenance of the sewerage system, and the replacement of all manhole covers with lockable poly-concrete covers. This is a municipal function but could be approached as a public-private partnership. The second, and equally important objective, is public education regarding the illegality and consequences of leading storm water into the sewerage reticulation system. This awareness-building exercise should be accompanied by the drafting of municipal regulations to this effect, together with a mechanism for compliance monitoring and imposition of fines for those contravening this regulation. The third is physical structures for litter entrapment, and a public awareness drive on pollution.</i> The two year goal would be to get BCM to conduct monthly water quality monitoring of all relevant variables per river segment. <i>This is likely to be primarily a cost issue. It is likely that community pressure could have some influence in this process, however to prevent this serving as a precedent for all streams in the city, the Ihlanza could be used as a BCM Pilot Project for water quality rehabilitation.</i>
WATER QUANTITY
Increase infiltration, particularly in the upper catchment; and reduce stormwater runoff volume and velocities. <i>The first objective is unlikely to be possible initially, due to costs of replacing hardened surfaces with permeable materials. The transformation of all open stormwater drains into grassy swales (Design 10, Appendix 5) would assist in meeting this objective however. Reduction of stormwater runoff volume and velocity requires the assistance of hydrologists and engineers to ensure that flood risks are not raised by measures such as increased channel roughness.</i>

Table 3.3 Continued. Generic Objectives (regular print) and recommended rehabilitation measures (*italicized*) for the rehabilitation of the Ihlanza River.

GEOMORPHOLOGY
The objective would be to move from the current, unstable state, towards a state of dynamic equilibrium in the system, where the river's energy is such that the sediment loads entering a stream reach are equal to those leaving it. Riley (1998) points out that it may be easier to design a stable channel with rigid beds and banks than to attempt this objective! She adds however that it is possible to design with this objective in mind, and if one does, the river project will be more sustainable over time. <i>This is a complex consideration and requires an understanding of river processes and the variables affecting channel function. Riley (1998) refers to Lane's (1955) equation for equilibrium:</i> <i>"the quantity of sediment x sediment size is proportional to the slope of the stream x the stream's discharge"</i>. <i>A change in any of these four variables requires a corresponding change in one of the other three variables in order to restore equilibrium. Rehabilitation actions, be they bank stabilisation, erosion control, or measures to address channel incision, must be designed with this equilibrium equation in mind. Measures to attend to physical structure should address the increase in stream power during storm events, and the resultant capacity of the river to carry more sediment than it has entering it.</i> Naturalise the stream form and instream habitat features. <i>Rutherford et al. (2000) recommend a number of different approaches to designing a more natural stream: historical reconstruction (using the pre-impact state as a template), reference reach approach (copy the characteristics of a remnant of a good quality stream), empirical catchment model approach (applying generic, empirical relationships, based on hydraulic geometry or regime relationships to predict the 'equilibrium' form of the stream – although this is not considered a highly reliable method and may not apply to SA streams), stable channel or erosion potential approaches (using the hydraulic-geomorphic approach and tractive stress or maximum allowable velocity approaches which allow a stable bed slope to be predicted, such that there is no net degradation of a reach), and the channel evolution approach, using classification (based on conceptual models of the morphological stages through which a stream evolves after major disturbance). In setting the objectives for the Ihlanza, the 'reference reach' approach has been largely followed, referring to the likely natural or reference channel form as described by Wadeson (Chapter 4, Natural State per segment). However, all designs which relate to channel form or instream habitat modifications will have to be vetted by a river hydraulician and a hydrologist to mitigate against increasing flood risks in the designated areas.</i>

Table 3.3 Continued. Generic Objectives (regular print) and recommended rehabilitation measures (*italicized*) for the rehabilitation of the Ihlanza River.

GROUND WATER
This has not been investigated at a specialist level. However, the assumption based on geomorphological and ecological studies is that the groundwater level has dropped in the order of metres, particularly in the upper catchment. If this assumption is shown to be correct by further studies, the objective would be to raise this level by the same height within a period of 5 to 10 years. <i>One requirement is for increased infiltration into the upper catchment. This, as already mentioned, is a major undertaking. However this problem should influence planners and regulators, such that use of permeable and vegetated surfacing materials (e.g. turfblock) become requirements for new developments. The conversion of hardened stormwater drainage canals to grassy swales (see Design 10, Appendix 5) would also have the effect of increasing infiltration. The raising of the present bed level in Reaches 10-12 would have the long-term effect of raising the groundwater table slightly, and enhancing the channel-floodplain linkage. This is considered further in the Objective pages for Reaches 10-12 (Chapter 5).</i>
SOCIAL
Enhance public awareness regarding the functions and value of this riverine corridor, through gradual rehabilitation of the river's ecological function and process, and the creation of attractive and environmentally-oriented amenities adjacent to the river and estuary. The ultimate objective is that the catchment community should understand the river and develop a sense of pride and custodianship over it. <i>The establishment of a Catchment Management Forum should be considered. Also see recommended measures for individual segments (Chapter 5).</i>
MONITORING
Ensure that the information required for catchment-specific records (rainfall, water quality, alien infestation) is gathered at appropriate intervals and at fixed sites. <i>This requires that monitoring a monitoring programme be established. The set of five (dysfunctional) rainfall gauges installed in the catchment by the former East London City Council require rehabilitation. Water quality sampling has been referred to. Invertebrate and fish sampling using biomonitoring indicators should ideally be done once per season every year.</i>

Specific objectives (and recommended rehabilitation measures to address these) have been developed and prioritised for each river segment, in three categories: Ecological, Infrastructural, and Social/Educational/Recreational (Chapter 5). Where possible, these are illustrated on the relevant reach maps in Volume 2 (Maps 5.1 to 5.30). The reason for the categorisation is that the objectives are likely to be addressed by different organisations or institutions, and this method simply clarifies which objectives are relevant to the various bodies. For example, it would make little economic sense for a private organisation to attempt to address infrastructural objectives, which are essentially the function of the local authority, BCM.

Exact spatial scope has not been described for the objectives. For example, where bank stabilisation is required, the exact number of metres has not been specified. This level of detail would however be necessary during the design phase, when costing of interventions would be necessary.

4. Determine the type of objective.

For the present project, objectives have been framed in terms of **outcome** rather than **output**, as the output relates specifically to the execution and survival of the intervention. As these treatments are recommended and have not yet been finalised or planned in detail, this would be premature.

3.1.8 CHECKING THE FEASIBILITY OF OBJECTIVES

1. Check affordability

Only the planning costs of this rehabilitation project were considered for the present study. Costings have not been prepared for the proposed designs and thus affordability of the various treatments has not been estimated. The affordability also needs to be checked against the available budgets, which are as yet unknown.

2. Check legality and legislative and administrative constraints

The majority of objectives set do not conflict with any of the known National legislation or local regulations. The exceptions are any proposed interventions in the channel (e.g. placement of gabion weirs across the channel, bank stabilisation).

The National Water Act (No.36 of 1998), includes the need for a licence for the following two activities, defined in the Act as 'water uses': impeding or diverting the flow of water in a water course; altering the bed, banks, course or characteristics of a water course (S21 (c) and (i) of NWA). The DWAF is entitled to promulgate regulations on the use of water (S26 of NWA), and to regulate or prohibit any activity in order to protect a water resource or instream or riparian habitat. If it is

desirable that water use be licensed in order to protect the water resource quality, then a responsible authority may undertake compulsory licensing (S43 of NWA).

There is also provision in the Act for gaining access to water resources for the purposes of assessing or rehabilitating them. In terms of Section 65, if a person is required under the Act to undertake rehabilitation or other remedial work on private land, and is unable to gain access to that land on reasonable terms, the Minister is empowered to expropriate the necessary land rights. The Minister may authorise a suitable person to enter a property in order to either undertake work necessary for stabilising or repairing the water resource and protecting the resource quality (S125 (2) (b) (ii)); or to install and operate any equipment necessary on a temporary basis to monitor and gather information on water resources (S125 (2) (b)(v)).

3. Check whether it is worthwhile doing (i.e. do the negative effects outweigh the positive ones?)

As designs for this project are only presented in conceptual form, these questions could only be answered at a broad scale and with a low level of confidence. However, it is recognised that these are the questions to be asked during the specialist design of stabilisation measures, structures to be placed in the river, etc., and that the riverside community and relevant local authorities should be consulted extensively both during this design phase and prior to any interventions.

4. Assess confidence in the objectives

As this issue relates to balancing costs, risks and outcomes in rehabilitation, this is best done once the full project plan is complete with costings.

5. Weigh up the feasibility on the basis of Tasks 1-4

If feasibility is still a question on the basis of the foregoing steps, three options can be considered (Rutherford et al. 2000):

Compromise: this will involve modification of objectives to tailor the project (where appropriate) to legal requirements, costs, and community requirements.

Do a trial run: where outcomes are uncertain, it may be possible to run a low-cost pilot trial of the treatments planned, both to estimate effects and to harness further public interest and support.

Recognise absolute unfeasibility: There may be scenarios where the potential negative effects outweigh benefits, or where legal constraints disallow the key rehabilitation actions. In certain instances it must be recognised that halting the project at this point is necessary.

3.1.9 DETAILED PROJECT DESIGN

Detailed project design was beyond the scope of this project (as discussed in the Methods (Chapter 2)). The decision was taken to present only conceptual designs for various interventions at this stage. These are considered sufficiently detailed to provide decision-makers in the catchment (e.g. BCM, property owners, businesses or institutions) with an idea of the design and interventions that would be required to meet the relevant objective. These designs could also be used to get cost-estimates from relevant service-providers.

Detailed project design – which is essentially the second phase of project management for the rehabilitation exercise – should commence only once there is sufficient interest, commitment and ‘buy-in’ from the relevant bodies to ensure that certain of the generic objectives (Table 3.3) will be addressed. At this stage is proceed with more detailed analytical design, assessment of design, and implementation.

The conceptual designs which illustrate various of the Objectives and Recommended Actions (Chapter 5) are presented in Appendix 5.

CHAPTER 4

PRESENT ECOPHYSICAL STATE OF THE IHANZA RIVER

4.1 ZONE A, SEGMENT 1, REACH 0 - 1

4.1.1 COORDINATES (DMS)

REACH	UPPER END LAT.	UPPER END LONG.
1	32° 59' 9.35" S	27° 54' 28.98" E

4.1.2 DESCRIPTION

Prior to human settlement and urban development, this uppermost section of the river would likely have been a wetland with an ill-defined channel. At present, it is entirely buried in underground culverts routed beneath the commercial and residential developments in upper Vincent. The earliest available aerial photographs from 1935 indicate that the river was already canalised in parts of this segment by that time (Figure 4.1).

Riley (1998) discusses the multiple hydraulic problems that can result from containing a river in culverts, or routing it through culverts. One of the problems highlighted is that these culverts are usually designed to carry a 1:10 or 1:25 year flood, so that 1:50 or 1:100 year floods are not accommodated by the reticulated system and will flow overland. From an ecological perspective, the damage to the buried river system is extreme: all light and habitat are lost to the system, and with these vanish all plant and animal biota. Connectivity between channel, banks and floodplain is lost. The links to the riparian corridor are removed. Flow diversity is lost and oxygenation reduced. From a social perspective, the historic, environmental and aesthetic assets of the stream have been lost. In many parts of the world, the 'daylighting' of formerly buried river channels is being addressed as a matter of some urgency (Pinkham 2000).

Aside from being a buried stream, this system is subject to a hydrology which is significantly modified from natural, in that the permeable surface in the upper catchment has been reduced to less than 5%. With this extensive impermeable surface, runoff rates are significantly increased during high rainfall events, and the frequency and magnitude of the smaller floods (e.g. 1:1 or 1:5 year) are typically increased, posing ongoing flood threats.

The burial of the Ithanza River has led, directly or indirectly, to a number of flooding problems, the most recent of which is discussed in Section 4.1.4.

4.1.3 URBAN DEVELOPMENTS AFFECTING THE RIVER

Increased hardened surface in upper catchment areas (approx. 95%).
Channel buried in culverts beneath the surface.
Urban hydrology.

4.1.4 SPECIFIC CONCERNS

Flood Risks

The hardened surface in the upper catchment is estimated at approximately 95% by local engineers. However, the stormwater drainage for this area was designed on the basis of only 80% impermeable surface. The existing drainage network in the upper catchment is thus considered insufficient to handle the runoff from large storm events. This problem cannot be easily addressed however, as an upgrading of the stormwater system would require the cooperation of commercial property owners in the area (who are responsible for stormwater reticulation on their properties) and the Buffalo City Municipality (who is responsible for stormwater reticulation along roads and through Public Open Space).

Vincent Park Shopping Centre was built over the former wetland area and river channel, at the lowest point of the upper catchment. A basement area was also excavated below ground level. Seepage is pumped continuously from this basement area (and from one other development in the upper catchment) and is discharged into the storm water drainage network (Koekemoer, pers.comm.).

The net result of these urban developments is a loss of infiltration to groundwater, and a likely lowering of the water table (although this has not been validated).

The drainage system is designed to receive storm water runoff from the upstream catchment via catchpits and culverts. However, during more extreme flood events (e.g. 1:20 or 1:50), flows may exceed the capacity of the conventional stormwater drainage system. Because of the extreme nature of the event, debris washed down roads can block catchpits and smaller culverts (Ninham Shand 1992). Runoff is thus directed overland, following surface topography.

Flood Damage

During the August 2002 floods in East London, over 457mm of rain fell in a 24 hour period (SA Meteorological Services 2003). It is estimated that up to 300mm of this fell within a 20 minute period, in the early hours of the morning. As the runoff was prevented from entering the stormwater system (as described above)

the flow was directed overland and into the Centre, causing flood damage estimated at tens of millions of Rands (see Appendix 2 for press report).

Great lengths were taken to discuss the upper catchment problems with the Centre Management and Engineers. A proposal was submitted to the owners of the Centre, Old Mutual Properties, to address the flood risk problem through the modelling of drainage and runoff in the upper catchment. In the final analysis, however, conventional engineering methods were used to address the flood risk problem, and these were only applied in the vicinity of Vincent Park Centre. An upper catchment water resource management plan is still considered a necessity.

4.1.5 GEOMORPHOLOGY

Present State	Attainable State
F	F

Natural State

No information or maps exist to illustrate the condition of the river in this section prior to canalisation (already present in 1935). It is likely that this area would have been largely wetland areas with an ill-defined channel.

Present Ecological State

Critically modified. Totally engineered and buried channel, no natural material in the channel perimeter.

4.1.6 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
E (16)	F (3.61)	F
Present State		
E/F		

Natural State

It is likely that this section would have been predominantly Eastern Thorn Bushveld mixed with Valley Thicket, with patches of grassland in the riparian zone where topography, fire and grazing impacts had promoted this. More exposed undulating areas are likely to have had a higher ratio of hardier woody species such as *Acacia karroo*, *Cussonia spicata*, *Diospyros dichrophylla* and *Apodytes dimidiata*. The more sheltered areas would be expected to have attained forest proportions, containing trees such as *Harpephyllum caffrum*, *Vepns undulata*, *Olea woodiana*, and *Rapanea melanophloeae*.

Present Ecological State

There is little or no remaining natural vegetation in this segment.

4.1.7 FISH

Natural State

Prior to the construction of canals in this segment, freshwater eel (*Anguilla mossambica*) and possibly chubbyhead barb (*Barbus anoplus*) could have moved into pools in the wetland or channel, which would likely only have been present during wet periods.

Present Ecological State

As this segment comprises only concrete-lined canals, no sampling or assessment of fish was possible. In its present state, this segment has no instream habitat and would not support fish life. The Present State would be assessed empirically as class F.

4.1.8 INVERTEBRATES

Natural State

In the natural state, the river in this section would probably have been a wetland type area with an ill-defined channel. Invertebrates present would exclude many flow-dependent species and Plecopterans (which require high quality water), but could include a relatively diverse community, including the aquatic life stages of the more resilient mayflies, dragonflies, damselflies, certain caddisflies, fly larvae, and several dipterans.

Present Ecological State

As this segment comprises only concrete-lined canals, no sampling or assessment of invertebrates was possible. In its present state, this segment has no instream habitat and is unlikely to support aquatic invertebrate life. The Present State would be assessed empirically as class F.

4.1.9 ASSETS AND PROBLEMS

As there are no Assets (remaining natural features) in this section, a consideration of Assets and Problems was not possible.



Figure 4.1. The canalised section of the Ihlanza River running through the upper part of the suburb of Vincent, in 1935. The white boundary marks the present position of the Vincent Park Centre, which is located atop the canal visible in the photograph.

4.2 ZONE A, SEGMENT 1, REACHES 1 & 2

4.2.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
1	32°59'9.35"S	27°54'28.98"E
2	32°59'11.31"S	27°54'32.35"E

4.2.2 DESCRIPTION

This entire reach is canalised for stormwater management. The river daylight for the first time at the top of Reach 1 (Map 4.1, Plate 1.1), where stormwater from the upper catchment flows into this canal. Both banks are zoned as Public Open Space, and are grassed as park-land in Reach 1. The lower end of Reach 1 is bounded by Neale Road.

In Reach 2, the continuation of the stormwater canal is considered by specialists to be aligned adjacent to the former, poorly-defined channel and wetland, as areas outside of the canal are poorly drained and frequently marshy. The banks are both relatively steep, invaded by exotic vegetation, and are zoned as Public Open Space (Plates 2.1, 2.2). According to BCM officials, this valley section was formerly quarried.

Manholes of the suburb's main sewer line are situated alongside the canal in Reaches 1 and 2 (Plate 1.2). The steel covers of these manholes are most often either missing or open, allowing for surcharge of diluted sewage directly into the channel during storm events. This surcharge is largely a result of the illegal discharge of storm water into the sewerage system, which results in the latter being over capacity during high rainfall events. Many of the water quality problems of the Ithanza are thought to originate in this segment of the river. The presence of extensive sewage fungus in the channel in Reaches 2 and 3 supports this.

The area is considered undesirable in terms of access, due to the use of the area by vagrants, the dumping of rubbish, and the use of the canal as a latrine.

4.2.3 URBAN DEVELOPMENTS AFFECTING THE RIVER

Increased hardened surface in upper catchment areas, and resulting modifications to hydrology.
Replacement of the original earth channel with a concrete-lined canal.
Re-routing of the river course and alteration of gradient in this section.

Poorly maintained sewage system running alongside the canal, with regular surcharge events into the canal during high rainfall periods.

Extensive invasion by alien vegetation.

4.2.4 SPECIFIC CONCERNS

Water quality deterioration.

Pollution from stormwater inputs in area.

Lack of habitat for instream biota.

Extensive invasion by alien vegetation.

Security issues relating to vagrants in the area.

4.2.5 GEOMORPHOLOGY

Present State	Attainable State
F	F

Natural State

No information or maps exist to illustrate the condition of the river in this section prior to canalisation. It is likely that this area would have been largely wetland areas with an ill-defined channel.

Present Ecological State

Critically modified. Totally engineered channel, no natural material in the channel perimeter.

4.2.6 VEGETATION

RIPARIMAN SCORE	RVI SCORE	GUT SCORE
E (16)	F (3.61)	F
Present State		Attainable State
E/F		D

Natural State

It is likely that this section would have been predominantly Eastern Thorn Bushveld mixed with Valley Thicket, having patches of grassland in the riparian

zone where topography as well as fire and grazing impacts had promoted this. More exposed undulating areas are likely to have had a higher ratio of hardier woody species such as *Acacia karoo*, *Cussonia spicata*, *Diospyros dichrophylla* and *Apodytes dimidiata*. The more sheltered areas would be expected to have attained forest proportions containing trees such as *Harpephyllum caffrum*, *Veprie undulata*, *Olea woodiana*, and *Rapanea melanophloea*.

Present State

There is little or no remaining natural vegetation in this segment. The river has been contained in a concrete canal for these reaches, through both Neale Road 'parkland' (Reach 1) and through a downstream area that was previously excavated for quarrying purposes (Reach 2). The few large indigenous trees in this section are fast-growing pioneer species and the remainder of the area has been populated almost exclusively by alien invasive species.

Dominant species

Melia azederach, *Solanum mauritanium*, *Cestrum laevigatum*

4.2.7 FISH

Natural State

Freshwater eel (*Anguilla mossambica*) and possibly chubbyhead barb (*Barbus anoplus*) present in pools, prior to the construction of canals in this segment.

Present State

As this segment comprises only concrete-lined canals, no sampling or assessment of fish was possible. In its present state, this segment has no instream habitat and would not support fish life. The Present State would therefore be assumed to be the poorest category (F).

4.2.8 INVERTEBRATES

Natural State

Assuming that in its natural state this river segment was a wetland area with a poorly-defined channel, good canopy cover and natural water quality, the expected invertebrate fauna would include relatively sensitive mayflies, caddisflies, dragonfly and damselfly larvae, snails, Hemipteran bugs, beetles, and a number of Dipteran (fly) larvae. Stoneflies and flow-dependent taxa would likely be absent from a wetland area.

Present State

As this segment comprises only concrete-lined canals, with extremely low flow depth, sampling of invertebrates was not possible, and only visual assessments were made. In its present state, this segment has no instream habitat and does not appear to support invertebrate life. The Present State would be assumed to be the poorest class (F).

4.2.9 ASSETS AND PROBLEMS

As there are no Assets (remaining natural features) in this section, a consideration of Assets and Problems was not possible.

4.2.10 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.1, 4.2	1.1 – 2.2

4.3 ZONE A, SEGMENT 3, REACHES 3 & 4

4.3.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
3	32°59'15.05"S	27°54'39.73"E
4	32°59'15.36"S	26°54'44.56"E

4.3.2 DESCRIPTION

Reach 3 is considered extensively disturbed, despite the presence of relictual indigenous riparian forest along sections of its right bank. Here, the river runs through an area occupied by Berea Gardens Valley retirement complex on the right bank, and by Port Rex High School on the left bank. River condition has been affected by upstream water quality, the culvert bridge at the upper end of Reach 2 (Chamberlain Rd), extensive dumping on both banks, and the sewer system routed alongside both banks and across the channel (see Plate 3.1; the lower instream crossing results in flow-backup and stagnancy).

On the left bank, land has been reclaimed through backfilling of an extensive area for school sports fields (Map 5.3, Plate 3.2). Excavation and dumping has left an unnatural, exposed and disturbed artificial bench on the left bank, adjacent to which is a steep embankment (reclaimed land) which has been compacted and grassed in patches, but remains a source of sediment input to the channel (Plate 3.2). The right bank of the river is somewhat less disturbed. It has remnant patches of Valley Thicket, which is threatened by disturbance, illegal plant removal and encroachment of alien vegetation.

The majority of the ground surface in Reach 3 consists of unsightly dumped rubble and rubbish, and is hazardous to walk over. The pool-riffle-run sequence is disturbed by the presence of the sewer pipe obstruction in the upper reach, which causes a loss of hydraulic diversity. Water quality is extremely poor, likely due to sewage surcharges in this reach and upstream. The water clarity is low, coloration is grey, and sewage fungus is typically abundant. Flow is low (<0.3m/s).

Reach 4

In this reach, the river has been incised down to bedrock due to altered hydrology and upstream canalization (causing increased flow velocity). The channel at the top of the reach is steep-sided, with exposed, poorly vegetated and unstable banks (Plate 4.1). The natural pool-riffle-run morphology of the reach has been disturbed by human disturbances and by the 2002 floods (Plate 4.2). In the

middle to lower sections of the reach, the floodplain comprises a manicured parkland managed by Berea Gardens Valley retirement complex. In this section, the left bank is eroded and relatively steep. The lower end of the reach is marked by a bridge across the channel within the Berea Gardens complex (Plate 4.3).

4.3.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Chamberlain Road culvert bridge.
Sewerage system running adjacent to river and across the channel
Prominent manholes.
Reclamation of land on the left bank for the creation of sports fields.
Extensive dumping of building rubble on the left bank at the top of Reach 3.
Removal of rare riparian plants from the right bank at the top of Reach 3.
Security issues for the residents of Berea Gardens Retirement complex.
Sewage-type odour emanating from the river.

4.3.4 GEOMORPHOLOGY

PRESENT STATE	ATTAINABLE STATE
E	D

Natural State

In this section, the river would have flowed in a well defined channel, with a width of approximately 1.5m and well-vegetated, stable banks. Channel morphology would likely have consisted of pool and rapid features, and habitat diversity would be good. Valley side slopes would have been steep but well covered.

Present State

The river is functioning but is completely altered from natural. Bed material is dominated by landfill debris and coarse eroded material. The river has a "plane bed" morphology. It is over-deepened in places and over-widened as a result of upstream flood peaks and engineering structures (canals). There is extensive human influence in this section in the form of sewer lines, land reclamation, roads etc.

4.3.5 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
E (16)	D (9.7)	D
Present State	Attainable State	
D	C	

Natural State

Here one expects that the steeper left banks of the river would have been densely vegetated by Valley Thicket, while the right banks would have been inhabited by a greater number of forest species due to the greater depths of topsoil. The forested sections would be expected to contain many geophytic species such as *Scadoxus puniceus*, *Haemanthus albidus* and *Sansevieria* sp. *Encephalartos villosus* and orchids such as *Mystacidium capense* may also have been found.

Present State

Although the right bank has partially intact sections of good vegetation including geophytes, alien plant invasion of bare ground is a serious problem. The riparian habitat is also being exploited for plant material of ornamental value by the informal sector for resale (Arum lilies, *Drimys*, *Phoenix reclinata* seedlings and other geophytes are being sold bare-rooted on local street corners. The survival rate of plants sold in this manner is very low). Water quality is extremely poor due to sewage overflows from upstream, directly into the river.

Dominant Taxa

Erythrina caffra (I), *Grewia occidentalis* (?), *Syringa* spp (E)

4.3.6 FISH

Present State	Attainable State
F	C

Natural State

In the natural state, it is likely that *Barbus anoplus*, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), *Glossogobius callidus* and even possibly *Sandelia bainesii* would be present in this segment.

Present State

No fish sampling was undertaken here as no fish would be expected, due to shallow flow, sewage fungus, and lack of habitable areas. On the basis of visual observation, the reach is assigned a class F.

4.3.7 INVERTEBRATES

REACH 3

SASS5 Score	No. of Taxa	ASPT	IHAS Score
0	0	0	48
Present State	Attainable State		
F	E		

REACH 4

SASS5 Score	No. of Taxa	ASPT	IHAS Score
6	3	2	48
Present State	Attainable State		
F	D		

Natural State

In the natural state with a pool-riffle-run configuration, good canopy cover and natural water quality, the expected fauna in this upper section would include a relatively diverse assemblage of stoneflies, mayflies, caddisflies, snails, beetles, Odonate larvae, and a number of dipteran (fly) larvae. Certain true bugs would be present.

Present State

The absence of fauna in Reach 3, and the three taxa present in Reach 4 reflects the extremely poor water quality and river condition in this river segment. The pollution-tolerant families collected in Reach 4 could survive under the worst of instream conditions, and the lack of additional taxa illustrates the severity of the problems linked to the present state.

Taxa Present

Reach 3: None Reach 4: Oligochaetes, Chironomids, Leeches

4.3.8 ASSETS AND PROBLEMS

ASSETS

Patches of Valley Thicket vegetation on right bank (Reach 3).

PROBLEMS

This vegetation is threatened both by exploitation of plant material for resale, and by disturbance and alien encroachment.

4.3.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.3, 4.4	3.1 – 4.3

4.4 ZONE B, SEGMENT 4, REACHES 5 & 6

4.4.1 COORDINATES:

REACH	UPPER END LAT.	UPPER END LONG.
5	32°59'18.28"S	27°54'48.42"E
6	32°59'19.58"S	27°54'52.07"E

4.4.2 DESCRIPTION

These two reaches run through the well manicured lawns and parklands of the Berea Gardens Valley retirement complex. The earth channel is 1.5 – 2m wide, sinuous in areas, and somewhat incised with relatively exposed banks of varying steepness and stability (Plates 5.1 – 6.4).

During high flows, the left bend in the upper section of Reach 5 is an area of local scour on the right bank (Plates 5.1,5.2), and this results in sedimentation and loss of some cobble habitat in the downstream sections. In the middle of Reach 5, the remnants of a concrete structure across part of the channel have resulted in scour on the left bank and the formation of a pool (Plate 5.3). In the middle and lower sections of Reach 5, the right bank has been stabilised with gabion baskets which have been partially planted (Plate 5.4).

The lower end of the gabion-protected right bank marks the beginning of Reach 6. This is a u-shaped channel with sand and cobble/stone substrates (Plate 6.1 and 6.2). The banks are steep, but are fairly well vegetated, as are the intermittent short sand/gravel bars in the channel. A culvert bridge in lower Reach 6, causes scour on the left bank, sedimentation, and pooling (Plate 6.3).

Regarding natural biota in this segment, residents have recorded sightings of several birds and of small buck in the past, but recent evidence of poaching indicates that any remaining fauna is endangered. Many wild-flower species have also been recorded. Although the area is fenced off in various sections for the security of the complex, access is still possible through the box culvert under Chamberlain Rd and under the North-East Expressway. A number of small snares were found during sampling.

During the early part of 2003, a 'Concert in the Park' was organized and held under the trees and on the lawns adjacent to the river. This was a great success

and was well-attended. The improvement of the river condition would benefit events such as this enormously.

4.4.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Altered hydrology (high flow and flood events).
Clearing of banks to create parkland (loss of floral diversity).
Culvert bridge (mid reach 6).

4.4.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

This section would have been a sinuous river with a narrow channel (1.5 – 2 m) which would migrate freely across the valley floor. Morphology would have consisted of pools and riffles. Banks and valley side-slopes would have been well vegetated.

Present State

The river is functioning in terms of the temporary movement of water and sediment and has remnants of natural morphology. The channel has scoured the channel banks in places and is wider than natural. As a result of channel widening there is a loss of habitat. There is evidence of incision and widening, with large-scale deposition of coarse bed material from landfill, bank undercuts, and undercutting of riparian trees (particularly due to scour around the root zones).

4.4.5 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
D (40)	D (9.5)	D
Present State		Attainable State
D		C

Natural State

It is likely that Segment 4 would have consisted of a combination of closed canopy forest and thicket vegetation with sections populated by sedges and small rushes where the channel consisted of a sandbed substrate. *Scholia brachypetala*, *Ficus sur* and *Cordia alliodora* would have been common.

Present State

Water quality is again poor due to sewage overflows and stormwater input. This area is maintained in a park-like fashion and serves as a recreational area for the many residents of Berea Gardens Valley complex. Although little natural vegetation remains on the banks, and the extended riparian zone is mainly exotic kikuyu lawn interspersed with garden beds, this area has good vegetation cover and alien invasive plants are mostly under control. The steep slopes adjacent to the right banks of Reaches 5 and 6 are planted with a combination of exotic ornamental shrubs such as bougainvillea and lavender (which are not invasive and do have soil retention value), and indigenous aloes. There is a return of some instream marginal vegetation in the form of sedges and grasses.

Dominant Taxa

Kikuyu grass, *Erythrina caffra*, *Phoenix reclinata*.

4.4.6 FISH

Present State	Attainable State
F	C

Natural State

It is likely that *Barbus anoplus*, at least 2 species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), *Glossogobius callidus* and even possibly *Sandelia bainesii* would have populated this river segment under natural conditions.

Present State

No fish were caught in this segment. It is unlikely that any occur, due to the poor water quality, lack of food resources, lack of instream shelter, typically low flows, and downstream barriers to movement.

4.4.8 INVERTEBRATES

Reach 5

SASS5 Score	No. of Taxa	ASPT	IHAS Score
6	3	2	47
Present State		Attainable State	
F		D	

Natural State

The expected faunal community would be similar to that expected in the upstream reaches, as the channel form and instream habitats would be similar. However, in Reaches 5 and 6, the likelihood of marginal vegetation would result in a higher diversity of biota, including Hemipteran bugs, molluscs, dragonfly and damselfly larvae, and certain mayfly species.

Present State

The invertebrate fauna in this reach is impoverished, as indicated by the scores attained. This was unexpected in the light of the improved water clarity, reduction in odour, and improved flow and habitat diversity. Again this score indicates a severely compromised ecology.

Taxa Present

Oligochaetes, Leeches, Chironomid larvae

4.4.9 ASSETS AND PROBLEMS

As there are no 'natural' features remaining, a consideration of Assets and Problems was not possible. The threats to these reaches, are recorded as water quality deterioration, urban hydrology, and cross-channel structures such as culvert bridges.

4.4.10 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.5, 4.6	5.1 - 6.4

4.5 ZONE B, SEGMENT 4, REACHES 7 - 9

4.5.1 COORDINATES:

REACH	UPPER END LAT.	UPPER END LONG.
7	32°59'18.37"S	27°54'57.47"E
8	32°59'18.58"S	27°55'2.35"E
9	32°59'20.81"S	27°55'7.35"E

4.5.2 DESCRIPTION

Reach 7 is a sinuous sand-bed section with boulders and cobbles strewn through the channel (Plate 6.2). The upper end of the reach is marked by two concrete-encased sewer pipes across the channel. The right bank of the reach is a continuation of the Berea Gardens Valley grassed parkland. The channel varies from 1.5 to 2m wide, with steep banks in parts, some areas of which are unstable and others of which are reasonably well-vegetated (Plates 7.1, 7.2). Birdlife in this area is fairly prolific (Table 4.1).

On the right side of the river, the floodplain is relatively flat and forms part of the parkland. The left valley slope is vegetated with indigenous woody plants. The lower end of Reach 7 is marked by a concrete culvert bridge. A concrete palisade fence is routed across the top of this bridge, for security reasons.

Reach 8 was formerly adopted by Port Rex High School, but little has been done in this reach recently. It comprises a relatively straight earth channel, with bedrock, sand, rock and gravel substrate. The valley sides are moderately sloped, and the right slope has been land-filled in parts. Immediately downstream of the culvert bridge (upper end of Reach 8), the banks are undercut as a result of scouring, and the channel is widened for some distance downstream, with sediment deposition evident. The banks are gently sloped and vegetated along much of the reach, and as such are considered relatively stable. The floodplains have been planted with both indigenous and non-indigenous species as a continuation of the parkland. The lower end of this reach is marked with a diamond-mesh fence across the river. This is the border of the Berea Gardens Valley complex.

Reach 9 is a sinuous, somewhat unkempt section of river. Much of the reach is channeled in culverts beneath under the North-East Expressway and Old Transkei Road (Maps 1.2, 4.9). In the upper part of Reach 9, the earth channel is 1.5-2m wide, with a sand, cobble and rock substrate. The banks are almost vertical, unvegetated and unstable, and the bank-tops are grassed with Kikuyu. Several

years ago, rain gauges were installed in this part of the catchment and higher, however, these are now defunct and no records of rainfall exist.

The channel cross-section for Reach 8 is presented in Figure 4.1.

4.5.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Sewer lines across the channel (upper Reach 7).

Multiple-culvert bridge (upper Reach 8).

Concrete palisade fence across river (upper Reach 8).

Fenceline over channel (lower end Reach 8).

4.5.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

A sinuous river with a narrow channel (1.5 - 2m) which is freely migrating across the valley floor. Morphology consists of pools and riffles, with well-vegetated banks and valley side slopes.

Present State

The river is functioning in terms of the temporary movement of water and sediment, and has remnants of its natural morphology. The channel has scoured the channel banks in places and is wider than natural. As a result of channel-widening there is a loss of habitat. There is evidence of incision and widening with large-scale deposition of coarse bed material from landfill, bank undercuts and undercutting of riparian trees.

4.5.6 VEGETATION

RIPARIMAN	RVI SCORE	GUT SCORE
C (70)	C (14.3)	C
Present State	Attainable State	
C	C	

Natural State

It is likely that Segment 4 would have consisted of a combination of closed canopy forest and thicket vegetation, with sections populated by sedges and small rushes. *Scholia brachypetala*, *Ficus sur* and *Cordia alliodora* would be common.

Present State

Apart from water quality, this section is in a reasonable condition considering the development that has taken place. There are large remnant woody trees still standing. Mature alien trees have been left standing to provide shade and habitat for birds. Stream banks are mostly covered, except for badly-incised areas near the fig trees on the left bank at the bottom of the reach. There appears to be contamination from an unknown source near the stand of *Belthambra* on the right bank at the base of the steep landfill slope. Although development has taken place, the banks have been revegetated with mostly indigenous material and some management is in place to control alien invasive plants. Sections of the instream area are being invaded by reed beds with *Phragmites australis* and *Arundo donax*. In places there is recruitment of sedges and Arum lilies, as well as some alien invasive plants. Flood water obstructions are the fence on the upper end and a bridge at the lower end.

This area is in the process of improving, particularly the condition of vegetation on the actual stream banks, with species such as *Anisodonta*, *Grewia occidentalis* and *Tecomaria* returning along the length of this reach. However, there is little recruitment of indigenous plants taking place beyond the narrow strip along the stream banks due to rigorous mowing practices of the Retirement Complex, along the whole of the bottom flood plain area. Stream banks are steep in some sections and will likely require stabilisation or terracing prior to revegetation.

Dominant Taxa

Melia azederach, *Erythrina caffra*, *Phytolacca dioica*.

4.5.7 FISH

Present State	Attainable State
F	C

Natural State

Barbus anoplus, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), the river goby (*Glossogobius callidus*), and even possibly *Sandelia bainsii* would have been present.

Present State

No fish were collected or visually observed in this section of the river. This is considered due to poor water quality and sedimentation.

4.5.8 INVERTEBRATES

Reach 8			
SASS5 Score	No. of Taxa	ASPT	IHAS Score
20	7	4.9	53
Present State		Attainable State	
F		E	

Natural State

It is likely that this section would have had a high diversity of invertebrates under natural conditions. Water quality would have been good, with high dissolved oxygen and low turbidity, with plentiful cobble and rock habitat, and a fair amount of leaf material as input. With riffle and shallow pool areas likely, the community would be expected to comprise a number of mayfly taxa, cased caddisflies, dragonflies and damselflies, beetles, fly larvae, and molluscs.

Present State

The invertebrate faunal diversity is still extremely poor, but has increased marginally, and the ASPT indicates that the fauna present is somewhat more sensitive than that present in the upper reaches. Nonetheless, the taxa present are considered resilient.

Taxa Present

Chironomid larvae, Culicid larvae, Oligochaetes, Leeches, *Potomonautes* sp. crab, Chlorolestid dragonfly, Simuliid larvae.

4.4.10 ASSETS AND PROBLEMS

ASSETS
Remnant woody vegetation in Reach 7.
Cobble and boulder bed habitat.
PROBLEMS
Clearing of floodplain areas (can lead to alien invasion).
Concrete culvert bridge.
Concrete palisade fence across channel.
Diamond-mesh fence across channel.

4.4.11 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.7, 4.8, 4.9	7.1 – 9.1

Table 4.1 List of Birds (common names only) as spotted by residents in Berea Gardens Valley retirement complex.

Blackcollared Barbet
 Blackeyed Bulbul
 Blackheaded Heron
 Blackheaded Oriole
 Bronze Mannikin
 Brownhooded Kingfisher
 Buffspotted Flufftail (heard only)
 Bully Canary
 Burchell's Coucal
 Cape Robin
 Cape Turtle Dove
 Cape Wagtail
 Cape White-eye
 Crowned Hornbill
 Diederick's Cuckoo
 Dusky Flycatcher
 Egyptian Geese
 European Starling
 Fiscal Flycatcher
 Fiscal Shrike
 Forktailed Drongo
 Grey Sunbird
 Greyheaded Shrike
 Greyheaded Sparrow
 Hadeda Ibis
 Hamerkop
 Horus Swift
 House Sparrow
 Knysna Lorie

Laughing Cuckoo
 Lesser Doublecollared Sunbird
 Lesser Striped Swallow
 Little Swift
 Olive Thrush
 Paradise Flycatcher
 Pied Crow
 Redbilled Woodhoopoe
 Redchested Cuckoo (heard only)
 Redeyed Dove
 Rednecked Francolin
 Redwinged Starling
 Sacred Ibis
 Sombre Bulbul
 Southern Boubou Shrike
 Speckled Mousebird
 Spectacled Weaver
 Spotted-backed Weaver
 Spotted (Cape) Dikkop
 Tawnyflanked Prinnia
 Whiterumped Swift
 Yellow weaver
 Yellowbilled Duck
 Yellowbilled Kite

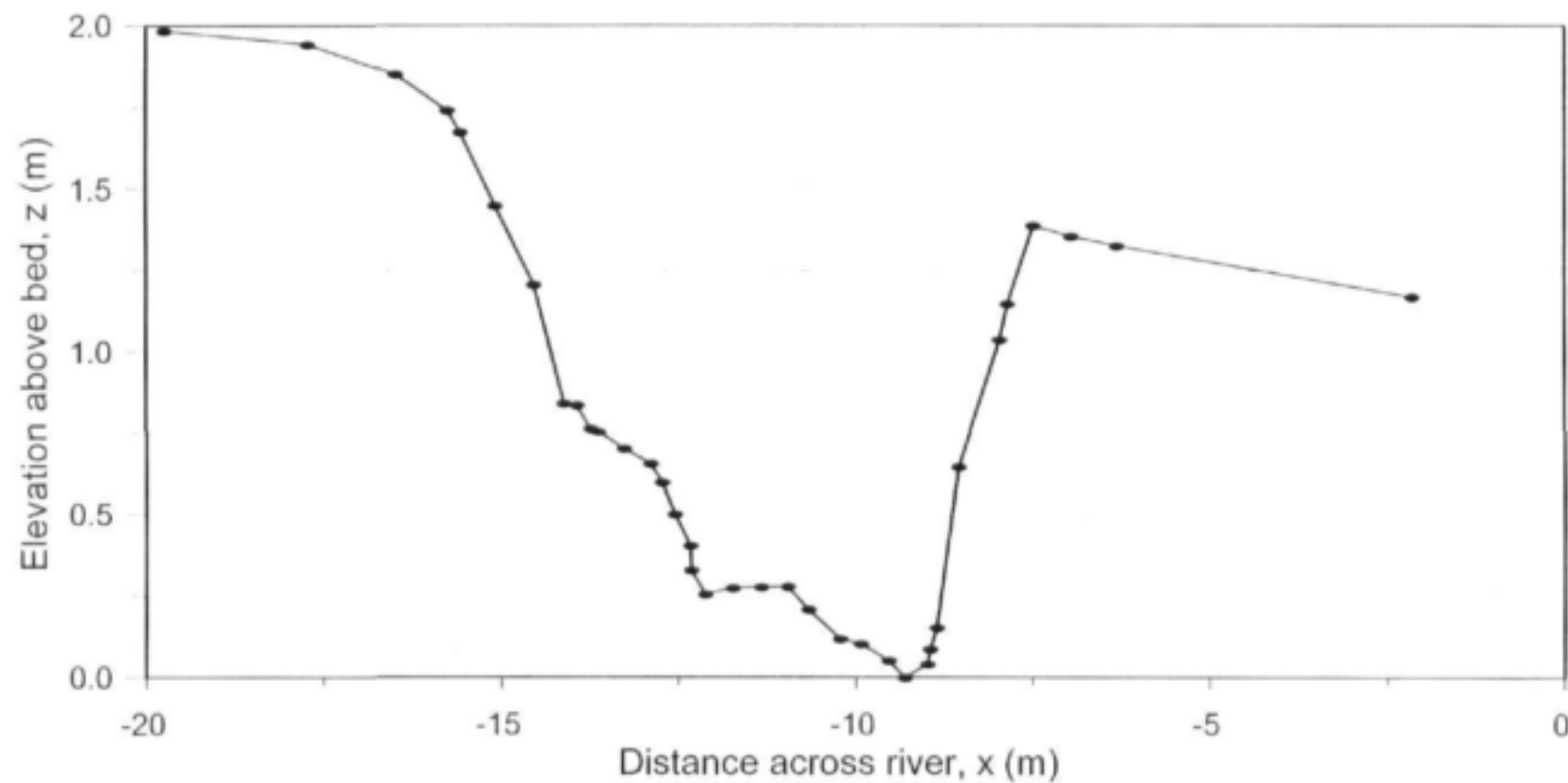


Figure 4.1. Cross-section of the channel in Reach 8 (see Map 4.8)

4.6 ZONE C, SEGMENT 5, REACHES 10 - 12

4.6.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
10	32°59'19.47"S	27°55'13.68"E
11	32°59'20.69"S	27°55'19.19"E
12	32°59'21.07"S	27°55'23.81"E

4.6.2 DESCRIPTION OF PRESENT STATE

In this segment, the river is 1.5 - 2m wide and deeply incised. It flows through the suburb of Stirling, and is bordered on the right bank by grassed Public Open Space (POS), and on the left bank by a combination of POS and residential areas.

Reach 10 is immediately downstream of the box culvert which runs beneath North-East Expressway and old Transkei Road. At the upper end of the reach, there is a large stilling basin designed to reduce the velocities of upstream runoff during high flows and floods (Plates 10.1, 10.2). Reach 10 has been incised down to bedrock due to elevated high flows from the upper catchment. The banks are almost vertical in places and are 1.5 - 4m high in places (Plates 10.3 and 10.4). The channel substrate is a combination of bedrock, rock and gravels. There is no marginal vegetation present. Water quality remains poor, and there is litter in the channel. The upper end of the reach is littered, and the river is used as a washing area and latrine by informal dwellers who live on the banks or under trees. This poses a health and security risk. The lower end of the reach is marked by a wooden suspension bridge across the river.

Reach 11 has a similar morphology to Reach 10, but is sinuous in the lower areas of the reach. From the middle to lower reaches, the river widens and the banks flatten somewhat. The banks remain unvegetated, steep and unstable. The substrate in this reach is bedrock, rock, cobble, gravel and sand.

In Reach 12, the bedrock-controlled channel has resulted in sideward erosion. The channel has widened to approximately 5m, and is less steep than Reaches 10 or 11 in cross-section. The lower end of this reach is marked by Schultz Road.

4.6.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Increase in runoff during storm events.
Box culvert and stilling basin (upper Reach 10).
Box culvert and road crossing (lower Reach 12).

4.6.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

This river segment would have been a relatively sinuous channel with limited incision into the landscape. The morphology would have been predominantly pool/riffle, with some bedrock rapids. The channel would have been relatively narrow, approximately 2m wide. There would have been a well-vegetated macro-channel, with banks bordered by a wide flood plain which would under natural conditions have been infrequently inundated.

Present State

Active incision in this section is controlled upstream by the culvert (Reach 9) and downstream by a concrete-lined canal (Reach 13). The channel is divorced from the landscape, with a large headcut moving up the channel. Banks are extremely unstable and the channel has incised down to bedrock in many places. Trees are being undercut and will be lost in the near future.

4.6.5 VEGETATION

Reach 10

RIPARIAN SCORE	RVI SCORE	GUT SCORE
E (20)	E (7.35)	D
Present State		Attainable State
E		D

Reach 12

RIPARIAN SCORE	RVI SCORE	GUT SCORE
D (54)	D (9.55)	D
Present State		Attainable State
D		C

Reach 10: Present State

Reach 10 below the NE Expressway runs through Public Open Space and is impacted by channel incision, headcutting, and gully erosion. There is little or no instream vegetation, and poor vegetation cover in sections due to severe stream bank erosion. A deep pool near the nursery school in the lower reaches of Reach 10 (near the footbridge) poses a safety hazard (Map 4.10). Trees and shrubs are sparse over 50% of this area, and biodiversity is low. Recruitment of alien vegetation appears to be on the increase. Other impacts include the harvesting of young *Phoenix reclinata* palm fronds for crafts, and the clearing and modification of riparian habitat for informal settlement.

Reach 12: Present State

Reach 12 is characterised by a large pool with incised banks at the upper end, downstream of which a shallow, sedimented area is in the process of being invaded by *Phragmites*, and is in part vegetated instream by *Stenotaphrum secundatum* and small sedges. Mature specimens of *Cassuarina* trees, which inhibit the growth of any other plants in their vicinity, overhang parts of the right bank on the lower section. Stormwater drainage channels intersect with the stream on either bank, upstream of the end of the reach and the river crossing represented by Schultz Road. These channels are exposed and eroded earth trenches and have been colonized by *Typha capensis*, which has the potential to spread to the streambanks. The stream banks and channel are littered. Although there are some mature remnant forest species such as White Milkwood, *Tarconanthus* and *Cordia alliodora*, there is little recruitment of indigenous riparian species.

Dominant Taxa

Reach 10

Melia azederach
Erythrina caffra
Phytolacca dioica

Reach 12

Cassuarina cunninghamia
Phoenix reclinata
Sideroxylon inerme

4.6.6 FISH

Present State	Attainable State
F	D

Natural State

It is likely that in this segment, *Barbus anoplus* and at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*) would occur. Additional species could include *Glossogobius callidus* and possibly *Sandelia bainesii*.

Present State

No fish were caught in this segment. This is assumed to be due to the poor water quality, lack of habitat, low instream primary productivity, and downstream structures or blockages limiting fish passage.

4.6.7 INVERTEBRATES

Reach 10

SASS5 Score	No. of Taxa	ASPT	IHAS Score
42	11	3.8	48
Present State		Attainable State	
D		C	

Reach 12:

SASS5 Score	No. of Taxa	ASPT	IHAS Score
34	9	3.8	54
Present State		Attainable State	
E		D	

Natural State

Under natural conditions it is likely that this reach would have had diverse instream habitat (pool/riffle/run), with marginal vegetation present. Assuming water quality is good, the invertebrate community would probably be diverse and include mayflies, a range of caddisflies, possibly stoneflies, a range of Dipterans, and several beetle species. The presence of marginal vegetation would increase the likelihood of snails, Hemipteran bugs, damselflies and dragonflies.

Present State

The community present is indicative of a disturbed riverine environment, with poor water quality. The presence of Simuliids suggests that the flow was adequate to sustain flow-dependent species, and the presence of Chorolestid dragonfly larvae represents some improvement in the sensitivity of the fauna as a whole, and the available food resources.

Taxa Present

Leeches, Potamonautid crab, Baetid mayflies, Chlorolestid dragonflies, Chironomids, Culicids, Simuliids, Corixid bugs, Ceratopogonids, Ephydriids, Tabanids, Tipulids, Oligochaetes.

4.6.9 ASSETS AND PROBLEMS

ASSETS

Instream habitat in Reach 12 is considered relatively natural.

PROBLEMS

Eroded stormwater drainage channels intersecting with river channel (causing sedimentation).

Culvert bridges.

Clearing of riparian vegetation on the left and right banks.

Altered hydrology, upstream culvert, downstream canal (increased flow velocities).

Steeply incised and unstable banks in Reaches 10 and 11.

4.6.10 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.10, 4.11, 4.12	11.1 – 12.1

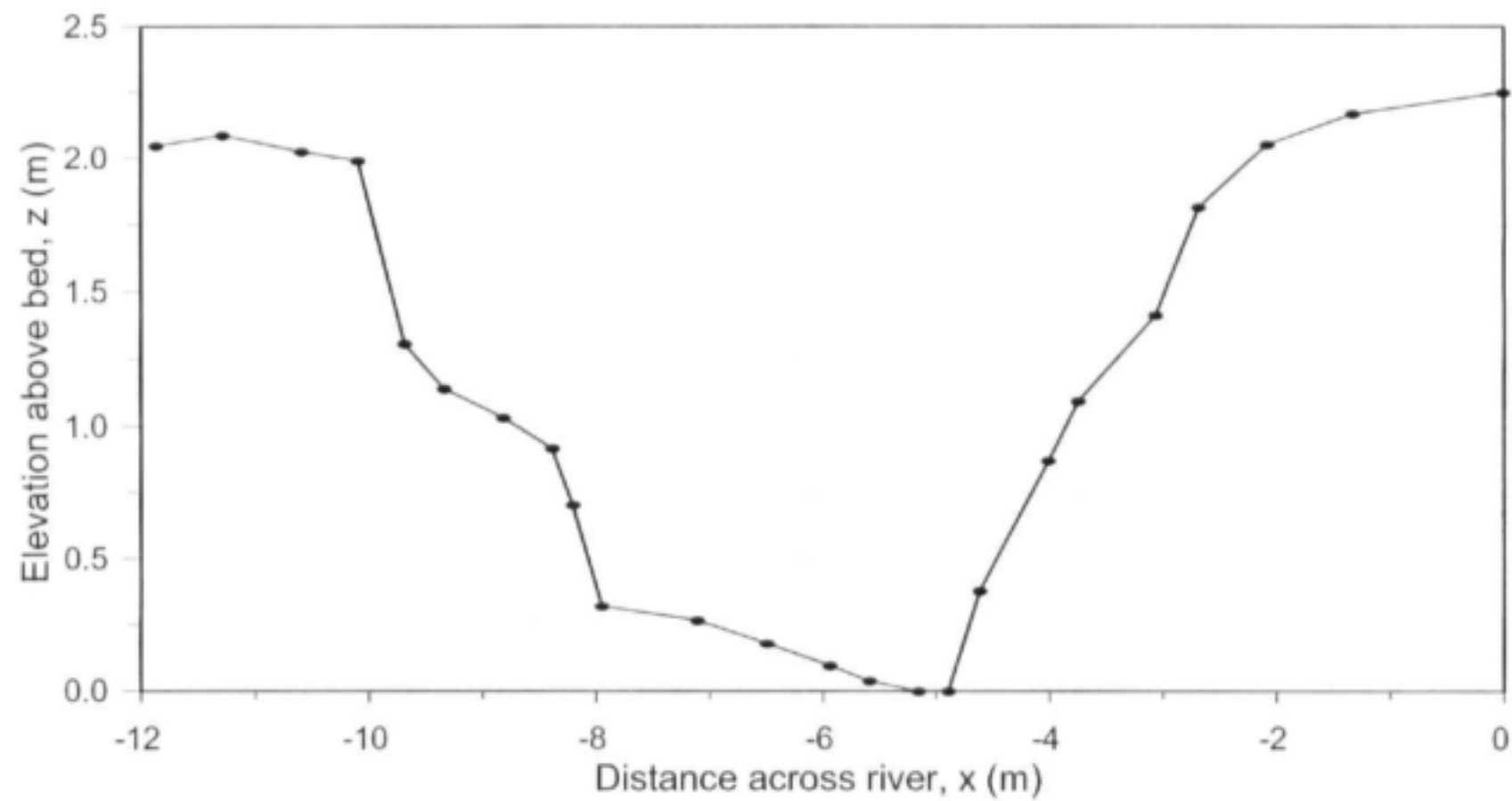


Figure 4.2 Cross-section of the channel in Site 11 (see Map 4.11).

4.7 ZONE C, SEGMENT 6, REACHES 13 & 14

4.7.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
13	32°59'19.37"S	27°55'27.71"E
14	32°59'18.49"S	27°55'32.31"E

4.7.2 DESCRIPTION

In this segment, the river runs between Schultz Road and Drake Road, in the suburb of Stirling. Land adjacent to both banks is zoned as Public Open Space. Reach 13 comprises a trapezoidal, concrete-lined stormwater canal (Plate 13.1).

Reach 14 commences where the canalised section ends. No bank stabilisation has been provided at this point, and the earth banks have been extensively scoured to form a deep, sandy pool (Plate 14.1). Downstream of the pool, the channel is wide and shallow, with gently sloping banks and grassed bank-tops. The instream substrate is boulder, rock and cobble. There is no marginal vegetation present in the channel. The floodplain on the right bank is zoned as Public Open Space, and is grassed and regularly mowed. The area on the left floodplain is occupied by a church, which has been regularly flooded. The municipal sewer runs alongside the right bank, and stormwater drainage channels intersect with the channel at intervals along the right and left banks.

4.7.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Culvert bridge (upper end of Reach 13).
Canalised section (Reach 13).
Stormwater drainage channels at intervals along river bank.

4.7.4 GEOMORPHOLOGY

Present State	Attainable State
F	D

Natural State:

Sinuuous channel with slight incision. Pool/riffle and pool/rapid morphology with well vegetated banks and a perched flood plain which is infrequently inundated.

Present State:

There is no geomorphological functioning in this segment as the river flows in a canal for some of the way. Where the flow discharges from the canal into the channel, extensive downcutting and widening occurs. The banks are unstable, trees are being undercut and there is a headcut moving upstream from the canal (through Reach 12).

4.7.5 VEGETATION

Reach 14

RIPARIAN	RVI SCORE	GUT SCORE
D (39)	E (8.95)	D
Present State	Attainable State	
D/E	C	

Natural State

This section is likely to have been characterised by closed canopy forest except for those areas which may have been frequently utilised by larger grazers. In these sections savannah and grassland could be expected to have encroached on the riparian zone, and portions adjacent the channel might contain stretches of rushes. The occurrence of *Phoenix reclinata* at the edges of the channel would be common and trees such as *Podocarpus falcatus* would likely also increase in numbers.

Present state

Reach 14

Situated in Public Open Space, this reach is populated mainly by grassland, with remnant woody trees populating the edges of the stream. There is significant erosion on stream-banks, such that vegetation on sections of the bank is degraded or absent. Litter is present in the channel as well as on the banks. There

is alien plant recruitment, and sections of the bank adjoining the church grounds on the lower left bank have been planted with exotic tree species. A stormwater channel enters the stream on the right bank, upstream of the culvert bridge across Drake Rd. The biodiversity and relative abundance of indigenous plants is well below the level expected found in the natural state.

Dominant Taxa:

Erythrina caffra, *Melia azederach*, *Phytolacca dioica*

4.7.6 FISH

Present State	Attainable State
F	D

Natural State

Barbus anoplus, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), *Glossogobius callidus* and even possibly *Sandelia bainesii* could have been present in these reaches. The freshwater mullet (*Myxus capensis*) may have penetrated naturally up to this segment.

Present State

No fish were caught in this reach. This is likely due to the poor water quality, and lack of habitat availability (exacerbated by sedimentation and fines caused by erosion processes).

4.7.7 INVERTEBRATES

Reach 14

SASS5 Score	No. of Taxa	ASPT	IHAS Score
28	6	4.7	51
Present State		Attainable State	
D		D	

Natural State

A fauna typical of the sinuous middle reaches of a river would have occurred in this segment under natural conditions. The likely stones-in-current fauna would have included mayflies, caddisflies, and possibly stoneflies. If marginal vegetation were present, the faunal assemblage would have included a number of Hemipteran bugs, and several snail taxa. The sand-bed sections likely in this river segment would have encouraged the presence of dragonflies, damselflies, certain

mayfly taxa and many of the dipteran larvae. Pool and stones-out-of-current fauna would include beetles and snails.

Present State

The invertebrate fauna of this segment reflects a disturbed urban environment with poor water quality, nutrient enrichment, and low oxygen conditions. The lack of marginal vegetation results in a low diversity of herbivorous taxa, and the presence of Ancyloid snails is likely associated with the presence of algae on rock surfaces. The absence of Simuliids in an area of flow over cobbles is unusual.

Taxa Present

Oligochaetes, Leeches, *Potamonautus* crabs, Baetid mayflies (2 species), Chlorolestid dragonflies, Chironomids, Culicids, Ephyrids, Syrphids, Tabanids, Ancyloid snails.

4.7.8 ASSETS AND PROBLEMS

ASSETS
A short section of intact instream habitat (lower end Reach 14).
PROBLEMS
Schultz Road River crossing (Upper end Reach 13)
Canalised section (downstream of Schultz Road, Reach 13).
Water quality deterioration.
Input of stormwater and sediments into river via stormwater drainage channels.
Litter and building rubble in the channel.

4.7.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.13, 4.14	

4.8 ZONE C, SEGMENT 7, REACHES 15-17

4.8.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
15	32°59'18.04"S	27°55'36.67"E
16	32°59'20.20"S	27°55'42.18"E
17	32°59'24.41"S	27°55'46.38"E

4.8.2 DESCRIPTION

This section of the river runs between Drake and Galway Roads. The segment has been adopted by the Selborne Primary School Grade 7 boys, whose teachers organized a litter collection and categorization exercise in the middle of 2002. This exercise was impressive in its execution, capacity building and output, and is described further in a press clipping (Appendix 2). Following the clean-up, a presentation on the river was made given to the Grade 7's, and they were given the opportunity to contribute to the objectives for the Zone, many of which are included in Chapter 5. The school has agreed to maintain their interest in this segment of the river.

In this section, the natural earth channel, has been widened as a result of upstream urban hydrology. In the lower reaches, although the channel is widened, the shallow bedrock sills and pools render the river aesthetically attractive (Plate 17.2), and the river is visible from the floodplain, making this area a natural recreational asset.

For the majority of this segment, the right and left banks of the river are grassed parkland areas. However, in the upper part of Reach 15, the left bank of the river has been extensively cleared for the purposes of a townhouse development. (Plate 15.1) Despite this individual being granted permission to develop on the floodplain (if a flood levee is built to raise the development above the 1:50 year floodline), no construction has taken place for a number of years, and the area has become a dumpsite for building rubble. It is unsightly and is considered bad for property values by residents in the area. The bottom end of this segment is marked by a culvert bridge on Galway Road, built at an angle to and across the channel.

4.8.3 DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Extensive clearing and dumping for development on the left bank of the river in Reach 15
Stormwater drainage channels intersecting with the river channel.
Galway Road culvert bridge at the lower end of Reach 17.

4.8.4 GEOMORPHOLOGY

Present State	Attainable State
D	C

Natural State

Sinuuous channel with limited incision and a pool/riffle morphology. Channel width would have been approximately 2m wide, and banks would have been well vegetated and stable.

Present State

This segment of the river has been altered by the dumping of large quantities of building rubble on the left bank. The river banks show some instability, particularly where the river enters and leaves canals and culverts. The river condition improves in the lower section of this segment but is still significantly altered from a natural state. The presence of very coarse angular material in this segment is unnatural and is probably as a result of bed and bank erosion, and dumping.

4.8.5 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
D (53)	D (10.66)	D
Present State		Attainable State
D		C

Natural State

This section is likely to have been characterised by closed canopy forest except for those areas which may have been frequently utilised by larger grazers. In these sections savannah and grassland could be expected to have encroached on the riparian zone and portions adjacent the channel might contain stretches of

rushes. The occurrence of *Phoenix reclinata* at the edges of the channel would be common and trees such as *Podocarpus falcatus* would be present.

Present State

Reach 16 is in relatively similar albeit slightly better condition than Reaches 13 and 14. Forest canopy cover is greater, and there is a greater diversity of indigenous plants. Alien plant invasion is evident by the presence of mature and juvenile species. A landfill site upstream appears to be contributing to the sedimentation, and reed species are invading the channel in places. A stormwater drainage channel intersects with the river near the lower end of Reach 15, in line with Banburgh Rd.

During floods and high flows, the scouring action of the unnaturally fast-flowing water is toppling mature trees, which then block the stream channel and alter stream flow dynamics. Geophytic species are absent.

Dominant Taxa

Erythrina caffra, *Syzgium paniculatum*, *Melia azederach*

4.8.6 FISH

Present State	Attainable State
F	C

Natural State

Probably *Barbus anoplus*, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), *Glossogobius callidus* and even possibly *Sandelia bainsii* would be present. The freshwater mullet (*Myxus capensis*) may have penetrated naturally up to this segment.

Present State

No fish were caught, observed or expected to be present in this segment. Water levels were low, pool habitat sparse, and water quality poor, with stagnancy in sections.

4.8.7 INVERTEBRATES

Reach 16

SASS5 Score	No. of Taxa	ASPT	IHAS Score
47	10	4.7	54

Present State	Attainable State
E	D

Natural State

Higher base flows would be expected in this segment under natural conditions. This, together with good water quality and clarity, would create a suitable environment for a fairly sensitive rheophilic community, including more sensitive mayfly genera, Simuliids and certain caddisflies. Fauna including Aeshnid dragonflies, Caenid mayflies and a number of dipteran larvae would be able to inhabit the sand and gravel interstices. It is assumed that marginal vegetation would be present at least in patches, and that this would serve as a refuge and food source for certain true bugs, snails, juvenile mayflies and Odonates.

Present State

The invertebrate fauna is in a poor condition in this reach, however the presence of Chlorolestid dragonflies and more than one species of Baetid mayfly raises the ASPT slightly. The majority of taxa present are however considered resilient both to low flows and to organic pollution.

Taxa Present

Oligochaetes, leeches, Potamonautid crabs, >2 Baetid mayfly species, Chlorolestid dragonflies, Chironomids, Culicids, Tabanids, Ancyliids

4.8.8 ASSETS AND PROBLEMS

ASSETS
Expected close-to-natural channel morphology and instream substrates.
PROBLEMS
Clearing on left bank (Reach 15).
Stormwater inputs to the channel.
Galway Road culvert bridge (lower Reach 17).

4.8.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.15, 4.16, 4.17	15.1 to 17.3

4.9 ZONE D, SEGMENT 8, REACHES 18 & 19

4.9.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
18	32°59'26.48"S	27°55'51.00"E
19	32°59'29.62"S	27°55'55.75"E

4.9.2 DESCRIPTION

The river in this segment runs through the suburb of Nahoon. Both banks are zoned as Public Open Space, however there are few access points along the segment, and many of the property owners have removed the fences between their properties, the Public Open Space, and the river, creating a continuous buffer zone. The channel has been widened to over 10m in sections in this segment. The channel morphology is pool-riffle, with several deep, sandy sections.

A concerned group of Galway Road residents, one of whom was previously a member of the Ihlanza River Watch Committee, have joined forces to address the problem of extreme alien vegetation invasion in the riparian zone adjacent to their properties. The group has initiated the clearing of alien vegetation and replanting with appropriate indigenous species under specialist guidance. This initiative has been a great success and deserves the support of the local authority. It is hoped that it will 'seed' other similar initiatives.

4.9.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Galway Road culvert bridge (upper end Reach 18).
Aging, poorly maintained sewer system alongside and across the channel.
Intersection of stormwater drainage channels with the river channel (source of sediment and pollution).

4.9.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

Under natural conditions, this section would likely have been a relatively narrow channel (2 – 2.5 m wide) with well vegetated, stable banks. Channel morphology would have been dominated by pools and riffles, with some local bedrock controls. The river is laterally confined by the hillslope, and therefore only has a narrow flood bench present.

Present State

The river is in reasonable condition despite the fact that channel morphology has been altered from natural. The river is dominated by pools and rapids, the latter comprising accumulations of coarse bed material. Under natural conditions, the coarse material would have been unable to move, the new hydrology now makes this possible. The channel has been over-widened, largely as a result of the river's inability to scour the bedrock bed. It is likely that a large portion of the coarse material in the bed has come from upstream and the eroded banks. There is large-scale loss of marginal vegetation in this segment as the banks have been undercut. There is a reasonable diversity of instream habitat.

4.9.5 WATER QUALITY

A summary of basic water quality data for Reach 18 for 2003 is presented in Appendix 3.

4.9.6 VEGETATION

RIPARIAN	RVI SCORE	GUT SCORE
D (45)	D (9.23)	D
Present State		Attainable State
D		C

Natural State

In this area, the height of the forest canopy would have increased with decreasing altitude, and distinctive vegetation layers would be likely. Clumps of geophytes such as *Haemanthus albiflos* and *Scadoxus puniceus* are likely on the forest floor

together with perennials such as *Dietes* and *Asparagus asparagoides*. *Ficus thonningii*, Cassine and *Rapanea* are common trees. Dune forest species such as *Allophylus natalensis*, *Deinbollia* and *Strelitzia nioi* would also be found here occasionally.

Present State

This section immediately downstream of the Galway Road river crossing is considered seriously disturbed. Some large woody forest specimens are present, but the area is heavily infested with alien vegetation which is inhibiting the recruitment of indigenous riparian vegetation. Certain residents use the area to dump garden refuse, and some sections have been cleared to grow vegetables. This area is in a state of degeneration in terms of vegetation.

The area from here down to Reach 24 is increasingly being returned to a more stable state, with the assistance of the Resident's Group, and has the potential to be a conservancy-type area that could possibly adjoin the proposed Nahoon Nature Reserve.

Dominant Taxa

Erythrina caffra, *Phytolacca*, *Cestrum laevigatum*.

4.9.7 FISH

Present State	Attainable State
F	D

Natural State

In this segment, it is likely that *Barbus anoplus*, possibly *Sandelia bairdii* and at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*) and *Glossogobius callidus* would be present. Freshwater mullet (*Myxus capensis*), a number of other catadromous fish species (e.g. *Mugil cephalus*, *Monodactylus faidiformis*), and freshwater prawns (*Macrobrachium spp.*) probably penetrated naturally up into this segment.

Present State

No fish were caught or observed in this segment. Sampling was not possible because of low water levels. The lack of fish fauna is attributed to low base flow (and resultant lack of instream habitat and passage for fish) in the river, poor water quality, and the downstream blockages preventing fish passage.

4.9.8 INVERTEBRATES

Reach 18:

SASS5 Score	No. of Taxa	ASPT	IHAS Score
46	11	4.2	50
Present State		Attainable State	
E		D	

Natural State

Higher base flows would be expected in this segment under natural conditions. This, together with natural water quality and clarity would provide conditions suitable to a fairly sensitive rheophilic community, comprising several mayfly genera (Baetids, Leptophlebiids, Heptageniids), Simuliids and certain caddisflies. The sand-dwelling community would include Aeshnid dragonflies, Caenid mayflies and numerous Dipteran larvae. It is assumed that marginal vegetation would be present in patches, and that this would serve as a refuge and food source for certain true bugs, snails, and juvenile mayflies and Odonates.

Present State

The invertebrate fauna is in a poor condition in this reach. The majority of taxa collected are considered resilient both to low flows and to organic pollution.

4.9.8 ASSETS AND PROBLEMS

ASSETS
Expected close-to-natural channel morphology.
PROBLEMS
Stormwater drainage channels intersecting with the river channel.
Galway Road culvert bridge (upper Reach 18).

4.9.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.18, 4.19	18.1 - 19.2

4.10 ZONE D, SEGMENT 8, REACHES 20 - 22

4.10.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
20	32°59'28.97"S	27°56'0.73"E
21	32°59'29.09"S	27°56'7.20"E
22	32°59'27.32"S	27°56'13.45"E

4.10.2 DESCRIPTION

These reaches run through land zoned as Public Open Space (POS) and Residential. As in the upper reaches of this segment, there are few access points to the POS.

The channel in the upper part of Reach 20 has been extensively widened into a deep pool section, due in part to bank collapse, and to the effects of transport of large sediments (cobbles and boulders) from upstream reaches, during the August 2002 floods. In Reach 21, the dominant substrates are coarse sand and cobbles, through which a low-flow channel courses.

The lower end of Reach 21 and Reach 22 are dominated by coarse sandy substrates, and banks are either exposed, unstable, or heavily infested with alien vegetation. The encroachment in this entire segment is gradually receiving attention as a result of the efforts the aforementioned Galway Road Residents (as discussed in Section 4.9).

4.10.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

- | |
|--|
| Eroded stormwater drainage channels intersecting with the river channel. |
| Aging sewerage system routed alongside river. |

4.10.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

A relatively narrow channel (2 – 2.5 m wide) with well-vegetated, stable banks would be expected under natural conditions. Channel morphology would have been dominated by pools and riffles, with some local bedrock controls. The river would have been laterally confined by the hill slope, and therefore only has a narrow flood bench present.

Present State

The river is in a reasonable condition despite the fact that channel morphology has been altered from natural. The river is dominated by pools and rapids. These rapids are made up of accumulations of coarse bed material. Under natural conditions, the coarse material would have been unable to move, the new hydrology now makes this possible. The channel has been over-widened, largely as a result of its inability to scour the bedrock bed. It is likely that a large portion of the coarse material in the bed has come from the eroded banks and from upstream reaches. There is large-scale loss of marginal vegetation in this segment as the banks have been undercut. There is a reasonable diversity of instream habitat.

4.10.5 VEGETATION

RIPARIAN	RVI SCORE	GUT SCORE
D (34)	D (10.59)	D
Present State		Attainable State
D		C

Natural State

In this area, the height of the forest canopy would have increased with the slight decrease in altitude, and distinctive vegetation layers would be likely. Clumps of geophytes such as *Haemanthus albiflos* and *Scadoxus puniceus* are likely on the forest floor, as well as perennials like *Dietes* and *Asparagus asparagoides*. *Ficus thonningii*, Cassia and *Rapanea* are common trees. Dune forest species such as *Allophylus natalensis*, *Deinbollia* and *Strelitzia nicotai* would also be found here occasionally.

Present State

This area lies between private residential properties. Most of the vegetation in this reach has been altered in some way by human intervention. Many mature trees have been retained, but undergrowth has been cleared and replaced with grasses and some exotic species. Although rehabilitation work has been initiated by some residents, others are using the area as a dumping ground for garden refuse. Alien plants are recruiting in those areas that were cleared, with no follow-up work.

Habitat for birds is good, however instream and general habitat should be improved.

Dominant Taxa

Erythrina caffra, *Phytolacca*, *Cestrum laevigatum*.

4.10.6 FISH

Present State	Attainable State
F	D

Natural State

As with the previous segment, *Barbus anoplus*, possibly *Sandelia bainesii*, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*) and *Glossogobius callidus* would likely have been present. Freshwater mullet (*Myxus capensis*), a number of other catadromous fish species (e.g. *Mugil cephalus*, *Monodactylus falciformis*), and freshwater prawns (*Macrobrachium spp.*) probably penetrated naturally up into this segment.

Present State

No species were caught in this segment, despite adequate pool habitat and flow depth. This is attributed to poor water quality and obstructions to fish passage from downstream.

4.10.7 INVERTEBRATES

Reach 20:

SASS5 Score	No. of Taxa	ASPT	IHAS Score
43	10	4.3	49
Present State		Attainable State	
E		D	

Natural State

With expected higher flows, natural water quality, and marginal vegetation present in this lower segment of the river, it is anticipated that the invertebrate fauna would have been a great deal more diverse and sensitive under natural conditions. The riffle and pool habitats would have supported a number of mayfly, caddisfly and Dipteran taxa, and the marginal vegetation and slower-flowing habitats would likely have hosted a range of true bugs, beetles, juvenile mayflies, snails, beetles and dragonfly and damselfly larvae.

Present State

The present fauna is hardy and resilient, with only one flow-dependent taxon present (Simuliidae). While there is adequate instream habitat and reasonable flow in this section, the low base flows, high bacterial counts and generally poor water quality, and lack of marginal vegetation habitat contribute to the poor faunal diversity and low overall invertebrate sensitivity (ASPT).

Taxa Present

Porifera (sponge), Oligochaetes, Potamonautid crabs, 2 species of Baetid mayflies, Caenid mayflies, Nepid bugs, Chironomids, Simuliids, Syrphids, Tabanids.

4.10.8 URBAN FEATURES

ASSETS
Stream morphology (pool, riffle, run) and instream habitat types.
PROBLEMS
Bank collapse and instability.
Lack of marginal vegetation.
Urban hydrology resulting in elevated high flows.
Poor water quality.
Poorly maintained sewerage system running alongside river

4.10.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.20, 4.21, 4.22	21.1 – 22.2

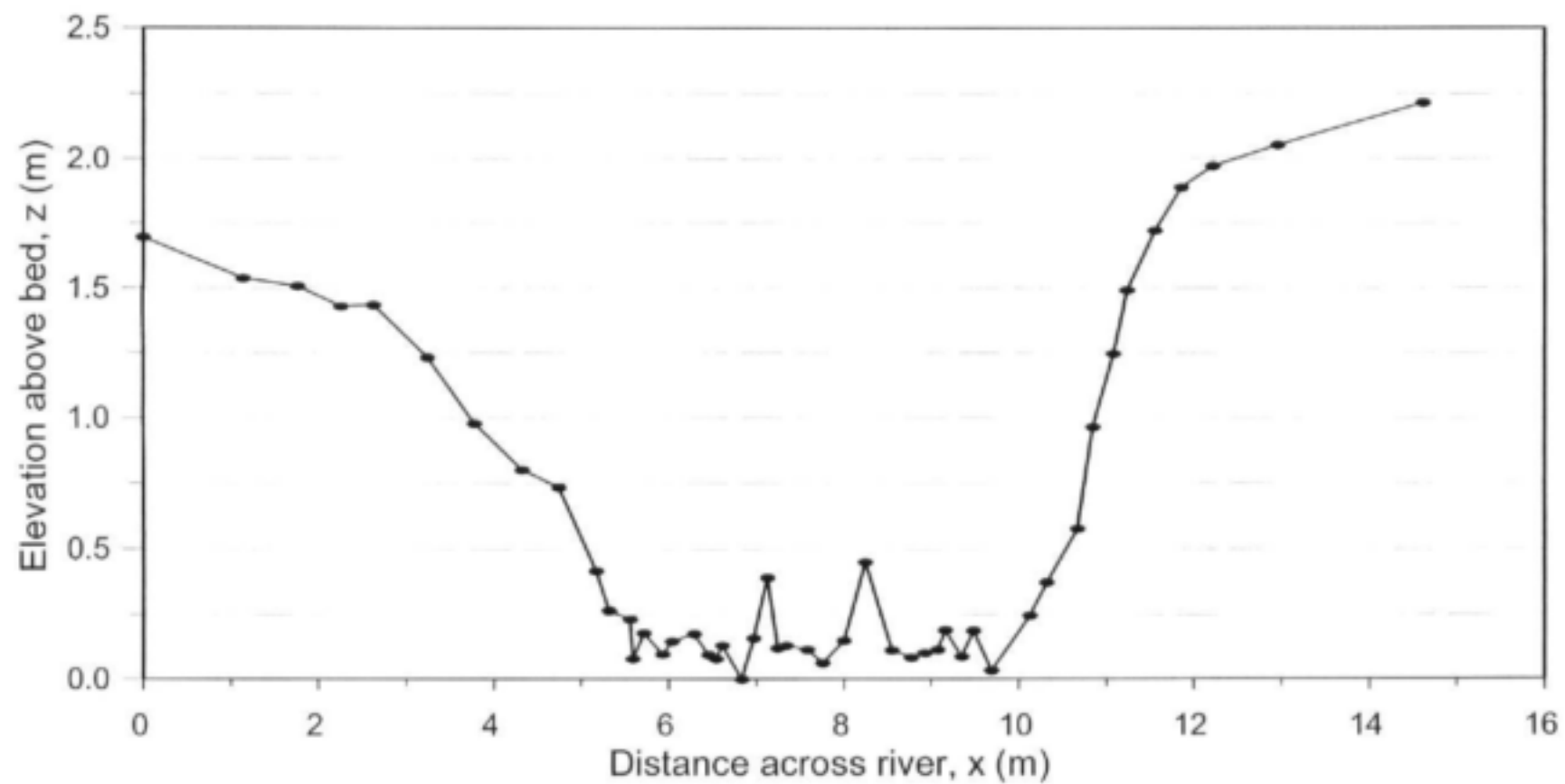


Figure 4.3 Cross-section of the Channel in Reach 21 (see Map 4.21).

4.11 ZONE D, SEGMENT 8, REACHES 23 & 24

4.11.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
23	32°59'25.31"S	27°56'17.81"E
24	32°59'26.57"S	27°56'24.64"E

4.11.2 DESCRIPTION

These two reaches are considered to be in a poor condition relative to the rest of Segment 8. Reach 23 runs through the suburb of Nahoon (east side), and Reach 24 runs to the left (north) of a former garden refuse site. Following closure of the site, it was populated by informal settlement, and has since been developed into the Nahoon Point Driving Range.

Both channel margins are zoned as Public Open Space, and are for the most part invaded by exotic vegetation. The channel is somewhat widened in this section, and the bedrock, cobble and boulder habitat has, in places, been covered by either coarse sands or by fines. This is likely the result of unstable, collapsed or cleared banks in this section and upstream, and sediment inputs from eroded stormwater drainage channels, particularly those on the steep left bank, which can be up to 20m in length. There are a number of tree blocks across the channel resulting in flow backup, pooling and further accumulation of fine sediments. The low baseflows during most of the year result in scarce riffle and rapid habitat in this section.

4.11.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Overhead sewer pipe bridge (lower Reach 23).
Eroded stormwater drainage channels, particularly on the steep left bank.

4.11.4 GEOMORPHOLOGY

Present State	Attainable State
D	D

Natural State

In the natural state this would have been a relatively narrow channel (2 – 2.5 m wide) with well-vegetated, stable banks. Channel morphology would have been dominated by pools and riffles, with some local bedrock controls. The river would be laterally confined by the hill slope, and therefore would only have had a narrow flood bench present.

Present State

The river is in reasonable condition, despite the fact that channel morphology has been altered from natural. The river is dominated by pools and rapids, the latter comprising accumulations of coarse bed material. Under natural conditions, the coarse material would have been unable to move, the new hydrology now makes this possible. The channel has been over-widened, largely as a result of the river's inability to scour the bedrock bed. It is likely that a large portion of the coarse material on the bed has come from the eroded banks, eroding stormwater drainage canals, and upstream reaches. There is large-scale loss of marginal vegetation in this segment as the banks have been undercut. There is a reasonable diversity of instream habitat in the upper reaches, but this declines in the lower reaches of the segment.

4.11.5 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
E (27)	E (4.1)	E
Present State		Attainable State
E		C

Natural State

In this area, the height of the forest canopy would have increased with the slight decrease altitude and distinctive vegetation layers would be likely. Clumps of geophytes such as *Haemanthus albidus* and *Scadoxus puniceus* are likely on the forest floor, as well as perennials like *Dietes* and *Asparagus asparagoides*. *Ficus thonningii*, *Cassia* and *Rapanea* are common trees. Dune forest species such as *Allophylus natalensis*, *Deinbollia* and *Streitzia nicolai* would also be found here occasionally.

Present State

During the time that the former refuse site was populated by informal settlement, clearing practices resulted in alien plant invasion. This has increased extensively since the informal dwellers were relocated, and the area is now covered mostly by impenetrable growth of exotics which are posing a threat to relatively intact riparian sites further downstream.

Dominant Taxa

Cardiospermum grandiflora, *Erythrina caffra*, *Cordia caffra*

4.11.6 FISH

Present State	Attainable State
F	D

Natural State

As with the previous segment, *Barbus anoplus*, possibly *Sandelia bairdii*, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*) and *Glossogobius callidus* would likely have been present. Freshwater mullet (*Myxus capensis*), a number of other catadromous fish species (e.g. *Mugil cephalus*, *Monodactylus falciformis*), and freshwater prawns (*Macrobrachium spp.*) probably penetrated naturally up into this segment.

Present State

No fish were caught or observed in this segment, despite the reasonably high water clarity. This was considered strange, particularly in the pool areas. However, tree blocks may block the passage of species, and other contributing factors would be low flows, poor water quality and the paucity of available habitat and shelter.

4.11.7 INVERTEBRATES

REACH 24

SASS5 Score	No. of Taxa	ASPT	IHAS Score
14	4	3.5	39
Present State		Attainable State	
E		D	

Natural State

The expected hydraulic habitat in these lower reaches reach would be predominantly bedrock, sand and gravel, with some areas of stones in current, stones out of current and marginal vegetation. Water clarity would likely be high. In the presence of the aforementioned habitats it is likely that there would be a reasonably diverse invertebrate community dominated by collectors (Dipterans and Oligochaetes), with certain shredders (e.g. Baetid, Caenid, Leptophlebid and Heptageniid mayflies; Hydropsychid and Leptocerid caddisflies), a small number of predators (e.g. Aeshnid, Coenagruid, Libellulid and Chlorolestid Odonates), and numerous true bugs and beetles. Expected non-insects would include Ancyrid, Planorbis and Lymnaeid snails, Potamonautid crabs, *Macrobrachium sp.* prawns, and a range of microcrustaceans.

Present State

The fauna in these reaches is poor, particularly since one would expect some measure of recovery in these less developed areas of the river. Low diversity and abundances were recorded. The lack of diversity is attributed both to poor water quality and the paucity of habitat (only sand and sediments were sampled). This is due in part to sedimentation resulting from collapsed bank conditions upstream and within the reaches, from tree blockages which have caused backup of flow and upstream sediment accumulation, and from eroding stormwater channels which introduce sand into the channel.

Taxa Present:

Baetid mayflies (2 species); Oligochaetes, Chironomids, Tabanids.

4.11.8 ASSETS AND PROBLEMS

ASSETS
Relatively natural hydraulic habitat in sections (despite sediments).
PROBLEMS
Extensive invasion by alien plant species
Sedimentation due to bank instability and stormwater drainage channels.
Tree blockages in the channel.

4.11.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.23, 4.25	23.1 – 24.1

4.11 ZONE D, SEGMENT 9, REACHES 25 & 26

4.12.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
25	32°59'28.63"S	27°56'27.72"E
26	32°59'26.05"S	27°56'32.42"E

4.12.2 DESCRIPTION

As described in the previous segment, the right bank of much of this segment was formerly an unlined garden refuse site, where many other forms of waste were also discarded. It is possible that seepage from this refuse site still affects downstream water quality.

The bank disturbance due to alien invasion in Reach 25 is significantly greater than that in Reach 26, and serves as a threat to the downstream riparian zone. The channel has been widened to 3-4m in both reaches, and the instream substrate is a sand-bedrock-boulder-cobbles. During normal baseflows there is little flow through Reach 25 (due in part to backup caused by a sewer pipe routed across the channel). Both banks are vegetated up to 100%, although in Reach 25 the vegetation on the right bank particularly is chiefly alien invasives.

The land leased by the Nahoon Point Driving Range (former refuse site) continues alongside the right bank of most of Reaches 25 and 26, outside of the riparian zone.

4.12.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Former clearing of the right bank (former waste site) for informal settlement and subsequent alien invasion of this zone.

Cross-channel sewerage pipe in mid-Reach 25.

4.12.4 GEOMORPHOLOGY

Present State	Attainable State
B	B

Natural State

Under natural conditions, steep valley side slopes with little or no flood bench would have been present. The channel pattern would have been fixed on the valley floor with very stable, well vegetated hillslopes (banks). Channel morphology would have consisted of pools and rapids, with some accumulations of smaller material making up riffle type features. The channel is likely to have been about 3m wide in this segment.

Present State

The channel has changed little from the natural condition, as a result of its inherent stability and inaccessibility. Changes from the natural state in this segment are associated with increased sediment inputs (probably from the erosion of hillslopes within the segment) and from changed hydrology upstream. There has been some widening of the channel due to increased flood peaks associated with urban hydrology.

4.12.5 VEGETATION

RIPARIAN	RVI SCORE	GUT SCORE
C (84)	C (16.06)	B
Present State	Attainable State	
C	B/C	

Natural State

In this area, the height of the forest canopy would have increased with the slight decrease in altitude, and distinctive vegetation layers would be likely. Clumps of geophytes such as *Haemanthus albidus* and *Scadoxus puniceus* are likely on the forest floor as well as perennials like *Dietes* and *Asparagus asparagoides*. *Ficus thonningii*, Cassine and *Rapanea* are common trees. Dune forest species such as *Allophylus natalensis*, *Deinbollia* and *Strelitzia nicotai* would also be found here occasionally.

Present State

While the upper section of this segment (Reach 25) is fairly extensively invaded by alien vegetation, the lower section (Reach 26) is in a good condition and has relatively intact vegetation. Biodiversity and vegetation cover are highest in these areas with a good cross-section of canopy and understorey growth. Geophytes, ferns and sedges are also present. These are sites of botanical significance, where vegetation mostly constitutes an asset, and it would be advisable to protect these areas from further degradation. This area has the potential for incorporation into a nature conservancy that could be amalgamated with the proposed Nahoon Nature Reserve along the coast (*this is described further in the objectives*). Although much of existing vegetation is intact, there is an increasing risk of encroachment by alien invaders, particularly from Reach 24.

Dominant Taxa

Inkberry, *Brachylaena discolor*, *Ficus sur*.

4.12.6 FISH

Present State	Attainable State
F	D

Natural State

Barbus anoplus, possibly *Sandelia bainesii*, at least two species of freshwater eels (*Anguilla mossambica*, *A. marmorata*) and *Glossogobius callidus* would likely have been present. Freshwater mullet (*Myxus capensis*), a number of other catadromous fish species (e.g. *Mugil cephalus*, *Monodactylus faiciformis*), and freshwater prawns (*Macrobrachium* spp.) probably penetrated naturally up into this segment. Mozambique tilapia (*Oreochromis mossambicus*) may also have been present in deeper pools.

Present State

No fish were caught or observed in this segment. This was considered strange, however the low water levels and the water quality may be accountable for this. A juvenile eel was sighted in the lower reaches of this segment some time after the sampling event, suggesting that movement up the channel is possible.

4.12.7 INVERTEBRATES

Reach 26:

SASS5 Score	No. of Taxa	ASPT	IHAS Score
46	11	4.2	62
Present State		Attainable State	
E		D	

Natural State

It is assumed that this segment would have had a pool/riffle morphology, and would have been shaded by forest canopy. Patches of marginal vegetation would be expected in shallow pool margins. The expected community would have included Baetid, Caenid and Leptophlebiid mayflies, Hydropsychid and Leptocerid caddisflies, Simuliid, Chironomid, Ceratopogonid, Tabanid and Tipulid fly larvae, snails, Hemipteran bugs, beetles, and crustaceans including microcrustaceans. Predators such as Coenagruid, Libellulid, Aeshnid and Gomphid dragonflies and damselflies would likely be present in low numbers.

Present State

Despite the apparent improvement in overall habitat quality and water clarity, the invertebrate fauna of these reaches is poor, and the low ASPT is a reflection of its overall resilience to organic pollution and disturbance. The lack of snails, beetles and true bugs is unexpected, but likely to be due in part to the lack of marginal vegetation in this segment, and to low primary productivity (instream macrophytes) in the stream.

Taxa Present

Leeches, Baetid mayflies, Chlorolestid dragonflies, Hydropsychid caddisflies, Chironomid and Syrphid fly larvae, Chlorolestid damselflies.

4.12.8 ASSETS AND PROBLEMS

ASSETS
Close-to-natural channel shape and instream habitat.
Relatively intact riparian canopy in Reach 26.
PROBLEMS
Cross-channel sewer pipe in upper Reach 25 (causing flow backup).
Alien encroachment on banks in Reach 25.
Sedimentation and fines throughout the segment.

4.12.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.25, 4.26	27.1 – 28.1

4.13 ZONE E, SEGMENT 9, REACHES 27 & 28

4.13.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
27	32°59'21.88"S	27°56'33.95"E
28	32°59'24.23"S	27°56'36.86"E

4.13.2 DESCRIPTION

In this and the lower segment, the river runs through Public Open Space and there is little development within 100-400m of the channel's edge. In the upper segment, the lower section of the Nahoon Point Driving Range is located alongside the right bank of the river. The riparian forest is largely intact, with areas of encroachment by alien invasives (Plates 27.1 – 28.1).

These reaches are typical of a first order stream in appearance, and similar in appearance to the headwater reaches of a larger river. The river morphology is riffle/run/pool, is probably little changed from normal and is in reasonable physical condition. The riparian vegetation on the steep valley slopes is intact and indigenous, providing canopy cover. Banks are stable and well vegetated along most of the segment, except in areas where there has been clearing or where stormwater channels have eroded, causing adjacent disturbance.

Flows are typically low. Instream habitat comprises bedrock, scattered boulders, and large cobbles.

4.13.3 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Poorly maintained sewerage system routed along the left bank of the river.
Stormwater inputs through eroded drainage channels.
Alien vegetation encroachment in patches, particularly on the left bank.

4.13.4 GEOMORPHOLOGY

Present State	Attainable State
B	B

Natural State

In the natural state, the river would have looked similar, with steep valley side slopes and little or no flood bench. The channel pattern would have been fixed on the valley floor with very stable, well vegetated hillslopes (banks). Channel morphology would have consisted of pools and rapids, with some accumulations of smaller material making up riffle-type features. The channel is likely to have been about 3m wide in this segment.

Present State

The channel has changed little from natural or reference condition, as a result of its inherent stability and inaccessibility. Changes from natural in this segment are associated with increased sediment inputs (probably from the erosion of hillslopes and stormwater drainage channels within the segment) and from changed hydrology upstream. There has been some widening of the channel due to increased flood peaks.

4.13.5 VEGETATION

RIPARIAN SCORE	RVI SCORE	GUT SCORE
B (99)	C (12.45)	C
Present State	Attainable State	
C	B/C	

Natural State

In this area the height of the forest canopy would have increased with the slight decrease in altitude, and distinctive vegetation layers would be likely. Clumps of geophytes such as *Haemanthus albillos* and *Scadoxus puniceus* would be likely on the forest floor, as well as perennials such as *Dietes* and *Asparagus asparagoides*. *Ficus thonningii*, *Cassine* and *Rapanea* would have been common trees. Dune forest species such as *Allophylus natalensis*, *Deinbollia* and *Strelitzia nicotai* would also have been found here occasionally.

Present State

These areas are in good condition and have relatively intact vegetation. Biodiversity and vegetation cover are the highest for the river in this segment, with a good cross-section of canopy and understorey growth. Geophytes, ferns and sedges are also present. These are sites of botanical significance, where vegetation mostly constitutes an asset. It would be advisable to protect these areas from further degradation, as they have the potential for incorporation into a nature conservancy, or could be amalgamated with the proposed Nahoon Nature Reserve if there were sufficient support. Although much of the existing vegetation

is intact, there is an increasing risk of encroachment by alien invaders, particularly from Reach 24.

Dominant Taxa

Brachylaena discolor, *Deinbollia oblongifolia*, *Allophylus natalensis*.

4.13.6 FISH

Present State	Attainable State
F	D

Natural State

Probably *Barbus anoplus* possibly *Sandelia bainesii* and *Glossogobius callidus*. Catadromous species should be present as close to estuary and habitat suitable - 2 species of freshwater eels (*Anguilla mossambica*, *A. marmorata*), freshwater mullet (*Myxus capensis*) as well as *Mugil cephalus* and *Monodactylus falciformis* and at least two species of freshwater prawns (*Macrobrachium spp.*) probably penetrated naturally up into this segment. Also Mozambique tilapia (*Oreochromis mossambicus*) in deeper pools

Present State

No fish were caught in these lower reaches during the sampling. A single *Glossogobius callidus* juvenile was however collected in the invertebrate samples. The likely reason for the lack of species in these lower reaches, where physical habitat and pools are plentiful, is the low flow levels, poor water quality (low oxygen levels), and possibly obstacles to fish passage (shallow bedrock areas).

4.13.7 INVERTEBRATES

Reach 28

SASS5 Score	No. of Taxa	ASPT	IHAS Score
35	7	5	65
Present State		Attainable State	
E		D	

Natural State

It is assumed that this section would have comprised pools, rapids and runs, and been shaded by forest canopy. Patches of marginal vegetation would be expected

in shallow pool margins. The expected community would have included Baetid, Caenid and Leptophlebiid mayflies, Hydropsychid and Leptocerid caddisflies, Simuliid, Chironomid, Ceratopogonid, Tabanid and Tipulid fly larvae, herbivorous snails, Hemipteran bugs, beetles, and crustaceans including microcrustaceans. Predators would likely be present in low numbers (Coenagrionid, Libellulid, Aeshnid and Gomphid dragonflies and damselflies).

Present State

The current poor state of the invertebrate fauna was unexpected in this reach due to an improvement in overall river condition and habitat availability. The fauna collected is typical of a resilient community inhabiting a polluted and ecologically disturbed river site. This could be attributed to the low flow over the available habitat, and the lack of instream production and marginal vegetation

Taxa Present

Annelida (leeches), Ephemeroptera (>2sp Baetids), Odonata (Chlorolestid), Trichoptera (Hydropsychids), Diptera (Chironomids, Syrphids).

4.13.9 ASSETS AND PROBLEMS

ASSETS
Channel morphology and instream habitat.
Riparian zone and vegetation
PROBLEMS
Threat of alien vegetation in nearby upstream reaches
Poorly maintained sewerage and stormwater systems on river banks.

4.13.10 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.27, 4.28	

4.14 ZONE F, SEGMENT 10, REACHES 29 & 30

The format of this chapter is somewhat different to that for the previous reaches of the river. This reflects a somewhat different approach relevant to the specialist evaluation of the estuary.

4.14.1 COORDINATES

REACH	UPPER END LAT.	UPPER END LONG.
29	32°59'24.46"S	27°56'39.25"E
30	32°59'21.04"S	27°56'45.50"E

Four stations were sampled in these two reaches. Stations 1 (mouth) & 2 (150m upstream of mouth) comprise Reach 30, and Stations 3 (300m upstream of mouth) & 4 (450m from mouth; head of estuary) comprise Reach 29.

4.14.2 URBAN DEVELOPMENTS NEGATIVELY AFFECTING THE RIVER

Aging sewerage system and eroded stormwater drainage network (left bank).
Aging sewer pipe bridge across estuary at Nahoon Beach (former access to the beach)
Odours emitted from sewage pump station on Nahoon Beach.

4.14.3 DESCRIPTION OF NATURAL STATE

Riparian Vegetation

In its natural state, the riparian zone would be similar to that currently in place. In the upper reaches, the zone is dense and reaches to the water's edge. Climax communities of indigenous coastal forest are dominant and comprise coral trees (*Erythrina* spp.), white milkwood (*Sideroxylon inerme*), coastal red milkwood (*Mimusops caffra*), dune bride's bush (*Pavetta revoluta*), dragon trees (*Dracaena* spp.), seplee (*Cordia* spp.), wild silver oak (*Brachylaena discolor*), euphorbias, and *Allophylus* spp. underlain by a dense understorey of *Hypoestes* and other creepers and grasses.

Towards the mid-reaches of the right bank, the climax forest extends to the back beach covering the steep fore-dunes that line this bank. Directly opposite on the left bank, a dense band of freshwater reeds (*Phragmites* and *Cyperus* spp.)

stretches for about 100m along the bank. The presence of these reeds suggests that the estuary is dominated by fresh water. Beyond the reed bank, coastal shrubs, such as *Chrysanthemoides monilifera*, intersperse with forest tree species. There are no salt marshes or submerged macrophytes. Seawards of the reedbed, the low fore-dunes alongside the estuary are covered with typical coastal trees and shrubs.

Banks

The natural state of the banks is likely to be similar to the current state. In the upper reaches, both right and left banks comprise rocky boulders and outcrops of bedrock that arise between compacted areas of muddy sediment. In the mid- and lower reaches of the right side, there is no bank immediately adjacent to the steep vegetated fore-dunes that line the estuary. On the left side landwards of the *Phragmites/Cyperus* reedbed, the bank is consolidated by the mixture of mud, sand and stones. Towards the mouth, the presence of vegetated fore-dunes alongside the estuary inhibits the formation of banks.

Instream Habitat

Naturally the upper estuary is shallow (0.5m deep), the water clear and largely fresh, and the substrate comprises bedrock and loose boulders covered with algae. The water column is shaded by overhanging trees. In the mid-reaches, the water is deepest (2-2.5m), and the substrate ranges from mud to sand with the occasional boulder. Light penetration is usually 50 - 60% but would vary according to wind velocities, state of the mouth and the rate of freshwater inflow. Salinity and nutrient levels in the water would also depend on these factors. In the mouth region, the water is less than 1m deep, clear, and overlies a sandy bottom.

BIOTA

Fish

In its natural state, a small (surface area < 2ha) estuary such as the Ihlanza would support an average of eight fish species and a maximum of 19, of which six would be considered rare. The fish fauna would comprise euryhaline (tolerant of a wide salinity range) marine and freshwater species, as well as estuarine species. Although the marine group would be dominated by juveniles (since estuaries serve as nursery grounds), sub-adults of various mullet species as well as the Cape stumpnose (*Rhabdosargus holubi*) would also occur. A few estuarine breeding species would be present e.g. estuarine roundherring (*Gilchristella aestuaria*), Cape silverside (*Atherina breviceps*) and river goby (*Glossogobius callidus*), with Mozambique tilapia (*Oreochromis mossambicus*) the only freshwater fish likely to be found. In addition, high densities of mullet (*Mugil cephalus* and *Myxus capensis*), Cape moony (*Monodactylus falciformis*) and river goby (*G. callidus*) would be expected in the low-salinity upper reaches and their distribution would extend above the ebb and flow into the lower reaches of the river.

Macroinvertebrates

Predominantly closed estuaries support fewer macroinvertebrate species than permanently open systems (e.g. Nahoon estuary). In small closed estuaries, the sandprawn (*Callinassa kraussi*) replaces the mudprawn (*Upogebia africana*) as the dominant prawn species; *U. africana* is abundant in open estuaries. Crabs e.g. marsh crabs (*Sesarma catenata*) would be evident on the floodplain and following an open mouth event, and some Penaeid prawns would enter the estuary from the sea.

Birds

Birds typical of aquatic environments (e.g. pied kingfisher, giant kingfisher, common sandpiper, whitefronted plover, yellowbilled ducks, egyptian geese, egrets, waders, weavers) and coastal vegetation (e.g. forest weaver, puffback shrike, blackheaded oriole, southern boubou, sombre bulbul, Cape weaver, Cape wagtail) could be expected.

Mammals

Mammals such as otters, water mongoose, small buck species and rodents (e.g. cane rats) would occur in the surrounding forest, moving into the estuary for food (crabs) and fresh water.

4.14.4 DESCRIPTION OF PRESENT STATE

PES (Vegetation)	PES (Fauna)
B	C

The area is impacted by the clearing of the lower section on both banks for the routing of the sewerage pipebridge, over the dunes, and the sewage pump station on the left bank. The pipebridge is routed across the estuary near the mouth (Plates 30.1, 30.2). It continues up over the sand dune on the right bank and is along the back of this dune to the Hood Point Sewage Treatment Works. Public pathways on the left bank of the river give partial access from the Bowling Green down through the coastal dune forest.

Periodic pollution of the estuary water results from pump failure (excess loading during holiday seasons) and sewage overflows along the pipeline further up river, as well as a constant influx of litter brought in by vagrants and informal dwellers. There is some impact caused by vagrants wearing pathways through dune forest, causing some erosion.

The estuary is currently in a degraded state largely due to four factors: infestation of indigenous vegetation by alien plant species; poor water quality related to sewage contamination and elevated nutrient levels; reduced faunal diversity and

abundance likely to be a consequence of the poor water quality; and the presence of intrusive man-made structures and litter emanating from the urban environment.

This state of degradation appears to be relatively stable. Except for the accidental sewage spillage or leakage currently evident in the upper and middle reaches, the system will already have experienced several 'worst case' water quality scenarios since the catchment is almost fully developed and sewage overflows during heavy rains are not extraordinary events. The current state of the biota reflects a response to the degraded water quality, flood regimes and present disturbance levels. The presence of vagrants in the area has deterred visitors; disturbance to the riparian vegetation is therefore limited. The upper estuary and its surrounds are not suitable for development largely owing to the instability of the dune environment and the potential impact of floods.

4.14.5 GEOMORPHOLOGY

Present State

B Class. Geomorphologically, the estuary is very similar to a reference (natural) condition. Banks remain stable and generally well vegetated. There is likely to be an increased sediment deposition within this zone, as a result of upstream inputs. There are some human-induced changes within this section but they are relatively insignificant.

4.14.6 VEGETATION

RIPARIAN	RVI SCORE	GUT SCORE
B (B9)	B/C (16.61)	C
Present State		Attainable State
B (specialist decision)		B

Present State

This is the visible section of the estuary to the beach surf zone. Vegetation consists of characteristic coastal dune scrub and forest with pioneer species such as *Chrysanthemoides* and *Brachylaena* and long term trees such as *Mimusops*. The understorey under the larger trees is characterized by herbaceous growth up to approximately 1m consisting of *Isoglossa* and *Hypoestes*. Areas cleared for pathways are covered partially by grass species such as *Stenotaphrum secundatum* and *Dactyloctenium australe*. Plant height is limited by wind, so that species on the seaward side or along the estuary are characteristically wind pruned.

Dominant Taxa

Brachylaena discolor, *Mimusops cafra*, *Chrysanthemoides monilifera*

4.14.7 INDICATORS OF DEVIATION FROM NATURAL STATE

The following are indications of the degree to which the estuary has changed from its natural state.

1. The occurrence of alien vegetation (*Lantana* and *Sesbania* spp.) on the left bank.
2. The absence of all fish (of freshwater and marine origin) and the extremely low numbers of swimming prawns (one individual *Palaemon* sp.) in the head region.
3. The absence of sandprawns (*Callinassa* spp.) and crabs (*Sesarma cafer*) from the mouth region.
4. Elevated levels of total coliform bacteria and the faecal bacterium *Escherichia coli* in the mid and upper reaches. (BCM water quality data, 2002-3) indicate a water body unsuitable for human contact (i.e. counts of > 100 per 100ml). Levels of contamination are particularly high (> 1 100 counts per 100ml) in the lower mid reaches about 100m upstream of the mouth.
5. Elevated levels of nutrients (nitrates, nitrites, ammonia and soluble reactive phosphorus) at the head and in the upper reaches of the estuary may reflect nutrient enrichment related to the decomposition of organic material within the upper estuary, or may indicate leaching of fertiliser compounds into the urbanised river system in the catchment. Some nutrient-generating processes are likely to occur naturally in the upper reaches and slightly elevated levels can be expected. However, the estuary may also act as a sink for soluble and particulate material from the catchment. With the mouth closed for much of the time, and the limited exchange of water with the near-shore when the system is open, the potential for eutrophication and thus micro-algal blooms is high. The absence of freshwater and marine fish as well as crustaceans from the upper reaches may be a consequence of these elevated nutrient levels.
6. The incidence and amount of freshwater inflow are likely to be greater than natural, as the greater part of the catchment is covered by impermeable surface. Floods and mouth-scouring are likely to occur more often, events that could affect the recruitment and colonisation of sandy areas by sandprawns and crabs as well as the structure and abundance of fish communities of both marine and freshwater origin.
7. A sewage pump station is clearly visible on the lower east side of the estuary. In addition, a sewage pipe bridge across the mouth region detracts from the natural aesthetic appeal and presents the potential for accidental spillage into the estuary.

8. The presence of vagrants who either live in the dense bush or visit the estuary valley is likely to disturb resident mammals and birds. Litter and excreta left in the area pollute the estuary and its environs, and present a threat to the personal security of tourists.

9. The presence of moderate quantities of litter mainly in the form of low-density plastic carrier bags in the upper reaches in particular is hazardous to wildlife and is aesthetically unacceptable.

4.14.8 ASSETS AND PROBLEMS

For the estuary, the Assets are described (as elsewhere) as elements of the present system that are likely to resemble the natural condition. In addition, the recreational or aesthetic value of these assets is described.

ASSETS:
1. The contours of the relatively narrow incised valley bordered by a high vegetated dune to the west and moderately sloping valley to the east create an environment close to natural with recreational appeal.
2. The estuary is about 400m in length and the water is generally clear presenting an ideal opportunity for ecotourism activities such as boating and canoeing.
3. The presence of indigenous climax forest vegetation that overhangs the upper reaches and covers the steep valley floor enhances the natural aesthetics.
4. Birdlife is abundant characterised by many coastal bush species. Mammals such as otters and bushbuck also frequent the estuary.
PROBLEMS
1. Sewage pollution resulting from sewer system spills or leaks from pipes carrying sewage to the East Bank Water Reclamation Works. As discussed earlier, diluted sewage can also enter the system during high flow events due to surcharge.
2. Any form of new development into the estuary valley, including additions to sewage canals or treatment works. It should be noted that sand slumping on the vegetated dune to the west of the estuary is a natural phenomenon, and no attempt should be made to introduce stabilisation measures.
3. Spread of alien invader plant species in the indigenous coastal forest. Frequent and random passages by tourists and vagrants into the riparian bush will create a myriad of paths and thus space for further infestation.
4. Litter originating in the catchment accumulates in the estuary and presents a threat to the pristine nature of the environment.
5. The use of fertilizers on lawns and gardens in the river catchment can enhance nutrient levels in the estuary. These levels may already be naturally elevated as a result of autochthonous estuarine processes. Eutrophication may result and promote the formation of microalgal blooms.

6. The large diameter sewer pipe bridge that crosses the estuary at the mouth severely compromises the pristine nature and aesthetic appeal of the river valley. This was formerly a footbridge, but is no longer open to the public since all railings have been removed, and sections of the cladding are in a state of disrepair. The pump station located on the west bank adjacent to the mouth, and the odours emanating from it, also impacts the aesthetic integrity of the system.

7. Random transgressions by visitors into the vegetation covering the steep fore-dune on the west side of the estuary and the vegetation in the valley on the east side.

4.14.9 MAPS AND PLATES

Map Numbers (Volume 2)	Plate Numbers (Appendix 4, Volume 2)
4.29, 4.30	30.1 – 30.3

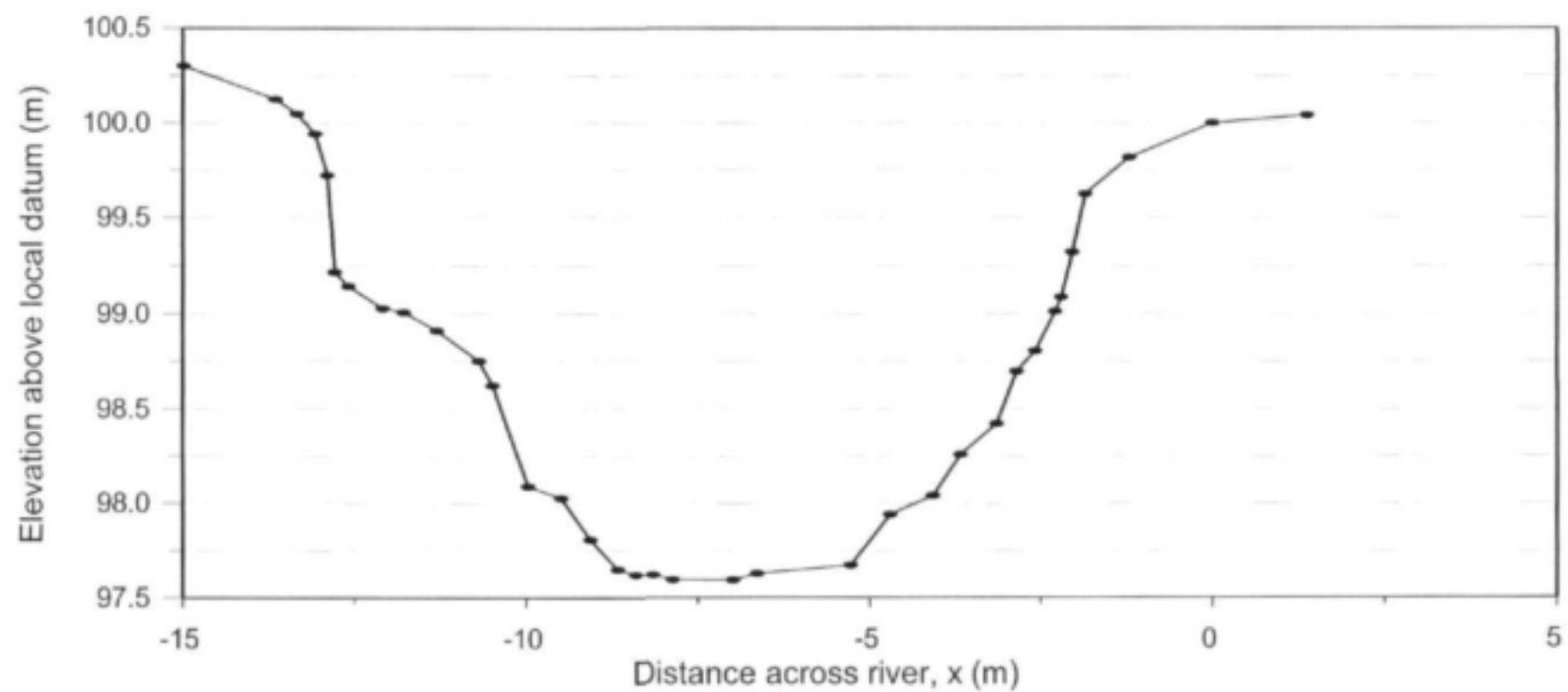


Figure 4.4. Cross-section of the channel in Upper Reach 29 (Map 5.29).

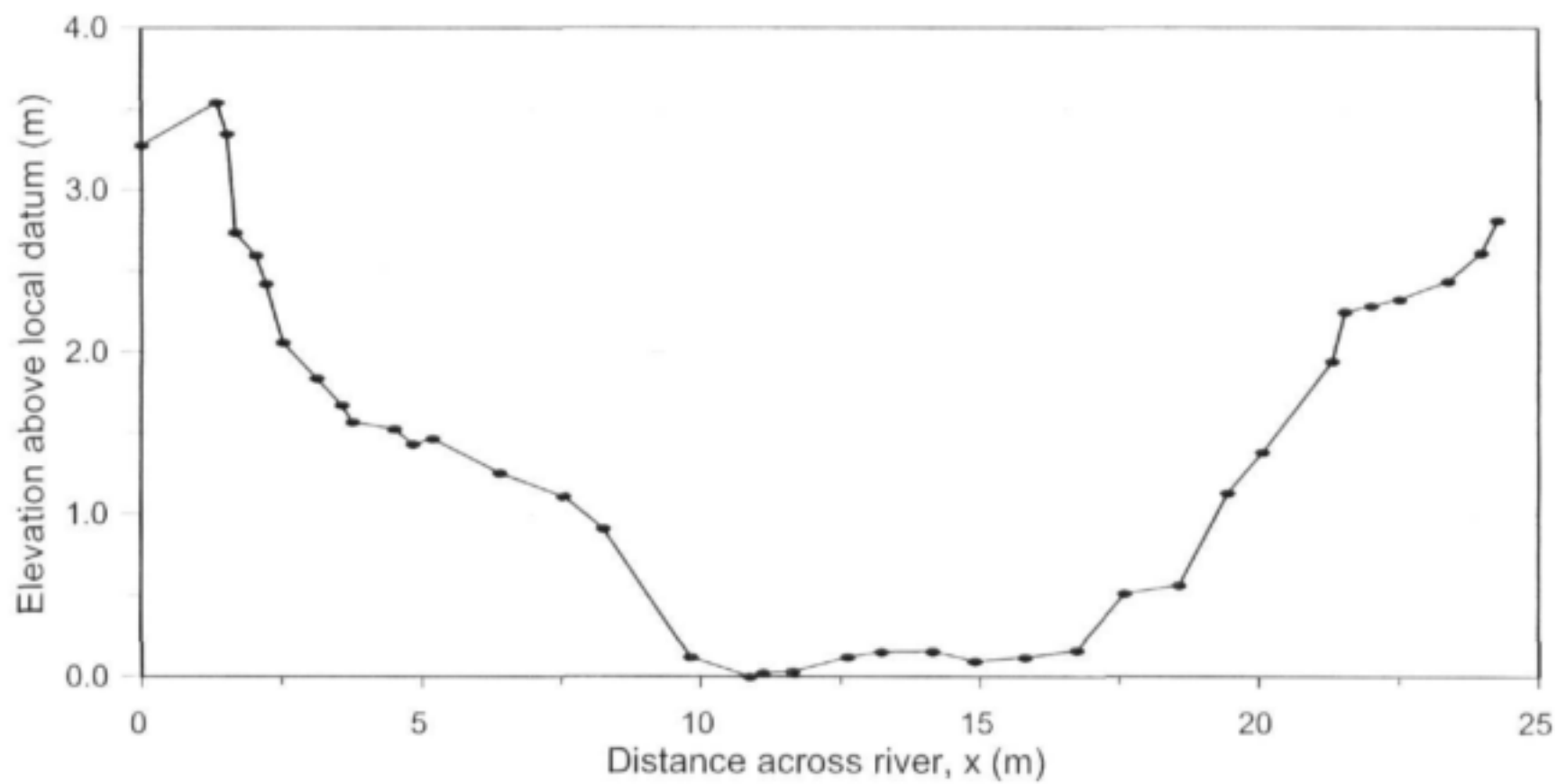


Figure 4.5 Cross section of the channel in Reach 30 (Map 5.30).

CHAPTER 5

OBJECTIVES AND RECOMMENDED REHABILITATION MEASURES

Note: In this Chapter, the 'Future Attainable State' (FAS) has been determined on the basis of specialist input. The FAS is now referred to by DWAF as the 'Future Desired State'. Objectives per river unit are presented in three categories: Ecophysical, Infrastructural and Social/Educational/Recreational. Each is assigned a label (e.g. Ea) which corresponds to the number given to the associated Recommended Rehabilitation Measure. Each objective is also prioritised within its category. Generic objectives and rehabilitation measures presented in Chapter 3 are referred to here, but are not repeated. A planting plan is included as Section 5.14. Conceptual designs for certain of the rehabilitation measures are listed and are presented in Appendix 5 (Volume 2).

5.1 ZONE A, SEGMENT 2, REACHES 1 & 2

5.1.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	F	F
Riparian Vegetation	E/F	E
Fish	F	E
Invertebrates	F	E
OVERALL	F	E

Where PES is Present Ecological State class and FAS is Future Attainable State class.

GEOMORPHOLOGY

It is considered impractical to attempt to change this segment back to an earth channel river of any sort. It is however considered important to try and manage the peak flood flows i.e. through flood attenuation, reduction of response time and reduction of energy. It would seem that it is also important in this segment to deal with urban pollution (including litter), so as to allow flood runoff to enter the stormwater network easily.

VEGETATION

Since there is little hope of restoring this area to its natural vegetation, and because it is situated in-between the highest problem area upstream and areas downstream which do have hope of improvement, it is proposed that this area be used entirely for remediation purposes, especially since the existing topography lends itself to this. The construction of a large detention pond in Reach 2, which would double as a biofilter, is proposed. This would reduce the downstream effects of flooding, and improve water quality.

FISH

There is a small chance of re-creating physical habitat suitable for fish life in this section. Improvement of water quality to the point that it is capable of supporting fish life is likely to be a long-term project.

INVERTEBRATES

If the objectives of water quality enhancement and improvement of instream habitat in this segment are met, invertebrates likely to colonise the segment should include the more resilient Dipterans (e.g. Chironomids, some Simuliids, Tabanids), certain Baetids (e.g. *Baetis harrisoni*), dragonfly and damselfly larvae (e.g. Gomphids, Aeshnids, Chlorolestids), Potamonautid crabs, Corixid and Hydrometrid bugs, and Gyrinid beetles. If water quality enhancement were a longer term phenomenon a more sensitive fauna would eventually be found here.

5.1.2 OVERALL GOAL FOR THE SEGMENT

Naturalisation of the water quality and the canal in Reach 1 such that it becomes an attractive recreational or parkland area.

The creation of a limited access, 'closed catchment' in Reach 2 with limited access. The primary goals for this area are flood detention, water quality remediation, and litter removal. The intention would be to clear the area of alien vegetation and establish a flood detention system with flow-through (i.e. a slight modification of that shown in Map 5.2). The detention pond should be further designed on the basis of bio-engineering principles, and should double as a biological filtration system and habitat.

If the objectives for this segment were met and the correct vegetation was planted, this closed area could be used as a limited-access bird-watching facility.

5.1.3 OBJECTIVES AND PRIORITIES

Obj.	ECOLOGICAL	Pr.
Ea	Improve water quality (see generic objectives, Chapter 3).	1
Eb	Naturalise bank vegetation (see generic objectives, Chapter 3).	2
Ec	Increase 'instream' habitat and hydraulic diversity as per generic objectives	3
	INFRASTRUCTURAL	
Ia	Utilise this canalised section of the river for flood detention.	1
Ib	Limit access to the area except to municipal officials, in order to secure lower reaches.	2
	SOCIAL/EDUCATIONAL/RECREATIONAL	
Sa	Once the closed catchment has been created, consider limited access for 'birders', and possibly the accompanying infrastructure (e.g. birdhides).	1

Where Obj = Objective and Pr = Priority

5.1.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOLOGICAL
Ea	See generic measures (Chapter 3) and Measure 1a (biological filtration). Link manholes in this reach to the BCM telemetry system to ensure that any surcharge or spillage into the river is relayed to the authorities immediately and is given high priority attention.
Eb	Clear alien vegetation. Link the replanting of appropriate indigenous vegetation to the Measure 1a.
Ec	Incorporate the increase of habitat diversity into the design of a detention system in this reach (Measure 1a).
Obj	INFRASTRUCTURAL
1a	The following recommendation arises from discussions between Mr Johan Koekemoer (BCM: Sewerage Manager, Directorate of Engineering Services), the specialist team, and geotechnical specialist Dr GV Price (Terreco cc., East London). Being relatively high in the catchment, this is an ideal position to create a flood detention system, with the primary function of attenuating the flood wave through ponding and slow release; and the additional function of providing biological filtration to incoming water. The detention basin would be modelled on that shown in Design 1 (Appendix 5), with a number of modifications which would require specialist design: i) allow continuous flow through the system to ensure provision of base flows to the downstream reaches (i.e. no valves as shown in Design 1), ii) placement or embedding of riprap or cobble on slopes of the detention system to increase surface area (flow oxygenation, biofiltration, habitat augmentation); iii) installation of a litter trap at the upper end of the detention system.
1b	Create a "closed catchment" around this canalised segment, through the construction of fencing as shown on Map 5.2 to protect and prevent access to the infrastructure associated with this Reach, and to prevent access to Reach 3 through the stormwater culvert which runs beneath the Chamberlain Rd bridge. This closed catchment would thus serve to protect the flood detention system, to prevent accidents in the area of the detention system, to prevent fouling and littering in the area, to increase safety for elderly downstream residents in the Berea Gardens Valley complex, and to protect the existing and planned indigenous riparian vegetation in Reaches 2 and 3.

Obj	SOCIAL/EDUCATIONAL/RECREATIONAL
Sa	The idea of creating a birding area in this section of the river was apparently raised by the former East London City Council, almost a decade ago. No records to this effect have been located, however this area is likely to be an excellent potential birding site, particularly once indigenous vegetation has been planted. If this idea is supported, it would be appropriate to develop the planting plan such that the vegetation encouraged birdlife.

Where Obj = Objective

5.1.5 DESIGN REQUIREMENTS

All conceptual designs are presented in Appendix 5, Volume 2.

Obj.	DESIGN
1a	DESIGN 1: Stormwater Detention Facility

5.2 ZONE A, SEGMENT 3, REACHES 3 & 4

5.2.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	E	D
Riparian Vegetation	D	C
Fish	F	E
Invertebrates	F	E
OVERALL	F	E

Where PES is Present Ecological State class and FAS is Future Attainable State class.

GEOMORPHOLOGY

This channel should be cleared of building rubble and the channel landscaped and stabilised. The idea for this channel would be to manage upstream floods and then open the channel into a compound system with stable banks and terracing. The channel margins would need to be planted with indigenous trees and shrubs. The middle section of this segment (Reach 4) could be considered for the creation of a fairly stable riffle/run/pool sequence. Alternatively, a number of small flood detention ponds below the bedrock chute in Reach 4 would serve to reduce flood energy and help improve water quality (this would however be unnecessary if the larger detention pond were to be built in Reach 2). No large-scale engineering should be carried out in this section until an assessment has been made of upstream mitigation measures.

VEGETATION

The indigenous vegetation in this section and downstream is in danger of deteriorating if invasive alien plants are not controlled. It is proposed that this area be planted with suitable indigenous material to return the reach to as natural a state as possible in terms of vegetation. Alien invasive plants are to be controlled. All reaches from 3 to 9 have the potential for being a valuable educational and recreational resource in the future.

FISH

It would be possible to restock *Barbus anoplus* here. Possibly smaller species of freshwater eel (*Anguilla mossambica*) would penetrate naturally from downstream. *Sandelia bainesii* is probably too sensitive to attempt re-introduction in this reach.

INVERTEBRATES

If water quality deterioration is addressed, a more diverse fauna would be expected. Initially this would be a resilient group, including Baetid and Caenid mayflies, Hydropsychid caddisflies, Simuliid larvae, Corixid bugs, Dytiscid beetles, Ancyloid snails, and Chironomid and various other Dipteran larvae.

5.2.2 OVERALL GOAL FOR THE SEGMENT

The goal is to renaturalise bank form and riparian vegetation, to protect the riparian forest in upper Reach 3, to improve water quality and flow diversity along Reaches 3 and 4, and to increase the diversity and abundance of biota. This section of the river is unlikely to become a recreational area for several years to come, unless the extensive clearing, replanting and water quality remediation measures recommended are implemented in the short term.

5.2.3 OBJECTIVES AND PRIORITIES

No.	ECOPHYSICAL	Pr.
Ea	Stabilise banks along both reaches (see generic objectives, Chapter 3). Enhance marginal vegetation habitat wherever possible.	1
Eb	Protect riparian vegetation on the right bank in Reach 3.	2
Ec	Increase habitat and flow diversity in Reach 3. Establish a stable riffle/pool/run configuration in Reach 4.	
Ed	Create a high flow channel in upper Reach 3.	
INFRASTRUCTURAL		
Ia	Attend to the sewerage system in Reaches 3 & 4.	1
Ib	Slow incoming flows from stormwater drainage channels.	2
SOCIAL/ EDUCATIONAL /RECREATIONAL		
Sa	Maintain and enhance the recreational area already present in this segment.	1

Where Obj = Objective and Pr = Priority

5.2.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Stabilisation measures for steep banks are presented in Design 2. This is only likely to be possible if the priority objectives for Reach 2 are met. Water quality enhancement may also be augmented by the creation of a pool-riffle-run sequence downstream of the bedrock chute in Reach 4, as detailed in Measure Ec.
Eb	See generic measures, Chapter 3. In this reach, enforcement of conservation legislation by local authorities on unlawful harvesting of indigenous plant material is necessary. In addition, education of harvesters would be encouraged, with a view to creating jobs by using manual labour for removal of alien plants. In Reach 3, Port Rex High School should be encouraged to adopt an environmental policy which involves the clearing of aliens and appropriate vegetation of steep left banks, with indigenous trees, forbs and grasses on the edge of playing fields. These activities should be considered part of a school-based environmental awareness educational program.
Ec	Remove all building rubble from the channel. Discuss with specialists measures for reducing the abundance of sewage fungus in Reach 3. Greater oxygenation of water through the upper section of Reach 3 could be effected by modification of the cross-channel sewer line (e.g. cutting a notch in the pipe). This would enhance the possibility of cleaning the water. Physical and hydraulic habitat diversity could be increased in the deeply incised Reach 4 by the creation of a relatively stable (i.e. immobile) pool-riffle-run sequence between the base of the bedrock chute and the end of the reach. A conceptual design for this is shown in Design 3 (Appendix 5). Modifications required are described in 5.2.5.
Ed	Clear all building rubble presently on the left bank bar (Plate 3.2, Map 5.3). With the specialist assistance of relevant hydrologists and engineers, reduce the present height of this artificially-filled bank area (Plate 3.2), such that it becomes a natural flow path for a flood of approx. 1:1 year return interval, i.e. a high flow channel. Cover the cleared infill area with topsoil and plant with indigenous Buffalo grass. Reduce the slope angle of the area adjacent to this fill area, in consultation with a geotechnical specialist, and stabilise and green the slope following appropriate soil bioengineering principles (see Design 2, Appendix 5).

Obj	INFRASTRUCTURAL
Ia	The sewer pipes crossing the channel (routed either across or over the channel) should ideally be rerouted alongside the stream over the longer term. The concrete-encased pipes (Reach 3 and 4) function as weirs, changing the local bed conditions and hydraulic habitat, and form an upstream trap for woody and other debris. In the interim, these cross-channel structures should be regularly cleared of debris to ensure overtopping is enabled. If possible, create a notch in the structure (with its invert below low-flow depth) to increase flow-through. Check functionality of all sewer pipes, and if out of use, dismantle and remove.
SOCIAL/EDUCATIONAL/RECREATIONAL	
Sa	If the ecophysical and infrastructural objectives for this and Reach 2 can be met, this could form the beginning of a nature trail alongside the river from Reach 3 to the end of Reach 8. This would entail the design and building of pathways and possibly a bird-hide in the lower reaches.

5.2.5 DESIGNS REQUIRED

Obj.	DESIGN No.
Eb	DESIGN 2: Various bank stabilisation measures (also see Section 5.3.5).
Ed	DESIGN 3: Design of a pool-riffle-run sequence. This should follow the pool-riffle-run sequence should follow fluvial geomorphological principles. As the substrate in this river is highly mobile (as evidenced by the extensive downstream relocation of cobble and boulders during the 2002 event), Wadeson (pers.comm) recommends that the pool and riffle sections be created as semi-permanent features, such that they will remain at least partially intact even post-floods. This, conceptually, requires the creation of a riffle-run-pool sequence, as shown in this Design 3, Appendix 5. However it has been suggested that the first several 'layers' of riffle substrate be covered with appropriately sized wire mesh and stapled into the bed and banks, such that it becomes a semi-permanent feature and cannot be moved during a high flow event. A heterogenous mix of small to large cobbles should then be laid over the top of this structure to create a natural appearance. Downstream of each riffle area, a run and pool will develop over time.

5.3.5 RECOMMENDED PLANTING PLAN

Bank stabilisation - Reach 3 - 70° slope on left bank up to rugby field

Option 1: Install a terraforce or Loffelstein wall for the entire height of the wall and plant it up with *Stenotaphrum secundatum*

Option 2:

- Install a stepped gabion wall at the toe of the bank up to a height of 2m.
- Install closed mesh geojute lining above gabion wall pegged into the bank with a combination of *Plumbago* and *Commiphora harveyi* (redstemmed corkwood) cuttings interplanted with dead wood stakes of wattle harvested from the alien clearing program.

Option 3:

- Alternatively stabilise bank with a gab-bloc revetment wall for the first 1,5m of the bank
- Soil pockets in this instance would be planted with *Stenotaphrum secundatum* (Buffalo grass) - the remainder of the bank would be stepped back marginally and lined with a medium weave Geojute textile. The planting thereof would consist of a Buffalo grass or creeping species such as *Senecio tamoides* or *Jasminum multipartitum*.

5.3 ZONE C, SEGMENT 4, REACHES 5 & 6

5.3.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	D	C
Fish	F	C
Invertebrates	F	D
OVERALL	D/E	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

The channel can be basically left as it is. The most recent flood has scoured a good conduit for the removal of extremely high flows. This flood channel needs to be kept open while the banks need to be stabilised with indigenous vegetation. No large -scale engineering should be carried out in this section until an assessment has been made of upstream mitigation measures.

VEGETATION

In this segment it would be possible and desirable to restore some ecological functioning to the riparian zone. Provision should be made for up to 60% shading of the stream, improved habitat for birds, and bank stabilisation as a result of selective planting. As this is a parkland, the aim is not to reforest the area. The following species could be planted relatively sparsely: *Grewia occidentalis*, *Rhus chirindensis*, *Podocarpus falcatus*, *Scholia latifolia*, *Vepris lanceolata*, *Scholia brachypetala*, *Ficus sur* and *Cordia allala*.

Depending on the intensity and type of grazing impacts that the region would have been subject to, it is likely that Segment 4 would have consisted of a combination of closed canopy forest and thicket vegetation, with sections populated by sedges and small rushes where the channel consisted of a sandbed substrate. *Scholia brachypetala*, *Ficus sur* and *Cordia allala* would be common.

FISH

In this segment, it may be possible to restock *Barbus anoplus*. Smaller species of freshwater eel (*Anguilla mossambica*) will penetrate naturally from downstream. *Sandelia bairdii* may survive in this reach if water quality improves and physical habitat becomes more suitable.

INVERTEBRATES

The invertebrates in this segment could improve one to two classes if water quality were remediated. Instream habitat in Reach 5 is relatively good, and should support a relatively diverse community including, at least, the more resilient Baetid and Caenid mayflies, Simuliid, Chironomid and Tabanid fly larvae, Aeschnid dragonflies, Hydropsychid caddisflies, Ancyloid snails, and Corixid bugs. An artificial increase in flow diversity in Reach 6, and the resulting increase in hydraulic habitat diversity, would lead to a similar increase in invertebrate diversity in this reach.

5.3.2 OVERALL GOAL FOR THE SEGMENT

The goal is to enhance and reinstate, as far as possible, ecological form and function in this segment of the river, while maintaining the grassed floodplain as a parkland for the residents of Berea Gardens Valley.

Instream interventions as recommended should improve habitat quality from a physical point of view, will create greater hydraulic diversity, and will assist with water quality remediation. Measures to stabilise banks in certain areas will assist in attempting to return some level of dynamic equilibrium to the system. The aesthetic appeal of the river and its banks and floodplains in this segment is of importance to the elderly residents, and is a high priority. The proposed creation of a walkway and fragrant garden in this section is intended to add amenity value and improve awareness of the river.

5.3.3 OBJECTIVES AND PRIORITIES FOR THE REACH

Obj.	ECOPHYSICAL	Pr.
Ea	Stabilise banks only where necessary in this segment. Naturalise riparian vegetation as per generic objectives, and introduce additional indigenous trees at the stream edge. For security reasons, dense shrubbery over large areas is to be avoided.	1
Eb	Optimise instream marginal vegetation habitat in both reaches, and control exotic reed (<i>Arundo donax</i>) encroachment in Reach 8.	2
Ec	Reduce the impact of cross-channel sewage pipelines on upstream hydraulic and physical habitat diversity.	3
Ed	Destroy any snares found, and monitor on a regular basis.	4
INFRASTRUCTURAL		
Ia	Attend to areas which are likely to become flow blockages during high flow and flood events.	1
Ib	Increase flow resistance in the steep stormwater drainage channel in in Reach 6 to prevent scour of opposite river bank.	2

Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL	
Ra	Create a boardwalk leading to a fragrant garden for the residents of the Berea Gardens Valley Complex. This should be accessible to those who are wheelchair-bound, disabled, or sight-impaired. This is described further in the following Section.	1

Where Obj = Objective and Pr = Priority

5.3.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Continue with gabion stabilisation of the right bank of Reach 5, with consideration of the options in Design 4 (Appendix 5). Terrace the steep left bank in Reach 5 and plant with indigenous vegetation. Replace kikuyu grass on the banks with indigenous Buffalo grass. At the toe of the left bank in Reach 5, plant (at intervals) appropriate <i>Cyperus</i> spp. or leafy riparian vegetation species into the sediment to create pockets of marginal vegetation. In Reach 6 upstream of the culvert bridge, the earth banks should be left as is at present, as these provide a source of sediment to the downstream channel and are not considered to be unstable. At the toe of the banks, vegetation has colonised on lateral or point bars, and this is considered to be beneficial habitat. Downstream of the bridge in Reach 6, in areas of scour (Plate 6.3), bank angle should be reduced and banks terraced to increase stability during highOj flows. At the lower end of Reach 6, the slope angle of the steeply incised right bank should be reduced, and the slope stabilised following a technique such as the Green Timber Crib Walls from African Gabions (Design 4, Appendix 5).
Eb	Continue with the same procedure for creation of riffle/pool/run sequences as that used in Reach 4.
Ec	Check functionality of present sewage pipes and if in disuse, remove from the channel. If active, consider means of increasing flow-through from the upper reaches, as in previous instances.
Ed	Appoint a male resident of the retirement complex or a gardener to do weekly checks for snares in Reaches 3 and 4.
Obj.	INFRASTRUCTURAL
Ia	Remove the disused concrete weir wall on the right bank in mid Reach 5. Discuss the impacts caused by culvert bridges with residents, and recommend alternatives to these structures.

Obj.	INFRASTRUCTURAL
Ib	Line stormwater input in Reach 6 with partially-embedded riprap to increase roughness and reduce the velocity (and thus erosional capacity) of stormwater runoff into the river. Stabilise the opposite bank and downstream bank areas following bioengineering principles (see examples in Designs 2 and 5, Appendix 5).
Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL
Sa	This segment of the river is presently used as recreational area for the residents of the Berea Gardens Valley complex. It is recommended that the parkland be maintained, and possibly that in the future the pedestrian bridge across the channel (top Reach 5) be reconstructed in a wheelchair-friendly manner. This would serve as the start of a raised walkway or boardwalk across the present floodplain (left bank of Reaches 5 and 6), and routed in the direction of Reaches 7 and 8, where birdlife is considered to be excellent. This is discussed further in the following Section.

5.3.5 DESIGNS REQUIRED

Obj.	DESIGN
Ea	DESIGN 4: Gabion Stabilisation with planting, green timber crib walls.
Ea	DESIGN 5: Stabilisation of banks (downstream of bridge). DESIGN 2 and 6: Stabilisation and greening of steep slopes on bend.
Ia	Rep DESIGN 5: Stabilisation of bank (opposite stormwater input).

5.3.6 RECOMMENDED PLANTING DETAILS

For rehabilitation of the slopes immediately below the bridge at the beginning of Reach 5:

- *Stenotaphrum secundatum* (Buffalo grass) on revetted slope of right bank, interspersed with pockets of *Dietes grandiflora*.
- Plant sedges and rushes or perennial bog plants at the toe of the left bank such as *Mariscus congestus*, *Juncus kraussii* and *Kniphofia* sp. to give continuity with the planting higher up on this bank.

Suggested Tree species for groves in the lawn area adjacent Reach 5 and 6, in seasonal colour groupings:

Residents opposite Berea gardens valley have a birds-eye view over the valley from their flats. Since reach 5 and 6 already consists of park-like manicured lawns and trees with sections of garden beds containing ornamentals, which are being maintained, it is more practical to enhance the current usage of this area rather than to attempt to restore it to an entirely natural habitat. To this end it is suggested that tree clusters with ornamental, aesthetic and ecological value be planted to provide a changing palette of seasonal colour as viewed across the valley by residents.

- Grouping one: - *Calodendrum capensis* (Cape chestnut)
Tabebuia heterophylla (Purple Tabebuia)
Ipomea alba (White Morning Glory tree)
Podocarpus falcatus (Common yellowwood)
Maerua caffra (Common bush cherry)
Metaleuca linariifolia (Snow-in-summer tree)
- Grouping two: - *Erythrina caffra* (Peach and orange varieties)
Dombeya rotundifolia (Wild pear)
Halleria lucida (Tree Fuchsia)
Commiphora harbeyi (Red stemmed Corkwood)
Citharexylum quadrangulare (Serrated leafed Fiddlewood tree)
Ochna semulata (Small leaved Plane)
Burchelia bubalina (Wild Pomegranate)
- Grouping three: *Millettia grandis* (umzimbeet)
Celtis africana (White Stinkwood)
Canonia capensis (Red Alder)
Grewia occidentalis (Cross-berry)
Dombeya cymosa (Natal Wild Pear)
- Grouping four: *Erythrina latissima* (Broad leaved Coral tree)
Ochna arborea (Cape Plane)
Rothmania globosa (September bells)
Gardenia thunbergia (Wild Gardenia)
- Grouping five: *Acacia zanthophloea* (Fever Tree)
Diospyros whyteana (Bladder-nut)
Syzigium cordatum (Waterberry)
Maerua caffra (Common bush-cherry)
Grewia lasiocarpa (Forest raisin)
Pavetta lanceolata (Forest brides bush)

5.4 ZONE C, SEGMENT 4, REACHES 7 - 9

5.4.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	C	C
Fish	F	C/E
Invertebrates	F	E
OVERALL	D/E	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

The channel can be basically left as it is. The most recent flood has scoured a good conduit for the removal of extremely high flows. This flood channel needs to be kept open while the banks need to be stabilised with indigenous vegetation. No large scale engineering should be carried out in this section until an assessment has been made of upstream mitigation.

VEGETATION

This area is in the process of improving, particularly the condition of vegetation on the actual stream banks, with species such as *Anisodonta*, *Grewia occidentalis* and *Tecomaria* returning along the length of this reach. However, there is little recruitment of indigenous plants taking place beyond the narrow strip along the stream banks, due to the rigorous mowing of the whole of the bottom floodplain area. Stream banks are still over-steep in some sections and will require stabilization or terracing prior to revegetation. If it were possible to remove the fences across the river in this area (they are lifted out of position by high flows in any event), this area could, in time to come, become part of an extensive river corridor conservancy or recreational area between Chamberlain Rd and the North-East Expressway.

FISH

Barbus anopius could be restocked in this section. Smaller species of freshwater eel (*Anguilla mossambica*) will penetrate naturally from downstream. *Sandelia bainesii* may survive in this reach in water quality improves and physical habitat becomes suitable.

INVERTEBRATES

With improved water quality and additional streambank and marginal vegetation planted, it is likely that there would be a significant improvement in the

invertebrate diversity and ASPT in these reaches. Baetid and Caenid mayflies, Simuliid, Chironomid and Tabanid fly larvae, Aeshnid dragonflies, Hydropsychid caddisflies, Ancyloid snails, and Corixid bugs would be likely to colonise this area.

5.4.2 OVERALL GOAL FOR THE SEGMENT

The main goal in this segment is to improve the ecophysical condition and reinstate dynamic equilibrium of the river, effecting an increase in diversity and abundance of instream and riparian biota. Alongside this, the aesthetic value of the area is to be protected and maintained, through ongoing maintenance of the planted parkland with mixed indigenous and exotic areas for the use of the residents of the retirement complex. A boardwalk through the gardens of the complex, ending in a fragrance garden, is recommended for construction at some time in the future. The use of this parkland area for 'Art in the Park' and 'Concerts at the Park' is highly recommended.

5.4.3 OBJECTIVES AND PRIORITIES

Ojb.	ECOPHYSICAL	Pr.
Ea	Clear alien vegetation and replant with a mix of appropriate indigenous and non-invasive ornamental species.	1
Eb	Optimise marginal vegetation habitat in both reaches, and control exotic reed (<i>Arundo donax</i>) encroachment in Reach 8.	2
Ec	Reduce the impact of cross-channel sewage pipelines on upstream hydraulic and physical habitat diversity.	3
Ed	Naturalise riparian vegetation (see generic objectives, Chapter 3).	4
Ef	Enhance water quality (see generic objectives, Chapter 3).	4
	INFRASTRUCTURAL	
Ia	Minimise areas which are likely to become flow blockages during high flow and flood events.	1
	SOCIAL/ EDUCATIONAL /RECREATIONAL	
Ra	Create a path or boardwalk leading through the parkland areas to a fragrant garden for the residents of the Berea Gardens Valley Complex. This should be accessible to those who are wheelchair-bound, disabled, or sight-impaired.	1

Where Obj = Objective and Pr = Priority

5.4.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	This applies particularly to the left bank at the upper end of Reach 7. Replant this area with appropriate indigenous riparian species. Mature specimens of invasive trees are possibly to be killed standing once the newly planted indigenous trees have become more mature. Recruitment of new invader plants is to be controlled.
Eb	Wherever possible create small 'pockets' of non-invasive marginal vegetation (e.g. <i>Cyperus spp</i> , <i>Juncus spp</i> , <i>Zantedeschia spp</i> , <i>Isolepis spp</i>), if possible with high filtration capacity. The creation of vegetation berms (Design 7, Appendix 5) may be considered. Develop a management plan for the control of reed encroachment in Reach 8.
Ec	Investigate the functionality of the two concrete-encased pipes crossing the channel at the upper end of Reach 7. If possible, remove one or both of these. Failing this, ensure that flow-through is improved, by creating a notch in the concrete casing as discussed for previous pipe-crossings.
	INFRASTRUCTURAL
Ia	At present, the concrete palisade fencing and the multiple culverts in the river crossing at the lower end of Reach 7 both serve as potential areas of debris blockage during high flows and floods. This is likely to result in backup of flow during high flow events, which threatens infrastructure. It is recommended that the removal of both structures be considered, as they do not appear to be serving any purpose at present. At a minimum however, stabilise banks both upstream and downstream of this structure, as proposed in Reach 6 (Design 6, Appendix 5).
	SOCIAL/ EDUCATIONAL /RECREATIONAL
Ra	Continue the boardwalk such that it leads to a fragrant garden and "braille trail" in the grove on the right bank of lower Reach 7 (Design 8a). This has been conceptualised along similar lines to the fragrant garden created in Kirstenbosch Gardens (Designs 8). Ensure that both the boardwalk and the raised garden are located raised above the 1974 floodlines.

5.4.5 DESIGN REQUIREMENTS

Obj.	DESIGN
Eb	DESIGN 7: Vegetation Berms
Ia	DESIGN 5: Stabilisation of banks upstream and downstream of impacts.

Obj	Design
Sa	DESIGN 8: Boardwalk pathway and Fragrant Garden. A Fragrant Garden typically features plants with aromatic properties and unusual textures. The plants are grown in waist-high, raised beds to enable visitors to touch them, feel them and smell them. Since this garden has been designed to highlight the interesting scent and texture properties of plants, a special effort has been made to enhance the experience for the sight impaired visitor. The Fragrance Garden is surrounded by a guard rail and contains plant information labels in large print, as well as braille.

5.5 ZONE C, SEGMENT 5, REACHES 10 – 12

5.5.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	E	D
Fish	F	D
Invertebrates	E	D
OVERALL	E	D

Where PES is Present Ecological State class and FAS is Future Attainable State class

FLOOD MITIGATION

The Stormwater Management plan for the Ihlanza catchment (Ninham Shand 1991) refers to the fact that the river channel in this zone has a small discharge capacity and is restricted by a number of bridges. As flooding has occurred along this reach on a number of occasions, causing damage to properties and infrastructure, a number of recommendations are made to address the capacity of this section of the river. One recommendation is to reduce the discharge capacity of the NEX (North-East Expressway) culvert, thereby causing a restriction during flooding which would result in a backup of flow upstream of the NEX (in Reach 9), after which the flood would gradually be released downstream.

As the specialist team on this project has proposed that a flood detention system be developed further upstream in Reach 2, it is unlikely to be necessary to create a second one in this area. However, the further recommendation in the report for flood protection is that the channel in this reach be enlarged through terracing, to provide additional flood capacity (Ninham Shand 1991). This measure would combine well with the objectives and rehabilitation measures recommended for the river in this zone, and could serve to improve the bank stability, riparian function, river-floodplain connectivity, and visual access to the river. The report goes on to recommend that an economic value be attached to the reduction of flood levels between NEX and Galway Road, and that an economic optimisation be performed of the benefits of implementing the recommended measures.

GEOMORPHOLOGY

Maintain the river in its present state. There is a need to stabilise banks to prevent further widening and reduce sediment production and vegetation loss. There are few options for improving habitat.

A possible rehabilitation option in this segment is the landscaping of banks to a gentler slope. This reduces the safety risk in this section, and will allow people

walking along the banks to feel more in touch with the river. Indigenous trees of various heights could be planted to fringe and shade this new channel.

VEGETATION

The low rate of recruitment of new indigenous woody species, unchecked erosion and use of plant material in Reach 10 indicates that this reach is in a state of decline. Reach 12 is in a slightly better condition than Reach 10 as regards erosion and vegetation, and one is inclined to say that this reach might regenerate itself without intervention, were it not for the presence and recruitment of alien vegetation, litter and pollution and use of plants for wood. The desired future state for this segment would be an aesthetically pleasing and safe public access with a more intact ecosystem and improved habitat.

Interrupted views underneath the canopy so that it remains still relatively safe for walking, as it is used frequently as a thoroughfare for schoolchildren. Indigenous trees (*Schotia brachypetala*, *Ficus sur* and *Cordia alliodora* would have occurred here naturally) should be planted at intervals along the length of the river bank to provide more shade and canopy cover, while creating habitat for wildlife.

FISH

In these reaches it is likely to be possible to restock *Barbus anoplus* and *Sandelia bainsii*, provided rehabilitation of physical habitat and water quality is successful. It is also probable that the freshwater eel (*Anguilla mossambica*) and possibly freshwater mullet (*Myxus capensis*) will penetrate naturally from downstream if barriers to upstream fish passage are removed.

INVERTEBRATES

An improvement in the water quality and bank stabilisation, and measures to address the lack of marginal vegetation in this segment would improve the diversity and sensitivity of the invertebrate community. Caddisflies would be expected (even if only Hydropsychids), and a greater diversity of mayflies, dragonfly and damselfly larvae, true bugs, and beetles would be likely.

5.5.2 OVERALL GOAL FOR THE SEGMENT

In this section, Zone C, the river runs mostly through a corridor of Public Open Space (Plates 10.1 – 17.3). There is easy access to the bankside areas for all riverside residents and the larger community. For these reasons, this area has been prioritised for both ecological rehabilitation and recreational use. The concept plan is for a "River Health Park" which stretches from Reach 10 to Reach 17 (Galway Road), and comprises walking and cycling paths and other amenities.

The goal is that this section of the catchment is transformed into a green corridor that the city can be proud of. Ideally, the public should perceive the River Health

Park as an asset to the area and a boost to their property values. River condition should be improved to sufficiently to increase the diversity of instream and riparian biota, such that the Ihlanza becomes a 'healthy' system.

The River Park area will raise public awareness of urban river processes, functions and roles, and how to restrict the impacts on these systems. Ideally, each segment in this zone should be adopted and maintained by a school, as in the case of the lowest segment, which has been adopted by Selborne Primary School Grade 7s.

OBJECTIVES AND PRIORITIES FOR THE REACH

Obj	ECOPHYSICAL	Pr.
Ea	Increase the connectivity between channel and floodplain.	1
Eb	Naturalise bankside vegetation (see generic objectives, Chapter 3).	2
INFRASTRUCTURAL		
Ia	Reduce sediment input to the river during storms.	1
Ib	Address the drainage of swimming pool water into the river.	2
SOCIAL/ EDUCATIONAL /RECREATIONAL		
Sa	This uppermost area of Zone C is prioritised for open-access and creation of a 'River Health Park' as a public amenity and an awareness-raising exercise. Initially the idea is to provide walking and bike pathways with semi-indigenous parkland for the length of this zone (North-East Expressway down to Galway Road). Gradually, the building of other recreational and sporting facilities, including an 'environmentally friendly' skateboard park (Design 8b), is recommended.	1
Sb	The 'dual tread' pathway recommended for construction in these and the lower reaches (Design 11) would provide a safe and natural conduit through the suburbs of Nahoon and Stirling for walkers, runners and cyclists. It would be necessary to ensure optimal public safety both in terms of contact with the river (water quality) and in terms of personal safety. It is thus critical that this plan be developed in collaboration with the riverside community and BCM City Police, and that it be implemented only if a satisfactory low-risk security plan (e.g. horse or bike patrols) can be devised alongside it.	2
Sc	Create visual access to the channel.	3
Sb	In the longer-term, provide safe recreational/sport type facilities for youngsters.	4

Where Obj = Objective and Pr = Priority

5.5.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	This objective can be addressed by implementing measures to raise the bed level, lower the overall gradient of the reach, and in so doing, raise the water table of the river and create greater connectivity between the channel and floodplain. A simple means of achieving this is to construct a series of low, notched full-width gabion or log weirs at intervals along the channel in Reaches 10 and 11 (as illustrated in Designs 9a-c). This will result in a 'string of cascades' and a series of pools through the upper parts of this segment. The notch in the weir allows for low flows to pass over the weir, and siltation will gradually occur on the upstream side of the weir. This measure, together with terracing of the channel on both banks (to provide a high flow area during floods) will over a period of several years address the lowered bed level in this segment. It will also have the overall effect of slowing velocities in this reach, which should reduce the effects of headcuts moving up the stream from Reach 13. Connectivity between the floodplain and the channel will be improved, the flood capacity of the channel increased, and visual access to the river improved. It is critical that the final design of these structures is informed by specialist hydrologists and hydraulicians. Low gradient (1:10) rockramps are required on the downstream end of each weir, to enable fish or eel migration in an upstream direction (as shown in Design 9c).
Eb	Planting of selected indigenous trees to provide approximately 20% cover is recommended. A planting plan is required and should be developed in consultation with the designer of the dual tread pathway. Selective pruning of current bankside trees will enhance visibility.
INFRASTRUCTURAL	
Ia	Transform stormwater canals into grassy swales as shown in Design 10. These are gently sloped, vegetated conveyance ditches in which pollutants are removed from stormwater by filtration through grass and infiltration into the soil. Increase the arc angle of the present stormwater trenches (in cross-section). Line the new drainage lines with coarse gravels, and cover with topsoil. Plant Buffalo grass or an indigenous equivalent and keep well watered until vegetation is established. Stabilise both banks of the lower end of the swale (Design 5).
Ib	BCM officials to address the drainage of swimming pool water into the river with relevant riverside residents.

Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL
Sa	The recommendation is for the construction of a dual tread pathway from Reach 10 to Reach 17 (as illustrated in Design 11 and Maps 5.10 to 5.17). This path should accommodate walkers, cyclists and runners. Ideally this would eventually be a circuit, but initially it is planned for the right bank only. At least the cycle lane of this pathway should be constructed from semi-permeable materials to ensure infiltration of rainwater. In Reach 10, the path should link to the footpath already trodden into the right bank. From the footbridge the pathway should meander at a distance of 10m or more from the river's edge, along the right bank, towards Drake Road. Pedestrian crossings in the form of either road markings or bridges over Schulz and Drake Road are recommended as an added urban feature and safety measure. A low railing on the north (left) side of the path, separating walking and cycle lanes should be provided for small children and elderly folk. The cycle lane on the left should be clearly demarcated. At intervals of 100-200m, benches are recommended. These could possibly be sponsored either by individuals or companies. At intervals of 150m, wooden bins (slot-entry) are required. Planting of indigenous trees is encouraged in this riverside area, with the proviso that there is an 80-100% clear view through these trees for safety purposes.
Sb	The path should ideally be lighted. The informal dwellers at the top end of Reach 10 should be relocated, and if possible included in some way in this rehabilitation plan.
Sc	Once sedimentation has occurred upstream of the low weirs, terrace and plant the right bank in Reaches 10 and 11 to create greater flood capacity and to create visual access to the river from the recreational bankside areas.
Sb	Children living in this area have listed, as one of their objectives for the improvement of the river corridor, the provision of a skateboard park close to a cycling path along the river. This suggestion has been endorsed by a number of parents, but has not been put to the vote of residents. It is recommended that an environmentally friendly skateboard park be designed and situated at the upper end of Reach 10, well outside of the floodline. A conceptual plan for this amenity is provided in Design 11a. This is, however, only an option if the problem of vagrants in this area is conclusively dealt with.

5.5.5 DESIGN REQUIREMENTS

Ea	DESIGN 9 a-c: Gabion, log and rock weirs. There are a number of conceptual designs which would be appropriate. The choice of design will depend on the costs involved. An illustration of a rock ramp downstream of fishway is provided in Design 9c.
la	DESIGN 10: Grassy swale.
Sa	DESIGN 11: Dual tread pathway for the River Health Park. DESIGN 11a: Skateboard Park.

5.6 ZONE C, SEGMENT 6, REACHES 13 & 14

5.6.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	F	D
Riparian Vegetation	D/E	C
Fish	F	D
Invertebrates	D	C
OVERALL	E	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

This section of the river could be improved to a D class by removing the canal and landscaping a new river channel. Banks would need to be stabilised with large trees in the new (wider) channel. Realistically, however, it is unlikely that the canal will be removed, as it will be considered a low priority overall. The focus should then be on the management of river instability problems, some of which will be sorted out by upstream flood management.

VEGETATION

As with Segment 5, this segment could attain an improved ecological and aesthetic state if diversity of the riparian zone species were increased. Natural riparian recovery could be encouraged by eliminating the causes of degradation.

FISH

It is possible to restock *Barbus anoplus* and *Sandelia bairdii* in this segment, provided rehabilitation of physical habitat and water quality is successful. If fish passage is continuous from lower reaches, it is likely that the freshwater eel (*Anguilla mossambica*) and possibly the freshwater mullet (*Myxus capensis*) could penetrate naturally from downstream.

INVERTEBRATES

To raise the PES one level, from class F to class E, requires an improvement in the SASS5 scores from present (Total 28, ASPT 4.7) to a Total Score between 30 and 60, and a variable ASPT variable (Thirion in prep., specialist knowledge). This is possible if water quality is addressed and marginal vegetation habitat is

supplemented. Over the longer term, it is likely possible to raise the class to a D if generic objectives (Chapter 3) are met.

5.6.2 OVERALL GOAL FOR THE SEGMENT

The overall goal for Zone C is presented in Section 5.5.

5.6.3 OBJECTIVES AND PRIORITIES FOR THE REACH

Ojb.	ECOPHYSICAL	Pr.
Ea	Improve the linkage between the channel and floodplain in this segment.	1
Eb	Increase diversity of bankside and riparian vegetation on left and right banks.	2
Ec	Reduce sedimentation and water pollution.	3
Ed	Increase instream habitat diversity where possible in Reach 13 (concrete canal) and Reach 14 (pool downstream of canal). Create pockets of marginal vegetation in Reaches 14 and 15.	4
Ee	Contingent on water quality improvement, restock <i>Barbus anoplus</i> and <i>Sandelia bairdii</i> in this segment.	
Obj.	INFRASTRUCTURAL	Pr.
Ia	Address and minimise disturbance caused to the river banks and channel by building operations on the left bank in Reach 13.	1
Ib	Address water quality issues (see generic objectives, Chapter 3).	2
Obj.	INFRASTRUCTURAL	Pr.
Ic	Ensure that stormwater canal sides in Reach 13 are checked, adequately stabilised, backfilled where necessary, and backfill areas are planted. Stabilise scoured banks immediately downstream of the stormwater canal in Reach 13 (Designs 2 or 5, Appendix 5).	3
Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL	Pr.
Sa	Ensure that security in this river segment is prioritised for recreational purposes.	1
Sb	Continue the development of the River Health Park through this section.	2
Sc	Create a 'trim' park exercise area on the far right bank of the river, adjacent to Roslin Road.	3

Where Obj = Objective and Pr = Priority

5.6.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Terrace the right bank of the river in Reach 14, downstream of the scour pool, as appropriate, to improve the linkage between the channel and the banks/floodplain, and to increase visibility of the river. Ensure that the lowest terrace is inundated with at least 10 cm water such that it can be planted to form a vegetation berm (Design 7, Appendix 5). Plant the unwetted terraces with appropriate indigenous vegetation to stabilise.
Eb	Plant both banks and adjacent Public Open Space areas with indigenous vegetation, according to a specialist planting plan.
Ec	See Measure 1b. Where possible in Reach 14, create 'pockets' of marginal vegetation, following Design 7.
Ed	The increase of habitat by the addition of embedded riprap in Reach 13 must be designed in consultation with hydraulic specialists and hydrologists, as this will have the effect of increasing hydraulic resistance and thus reducing the velocity of high flows and floods. This could have upstream impacts. This measure is only beneficial if it does not increase the threat of flood damage. The benefits include slowing of flow in the upper reaches relative to the present situation, where the canal is designed to increase flow velocity and results in consequent acceleration of upstream flows, with erosional effects on the upstream earth channel.
Ee	The consideration and planning of the restocking of <i>Barbus anoplus</i> and <i>Sandelia bairdii</i> is contingent on improved water quality. If this should become a reality, these actions should be preceded by at least a full season's water quality monitoring, to ensure suitable conditions for these fish. Fish specialists should be integral to this planning, particularly with regard to <i>S. bairdii</i> stocking, to ensure that the correct breeding and other habitats are available instream, and that timing of the stocking is appropriate to life-cycle stages of the species.
Obj.	INFRASTRUCTURAL
Ia	Update the 1:50 year floodlines. Discuss with relevant stakeholders the possible revision of local bylaws, such that developments are disallowed below the 1:50 year floodline, or within a specified buffer distance from the channel (this to be determined in consultation with river and riparian specialists). Consider regulations to ensure compliance with the National Water Act Section (No. 36 of 1998) regarding interventions in the channel.
Ib	Address sediment inputs as per generic measures (Chapter 5). In particular, transform drainage channels into grassy swales (Design 10).
Ic	Apply an appropriate bank-stabilisation option on both banks to address the scour downstream of the concrete canal (e.g. Design 5).

Obj.	SOCIAL / EDUCATIONAL / RECREATIONAL
Sa	BCM to remove all unsafe playground equipment on the right bank. Visibility to be maintained across banks and through channel by clearing of dense vegetation and selective pruning where appropriate. Encourage the implementation of regular foot, cycle or horse patrols in consultation with BCM.
Sb	Continuation of 'River Health Park' dual tread path construction and maintenance.
Sc	Develop a 'fitness' park along the same design lines as those used for trim parks nationally and internationally.

5.6.5 DESIGNS REQUIRED

All conceptual designs are presented in Appendix 5.

Obj.	DESIGN
Ec	DESIGN 7: Vegetation berms
Ed	DESIGN 12: Embedded riprap to be overlaid on areas of the canal
Ib	DESIGN 10: Grassy swales
Ic	DESIGN 5/5a: Bank stabilisation in areas of scour
Sa	DESIGN 11: Dual Tread Pathway for River Health Park
Sb	DESIGNS 13a & b. Fitness Park

5.7 ZONE C, SEGMENT 7, REACHES 15 – 17

5.7.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	D	C
Fish	F	C
Invertebrates	E	D
OVERALL	D/E	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

This segment should remain a D class, however there are likely to be further problems (change) related to the construction of flood levees on the left bank (upper end of Reach 15). Floods that naturally overtop the channel banks will be forced on to the right side and could cause scour on this bank, while also serving as a flood threat to residents in Roslin Road. Alternatively, if flood flows are restricted to the channel, this will cause increased velocity, erosion, headcuts etc.

This segment of the river could be rehabilitated relatively easily by some landscape modifications. The channel could be transformed by terracing into a compound feature (channel within a channel). The shallower channel is then designed to allow the natural modification of the bed and banks for the frequent low-flow conditions. The larger, deeper channel (high flow channel) is molded into the surrounding flood plain, through terracing, i.e. gently sloping banks and planting appropriate trees on the margins (for stability). (Note that this has not been included as a recommended rehabilitation measure until further hydrological information is available).

VEGETATION

Invasion of alien plant species is occurring at a higher rate than recruitment of indigenous plants, and this site will require management to prevent it from degrading further. With additional planting of appropriate species and the creation of greater heterogeneity, the riparian vegetation condition is likely to improve to a class C.

FISH

Barbus anoplus and *Sandelia bainesii* could be stocked in these reaches, provided the rehabilitation of physical habitat and water quality were successful. It is likely that the freshwater eel (*Anguilla mossambica*) and possibly the freshwater mullet *Myxus capensis* would penetrate naturally from downstream.

INVERTEBRATES

If the objectives of improving water quality and creating pockets of marginal vegetation in this segment are realised, a more diverse and sensitive invertebrate faunal community would result. The addition of 2 to 3 more taxa with scores of 3-5 would raise the Total SASS score sufficiently to elevate the condition class to a D.

5.7.2 OVERALL GOAL FOR THE SEGMENT

The overall goal for Zone C is presented in Section 5.5.

5.7.3 OBJECTIVES AND PRIORITIES FOR THE SEGMENT

No.	ECOPHYSICAL	Pr.
Ea	Improve instream habitat quality.	1
Eb	Stabilise banks as appropriate (lower end Reach 15, upper and lower end Reach 16).	2
Ec	Naturalise bankside and riparian vegetation (see generic objectives, Chapter 3).	3
INFRASTRUCTURAL		
Ia	Address the present clearing, dumping and building operations and levee creation on the left bank in Reach 15.	1
Ib	Reduce sedimentation and pollution (see generic objectives, Chapter 3).	2
Ic	Attend to present dumping of building material on streambanks and in channel.	3
SOCIAL/ EDUCATIONAL /RECREATIONAL		
Sa	Continue of the River Health Park along the right bank of the river.	1
Sb	Ensure safety for social /educational/recreational users.	2

Where Obj = Objective and Pr = Priority

5.7.5 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Clear all building rubble and litter from the channel. Maintain the channel clear of litter.
Eb	Consult with bioengineering specialists regarding an appropriate method for bank stabilisation (see Design 2). Where appropriate, realign logs and branches in the river to divert stream flow away from unstable banks, and provide bank armoring.
Ec	Clear invasive alien reeds from the right bank in lower Reach 17. Plant indigenous trees and shrubs at intervals along the length of the river bank to provide shade and create habitat for wildlife. Manage vegetation maintenance in a manner that allows selective recruitment of indigenous riparian species. Monitor and control recruitment of alien plants.
INFRASTRUCTURAL	
Ia	As building permission has already been granted to the developer, addressing the issues associated with the development would require careful handling. BCM as the authority who granted permission for development are likely the best people to intervene on behalf of the project.
Ib	Specifically, transform present stormwater trenches to grassed swales.
Ic	BCM and riverside community members to take the relevant residents to task about dumping. This sort of issue should be raised at rate payers meetings.
RECREATIONAL	
Sa	Continuation of dual tread path construction and River Health Park (Maps 5.15-17). The upper portion of Reach 17 is an attractive section of the river and 2-3 seating benches should be placed here.
Sb	Visibility to be maintained across the river banks and through the channel by clearing of dense vegetation. Regular foot, cycle or horse patrols to be instituted.

5.7.6 DESIGN REQUIREMENTS

Obj.	DESIGN
Ib	DESIGN 10: Grassy swales
Sa	DESIGN 11: Dual tread path

5.8 ZONE D, SEGMENT 8, REACHES 18 & 19

5.8.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	D	C
Fish	F	D
Invertebrates	E	D
OVERALL	D/E	D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

The river is likely to remain within the same class in this segment, as local residents seem committed to looking after the river. There is a need for bank stabilisation of the newly widened channel, and this is occurring to some extent with the planting of large indigenous trees on the banks and in the riparian zone by local residents. If this segment is maintained the in-channel sediments will be re-distributed naturally to form new bed forms.

VEGETATION

This area is in a state of degeneration in terms of vegetation. However, as already noted, the Galway Road Residents Group is making progress with addressing this problem. If all objectives are met, the riparian vegetation condition would improve markedly within a fairly short space of time. The area from here to Reach 24 has the potential to be a conservancy type area that could adjoin the proposed Nahoon Nature Reserve.

FISH

It would be possible to restock *Barbus anoplus* and *Sandelia bainesii*, provided water quality improvement were successful. Freshwater eels (*Anguilla mossambica* and *Anguilla marmorata*) and possibly freshwater mullet (*Myxus capensis*), as well as the other catadromous species that should be present in this region in the natural state should penetrate naturally from downstream once habitat improves. Mozambique tilapia (*Oreochromis mossambicus*) should also be present.

INVERTEBRATES

Improved water quality and the presence of pockets of marginal vegetation in this segment would ensure a more diverse and sensitive invertebrate faunal

community. The addition of 2 to 3 more taxa with sensitivity scores of >3 would raise the Total SASS Score sufficiently to elevate the condition class to a D.

5.8.2 OVERALL GOAL FOR THE SEGMENT

The vision in Segment 8 (and the whole of Zone D) is that the river banks be naturalised and ecological function be reinstated successfully in the riparian corridor and river channel. The diversity and abundance of biota (fish, invertebrates and birds) is expected to increase as this occurs. It is likely that public access to this section will remain limited, and that the home-owners along this reach will become the 'custodians' of the river and banks. A great deal of work has already been done, with specialist input, to clear aliens and revegetate the banks with diverse, appropriate riparian taxa. Measures to enhance the overall dynamic equilibrium in this reach are possible and likely within the next two to five years.

5.8.3 OBJECTIVES AND PRIORITIES

Obj.	ECOPHYSICAL	Pr.
Ea	Reduce bank instability in all three reaches. Use this opportunity to create fish and invertebrate habitat.	1
Eb	Increase habitat heterogeneity and quality.	2
Ec	Naturalise bankside and riparian vegetation (see generic objectives, Chapter 3).	3
Ed	Reduce flow back ups and restriction, reduce pool stagnancy in sections.	4
	INFRASTRUCTURAL	
Ia	Reduce sedimentation and pollution (see generic objectives, Chapter 3).	1
Ib	Address present dumping on streambanks and in channel (see generic objectives, Chapter 3).	1
	SOCIAL/ EDUCATIONAL /RECREATIONAL	
Sa	Continue the liaison and interaction with the Galway Road Residents Group, regarding their clearing and replanting operations on the banks in this section.	1
Sb	Limit public access in this area at least in the short-term.	2

Where Obj = Objective and Pr = Priority

5.8.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Reach 18: Stabilise steep left bank at the top of the reach, address left bank scour downstream of the pipebridge; partially remove tree block at lower end of reach; stabilise and replant the eroded left bank upstream of the present tree block (Map 5.18, Designs 2 and 5). Reach 19: Stabilise areas where bank collapse is presently occurring (Map 5.19, Designs 2 and 5). Reach 20: Reduce slope of the steep right bank at the top of the reach alongside the pool, particularly where bank collapse is occurring (Map 5.20, Designs 2 and 5). Install artificial fish shelters along the pools in Reaches 19 and 20, or where areas of scour already exist, as part of this stabilisation operation (Designs 14a-c).
Eb	Remove all building rubble from the channel. Create vegetation berms at appropriate intervals (Design 7) using relevant marginal vegetation species.
Ec	Maintain Reach 18 clear of invasive alien reeds (left bank). Plant low shrubs and appropriate forbs and ensure visibility in this section. In Reach 19, work with local homeowners on bankside properties to ensure that clearing and removal of alien vegetation is done correctly, and that fast-growing indigenous trees and shrubs are planted. Encourage adjacent property owners to participate in a long-term weed control program
Ed	Clear flow path in middle and lower end of Reach 18 by partial removal of tree blocks in channel.
Obj.	INFRASTRUCTURAL
Ia	Address leakage in pipe bridge over river (mid Reach 18, Plate 18.3). Transform present stormwater drainage channels to grassy swales (Design 10).
Ib	BCM and riverside community members to take other residents to task about dumping. Clear all building rubble from the channel.

Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL
Sa	Work with the Galway Road Residents and BCM to continue the clearing and replanting (naturalisation) of the riparian buffer strip. Encourage the maintenance of Public Open Space, and the removal of fencelines through this corridor. Devise, with the community, a longer-term programme for the ongoing maintenance and management of this segment.
Sb	This requires no specific action, as public access is already restricted due to the configuration of the urban areas.

5.8.5 DESIGNS REQUIRED

Obj.	DESIGN
Ea	DESIGNS 2 and 5: Bank stabilisation measures DESIGN 14 a-c Fish Shelters
Eb	DESIGN 7: Vegetation berms
Ia	DESIGN 10: Grassy swales

5.9 ZONE D, SEGMENT 8, REACHES 20 – 22

5.9.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	D	C
Fish	F	D
Invertebrates	E	D
OVERALL	D/E	D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

The river is likely to remain within the same class in this segment as local residents seem committed to looking after the river. There is a need for bank stabilisation of the new widened channel, this is occurring with the planting of indigenous trees. If this segment is maintained, the in-channel sediments will be re-distributed naturally to form new bed forms.

VEGETATION

The area from here down to Reach 24 has the potential to be a conservancy type area that could adjoin the proposed Nahoon Nature Reserve.

FISH

Barbus anoplius and *Sandelia bainesii* could be restocked, provided water quality improvement were successful. Freshwater eels (*Anguilla mossambica* and *Anguilla marmorata*) and possibly freshwater mullet (*Myxus capensis*), as well as the other catadromous species that should be present in this region in the natural state should penetrate naturally from downstream once habitat improves. Mozambique tilapia (*Oreochromis mossambicus*) should also be present.

INVERTEBRATES

In the event that the in-channel sediments were redistributed, new bedforms resulted, portions of the silt-covered cobble and rock were exposed, and leafy marginal vegetation were planted, it is likely that a more diverse invertebrate community would gradually colonise this segment. The community would be expected to include a more diverse age structure, more sensitive and diverse

mayflies (e.g. Leptophlebiids, Heptageniids), a number of Odonate taxa (at a minimum Aeshnids, Gomphids, Coenagrionids, Libellulids); abundant and diverse Hemipteran bugs (particularly corixids, Notonectids, Plekids) and numerous beetle species (e.g. Dytiscids, Gyrinids, Hydraenids, Elmids)

5.9.2 OVERALL GOAL FOR THE SEGMENT

The overall goal for Zone D is recorded in Section 5.8.

5.9.3 OBJECTIVES AND PRIORITIES FOR THE REACH

Obj	ECOPHYSICAL	Pr.
Ea	Clear and stabilise the alien-invaded left bank at the upper end of Reach 21.	
Eb	Increase instream physical and hydraulic habitat.	
INFRASTRUCTURAL		
Ia	Reduce sediment inputs to the river from the left bank in particular. Reduce point source and non-point source pollution.	1
Ib	Put a halt to piped inputs to river from swimming pools.	2
Ic	Clear dumped material on streambanks and in channel.	3
Obj	SOCIAL/ EDUCATIONAL /RECREATIONAL	
Sa	Contingent on meeting Objective Ia, create a mountain bike trail along the sewerage servitude line at the top of the left bank.	1

Where Obj = Objective and Pr = Priority

5.9.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Clear alien vegetation from the left bank at the top end of Reach 21. This left bank is sandy, steep and highly erodible. Once cleared it will be increasingly unstable and will require both structural stabilisation and replanting. The use of a brushmattress technique (Design 15) for stabilisation may be a good starting point for the property owners and others in the area to learn about soil bioengineering approaches to bank stabilisation. Indigenous cuttings, pole plantings and live stakes (possibly <i>Salix mucronata</i>) should be used together with geotextile and cobble/boulder gathered from nearby sources.
Eb	Physical and hydraulic diversity could be increased in mid-Reach 22 by a number of methods. Firstly the partial removal of the large tree blocks in this section will increase velocity through the channel and scour some of the deposited sediment. Secondly, approximately 20m downstream of the bend in upper Reach 22, the placement of a flow deflector (Design 16) would have the effect of slightly narrowing the channel, increasing local velocity, scouring part of the extensive pool, increasing the diversity of flow types, oxygenating the water, and creating silt bars (Cowx and Welcomme 1998). The overall effect would be an increase in physical and hydraulic habitat in this reach. Downstream of the flow deflector in mid Reach 22, large angular boulders should be placed in the centre of the channel (see Design 17), where they will create additional hydraulic disturbance and produce localised bed scour, deposition, oxygenation, and surface area for invertebrate biota to colonise (e.g. Rutherford et al. 2000). The pattern of placement of these rocks may be varied.
Ia	The key focus in this and all downstream reaches is the upgrading of the sewerage line, servitude and stormwater input trenches. This represents an extensive project, but could link effectively with Social Objective Sa, which is the design of a bike trail along this servitude. This requires a number of actions. All sewage manhole covers should be replaced with polyconcrete covers, kept sealed, and checked weekly by patrol. They should be concealed by painting (green/brown) and growing of indigenous creepers over their sides. The extensive erosion and sediment delivery occurring from eroded areas around the stormwater drainage channels (e.g. Plate 23.3) should be addressed by backfilling, compacting and stabilising the areas around the affected pipelines, and transforming stormwater ditches to grassy swales with check dams (Design 10).

Obj.	INFRASTRUCTURAL
Ib	Pipes led from swimming pools into the river by local homeowners should be removed from the channel and redirected into the appropriate drainage system.
Ic	BCM and riverside community members to take responsible residents to task about dumping. Also clear all building rubble from the channel.
Obj.	SOCIAL/ EDUCATIONAL /RECREATIONAL
Sa	If Objective Ia can be met, consideration could be given to the creation of a mountain bike trail along the sewage servitude on the top of the left bank of the river. This is seen to be a longer-term plan and possibility. If it is realised in time, all manholes in the servitude would require lockable manhole covers and should be camouflaged either using paint or covering with plants. The track surface would ideally be created from appropriately-sized woodchips (20cm compacted) which would prevent growth of alien vegetation along this cleared area. It would be necessary to do selective pruning of the vegetation on both the downslope and upslope, on an ongoing basis, to clear sufficient branches to ensure at least 10m visibility in all directions, for security reasons. Security measures or entry fees would be required.

5.9.5 DESIGNS REQUIRED

Obj	DESIGN
Ea	DESIGN 15: Brushmattress technique
Eb	DESIGN 16: Flow deflectors DESIGN 17: Angular rocks in the channel
Ec	DESIGN 10: Grassy Swales

5.10 ZONE D, SEGMENT 8, REACHES 23 & 24

5.10.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	D	D
Riparian Vegetation	E	C
Fish	F	D
Invertebrates	E	D
OVERALL	E/F	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

The river is likely to remain within the same class in this segment as local residents seem committed to looking after the river. There is a need for bank stabilisation of the new widened channel, this is occurring with the planting of large indigenous trees. If this segment is maintained, the in-channel sediments will be re-distributed naturally and new bed forms will result.

VEGETATION

The site is now adjacent to the Nahoon Point Golf Driving Range, which was created atop the former refuse site. The current tenant has intimated that he would like to extend his property to include a Mashee golf course, tea garden and nature area with limited access down to the river. Since it is preferable not to disturb areas downstream, it is proposed that this area be developed conservatively along these lines, and that vegetation buffer zones of 30-50m be required. The proximity of James Pearce Park which has other recreational facilities increases the suitability of this area for low-impact development as a recreational and conservation area.

FISH

It would be possible to restock *Barbus anoptus* and *Sandelia bainesii*, provided water quality improvement successful. Freshwater eels (*Anguilla mossambica* and *Anguilla marmorata*) and possibly freshwater mullet (*Myxus capensis*), as well as the other catadromous species that should be present in this region in the natural state (see above) should penetrate naturally from downstream once habitat improves. Mozambique tilapia (*Oreochromis mossambicus*) should also be present.

INVERTEBRATES

It is likely that with improved water quality, connectivity and the creation of small areas of stones in current, stones out of current and marginal vegetation, the invertebrate fauna could include a number of Dipteran fly larvae (Chironomids, Simuliids, Ceratopogonids, Tipulids), Ephemeroptera (Baetids, Caenids), Odonata (Coenagrionidae, Libellulidae, Gomphidae, Aeshnidae), Hemipteran bugs (Corixidae, Pleidae), Coleoptera (Dytiscidae, Gyrinidae), Gastropod snails (Ancyliids, Physids), crabs, freshwater prawns, and microcrustaceans. This would raise the SASS5 and ASPT scores significantly.

5.10.2 OVERALL GOAL FOR THE SEGMENT

The overall goal for Zone D is recorded in Section 5.8.

5.10.3 OBJECTIVES AND PRIORITIES FOR THE REACHES

No.	ECOPHYSICAL	Pr.
Ea	Prioritise these and all downstream reaches for protection of the riparian zone	1
Eb	Increase physical and hydraulic habitat diversity and quality.	2
Ec	Naturalise riparian area (see generic objectives, Chapter 3).	3
INFRASTRUCTURAL		
Ia	Reduce sediment inputs to the river from the left bank in particular. Reduce point source and non-point source pollution.	1
SOCIAL/ EDUCATIONAL /RECREATIONAL		
Sa	In the event of the mountainbike trail being considered possible, provide an access route to this trail from Epsom Road side by creating a boardwalk bridge above the overhead sewage pipe in Reach 23 (see routing in Maps 5.23 – 5.28).	1

Where Obj = Objective and Pr = Priority

5.10.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Incorporate this reach as indigenous parkland (preferably with conservation status) in the future planning of the Driving Range development. This area may have benches and a professionally-planned nature trail (see Objectives for Reaches 29 and 30).
Eb	In mid-Reach 23, the placing of large angular boulders in the centre of the channel (see Design 17), would create additional hydraulic disturbance and produce localised bed scour, deposition, oxygenation, and surface area for invertebrate biota to colonise (e.g. Rutherford et al. 2000). The pattern of placement of these rocks may be varied.
Ec	Clear the extensively invaded left and right banks. This should be organised as a community initiative, to link in with the activities of the upstream homeowners.
	INFRASTRUCTURAL
Ia	Continue activities recommended for Reaches 21 and 22.
	RECREATIONAL
Sa	This would require specialist design to ensure adequate structural strengthening of the pipebridge to cater for the construction of a boardwalk for mountain bikers. It would also require the construction of a stairway from this crossing up to the bike trail.

5.10.5 DESIGN REQUIREMENTS

Conceptual designs are presented in Appendix 5.

Obj.	DESIGN
Eb	DESIGN 17: Angular rocks in the channel
Sa	MOUNTAIN BIKE TRAIL (Routing shown in Maps 5.23-5.29, no design provided) <i>In the event that the objectives of clearing alien vegetation and upgrading the sewerage system have been achieved, and if agreed to by relevant authorities and adjacent homeowners: Design of a mountain-bike trail along the present sewerage servitude, from Reaches 22 to 29. Access to this trail would be limited for safety reasons. Ideally there would be some arrangement by which the trail would start within the Driving Range parkland area and would cross the river via the sewerage pipe-bridge at the end of Reach 23.</i>

5.11 ZONE E, SEGMENT 9, REACHES 25 & 26

5.11.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	B	B
Riparian Vegetation	C	B/C
Fish	F	B
Invertebrates	E	D
OVERALL	D	C

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

This segment of river should remain in its present state and could even improve within the class if upstream management is successful. There is a need to maintain the present inaccessibility and maintain the dense vegetation on steep hill slopes. Upstream erosion as a result of storm water runoff from roads needs to be managed

VEGETATION

The vegetation in the area from here down to the mouth should be flagged for 'Protected Area' status and incorporated into the proposed Nahoon Nature Reserve. A vegetation control and maintenance plan is required as a matter of urgency to afford this area the conservation protection it requires.

FISH

Provided water quality improvement was successful, *Barbus anoplus* and *Sandelia bainesii* could be restocked. Freshwater eels (*Anguilla mossambica* and *Anguilla marmorata*) and freshwater mullet (*Myxus capensis*), as well as the other catadromous fish and macrocrustacean species that should be present in this region in the natural state should penetrate naturally from downstream once habitat improves. Mozambique tilapia (*Oreochromis mossambicus*) should also be present.

INVERTEBRATES

In the event that water quality were improved, patches of marginal vegetation were planted, and flow connectivity was enhanced, the expected community would likely be dominated by Baetid, Caenid and Leptophlebiid mayflies, and Hydropsychid and Leptocerid caddisflies. Subdominant taxa would include, as in

the Natural state, collectors (Simuliid, Chironomid, Ceratopogonid, Tipulid and Tabanid Dipterans), herbivorous snails, Hemipteran bugs and beetles, and crustaceans including microcrustaceans. Predators would likely be present in low numbers (Coenagrionid, Libellulid, Aeshnid and Gomphid Odonates).

5.11.2 OVERALL GOAL FOR THE SEGMENT

A naturalised section of the river with riparian forest returned toward its likely pre-impact indigenous state, with diverse instream habitat including marginal vegetation on the fringes of shallow pools. Limited pathways and sitting areas in the indigenous parkland should be permitted in Reach 25, on the right bank (this would be the extension of the present Nahoon Point Driving Range).

5.11.3 OBJECTIVES AND PRIORITIES FOR THE REACH

Obj.	ECOPHYSICAL	Pr.
Ea	Protect all remaining indigenous riparian thicket (see generic objectives, Chapter 3).	1
Eb	Naturalise riparian vegetation throughout segment. See previous objectives regarding the development of the Mashee golf course.	2
Ec	Improve diversity of fish and invertebrate habitat in Reach 26.	3
Obj	INFRASTRUCTURAL	
Ia	Reduce sediment inputs to the river from the steep left bank in particular.	1
Ib	Modify the structure of (and clear debris from) the concrete-encased sewerage pipe across the channel in mid-Reach 25. A notch in this structure would facilitate a reduction in flow backup and stagnancy, and an increase in flow diversity and oxygenation in this reach.	2

Where Obj = Objective and Pr = Priority

Obj	SOCIAL/ EDUCATIONAL / RECREATIONAL	Pr
Sa	Objectives as for previous reaches regarding the development of the Mashee course and nature area. Access to the river downstream of Reach 26 should however be limited.	1
Sb	In the event of the mountain bike trail along the present sewer servitude being feasible, the trail would continue through Reaches 25 and 26.	2

Where Obj = Objective and Pr = Priority

5.11.4 SPECIFIC ACTIONS RECOMMENDED

Obj.	ECOPHYSICAL
Ea	The highest priority is to protect the remaining environmental assets in these reaches. The riparian thicket is relatively intact from Reach 26 downwards, and management measures should be put in place to maintain it in this condition and to clear and control any emerging alien vegetation patches. Discuss with the relevant city authorities the potential for acquiring some level of protection status for the river, from this segment down to the mouth. As already mentioned, the section from Reach 26 to the sea should be incorporated into the proposed Nahoon Nature Reserve (see Sections 5.11 and 5.12).
Eb	Clear all alien vegetation from left and right banks, and replant with appropriate indigenous vegetation. As this land is to be leased by the Nahoon Point Driving Range, all plans should be made in consultation with the tenants of the land, and the land-owners, BCM.
Ec	Construct fish shelters in Pool in Reach 26,27 (Design 14)
	INFRASTRUCTURAL
Ia	Continue activities recommended for Reaches 21 and 22 (see generic measures, Chapter 3).
Ib	Create a notch in the concrete-encased cross-channel sewerage pipeline to enable flow-through at low flow levels.
Obj	SOCIAL / EDUCATIONAL / RECREATIONAL
Sa	Participate wherever possible in the planning and development of the Mashee Golf course and ensure that the riparian buffer strip be kept as intact as possible, with a minimum width of 30m and a preferred width of 50m.
Sb	Continuation of the mountain bike trail using the sewerage servitude, as already discussed for Reaches 23 and 24.

5.11.5 DESIGN REQUIREMENTS

Obj.	DESIGN
Ec	DESIGN 14: Fish Shelters
Ia	DESIGN 10: Grassy Swales

5.12 ZONE E, SEGMENT 9, REACHES 27 & 28

5.12.1 PRESENT ECOLOGICAL STATE & FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	B	B
Riparian Vegetation	C	B
Fish	E/F	D
Invertebrates	E	D
OVERALL	D/E	C/D

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

This segment of river should remain in its present state and could even improve within the class if upstream management were successful. There is a need to maintain the present inaccessibility, and maintain the dense vegetation on steep hill slopes. Upstream erosion as a result of storm water runoff from roads needs to be managed.

VEGETATION

These are considered sites of botanical significance, where vegetation mostly constitutes an asset, and the trajectory of change is probably zero. However, alien encroachment from nearby upstream reaches is considered an increasing threat. The present state, complexity and diversity of riparian forest could be maintained if measures were taken to address upstream invaders, and the small areas of local invasion in these reaches. It is considered advisable to protect these areas from further degradation as they have the potential for incorporation into the proposed Nahoon Nature Reserve.

FISH

One could restock *Barbus anopius* and *Sandelia bainesii*, provided water quality improvement had been successful. Freshwater eels (*Anguilla mossambica* and *Anguilla marmorata*) and freshwater mullet (*Myxus capensis*) as well as the other catadromous fish and macrocrustacean species that should be present in this region in the natural state should penetrate naturally from downstream once habitat improves. Mozambique tilapia (*Oreochromis mossambicus*) should also be present.

INVERTEBRATES

The fauna of this reach could be improved to a class D, contingent on the improvement of upstream water quality, and the possible creation of small areas of marginal vegetation. Under these conditions, additional invertebrates expected to drift to this site from improved upstream reaches, or to colonise the reaches aerially, would include Caenid and Leptophlebiid mayflies, Leptocerid caddisflies, Simuliid, Chironomid, Tabanid and Ceratopogonid fly larvae, Ancyliid Snails, Corixid, Notonectid and Pleid hemipterans, Aeshnid, Gomphid and Coenagrionid dragonflies and Libellulid damselflies, Oligochaete worms, Potamonautid crabs, microcrustaceans, and Turbellarians.

5.12.2 OVERALL GOAL FOR THE SEGMENT

The goal is for a managed, protected and limited access riverine corridor area with Protected Area status, linked to the greater Nahoon Nature Reserve and serving as a source area for fauna and flora (including seeds) for the upper river. Access to the river should be limited in these two reaches.

5.12.3 OBJECTIVES AND PRIORITIES FOR THE REACH

Obj.	ECOPHYSICAL	Pr.
Ea	As discussed, the primary objective for this and the Segment 10 of the river is to have it incorporated into the proposed Nahoon Nature Reserve, which comprises a strip of mostly undeveloped land between the Nahoon River mouth and Eastern Beach. This would ensure protection of the remaining integrity of the remaining indigenous riparian vegetation, particularly in this area, and thus also protect the source area for biodiversity in both upstream reaches of the river and the adjacent beach and marine areas.	1
Eb	Protect indigenous riparian vegetation. Maintain a riparian buffer of minimum 30m-50m from channel edge (minimum 30m).	2
Ec	Increase the diversity of fish in this segment which is sufficiently close to ebb and flow to have a number of taxa (e.g. Moonies <i>Monodactylus falciformis</i> , Flathead Mullet <i>Mugil cephalus</i> , and the Goby <i>Glossogobius callidus</i>).	3

INFRASTRUCTURAL		
Ia	Reduce sediment inputs to the river from the steep left bank in particular (see generic objectives, Chapter 3).	1
SOCIAL/ EDUCATIONAL /RECREATIONAL		
Sa	Limit access to the river and the riparian buffer strip in these two reaches. in this area (the mountainbike trail would be sufficiently distant).	1

Where Obj = Objective and Pr = Priority

5.12.4 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	This process can only be undertaken as part of the larger initiative regarding the coastal conservation area. Motivation should be forwarded to the relevant roleplayers and where possible and appropriate, arguments or presentations made to back up this proposition. The key motivations are: that this short strip of forest serves as a source area for seeds for the riparian coastal dune forest, it is the southernmost known distribution for the Forest Mahogany (<i>Trichilia dregeana</i>), that it provides habitat and a natural corridor for uncommon birds (e.g. Knysna loerie) and animals (e.g. otter, water mongoose), and that it serves as a representative area of this type of this coastal dune forest in the East London area. It would be necessary to solicit public support for this objective via a public consultation process, and the use of articles in the press. In the event of the protection being achieved, measures should be taken to draw up a plan for the ongoing management, maintenance and monitoring of both the floral and faunal diversity in this section of the river.
Eb	The construction of a Mashee golf course along the right bank of the river in Reach 27 should be dealt with sensitively, as already discussed. The tenant should be responsible for clearing all exotic vegetation from within the property, under the supervision of a specialist horticulturist. All plants removed should be cared for in the BCM nursery.
Ec	Create artificial fish habitat in the form of fish shelters or rocky overhangs in the sand-bed pools in Reaches 27 and 28, following an appropriate design as agreed with fish biologists (see Design 14). If considered appropriate habitat, stock these pools with small numbers of <i>Sandelia bainesii</i> .

Obj	INFRASTRUCTURAL
Ia	As per generic Actions. Continue activities recommended for Reaches 21 and 22.
RECREATIONAL	
Sa	Planning of nature trails or pathways should be undertaken in consultation with a landscape architect and specialist horticulturist

5.12.5 DESIGN REQUIREMENTS

Obj	DESIGN
Ec	DESIGN 14: Fish Shelter
Ia	DESIGN 10: Grassy swale
Sa	Bike Path (see Section 5.11)

5.13 ZONE F, SEGMENT 10, REACHES 29 & 30

5.13.1 FUTURE ATTAINABLE STATE

	PES	FAS
Geomorphology	B	B
Riparian Vegetation	B/C	B
Fish	E/F	C
Water Quality	D	C
OVERALL	D	C

Where PES is Present Ecological State class and FAS is Future Attainable State class

GEOMORPHOLOGY

This segment is likely to remain in the same condition if all present factors remain the same. There is likely to be some improvement if there is reduced access to the estuary, and if upstream erosion is managed.

VEGETATION

Vegetation in this segment is relatively intact and will remain in this condition if it is maintained and protected. A management plan is recommended for the entire section of river marked for conservation. Any alien vegetation arising in this area should be removed on an ongoing basis to prevent infestation. Clearing for any form of development should be done with specialist supervision, and followed up with planting of appropriate indigenous species.

FISH

If upstream water quality issues are addressed and longitudinal connectivity in the river is improved, it is likely that the upper estuarine area will be used by marine fish species as a nursery area. In addition, one would expect catadromous fish species to move up the estuary and into the freshwater sections of the river.

INVERTEBRATES

No invertebrate information is provided for this reach, as there is as yet not a specific biomonitoring system available for estuarine invertebrates.

5.13.2 OVERALL GOAL FOR THE SEGMENT

The goal is for a scenically attractive, unpolluted recreational asset demonstrating healthy ecological function, and developed and maintained primarily for conservation purposes, and secondarily for low-level recreational use. These important river reaches should become able to support the full spectrum of biota that naturally migrate between freshwater and estuarine zones as part of their life history. A safe area with low-impact public access to the beach via a boardwalk leading from Beach Road (bowling green) in Nahoon is envisaged. The reduction of sewage odours from the Pump Station is a high priority.

5.13.2 OBJECTIVES AND PRIORITIES FOR THE REACH

No.	ECOPHYSICAL	Pr.
Ea	Protect and manage indigenous vegetation in the estuary. Attain protected area status for Reaches 29 and 30.	1
Eb	Increase fish diversity and abundance in the upper reaches of the estuary.	21
	INFRASTRUCTURAL	
Ia	Reduce the odours at the mouth (emitted by Nahoon Sewage Pump Station).	1
Ib	Remove man-made structures as far as possible, and camouflage those that cannot be removed (e.g. by painting or planting). Remove the beachward concrete retaining wall on the west side of the estuary mouth.	2
	SOCIAL/ EDUCATIONAL /RECREATIONAL	
Sa	Create an open boardwalk from the upper section of the estuary, down the left bank, across the pipe bridge, and onto the beach on the right bank at the mouth (Map 5.30). Install appropriate signage. This should be considered one of two main entrances to the beach, and an urban feature.	1
Sb	Limit access to the sewage pump station and use vegetation to screen odours from the public on the boardwalk and the beach. Limit access to other areas of the estuary to protect this sensitive ecosystem.	2
Sc	Encourage the adoption of the estuary by either local residents, the Surf Lifesaving Club or an appropriate group (e.g. birders).	3
Sd	Create a safe swimming environment for small children in the mouth (as it is most often closed), and for older children and adults in the near-inshore marine areas. This requires the lowering of the bacterial count at the estuary sampling point to an acceptable recreational standard (as defined by DWAF Water Quality Guidelines for Recreational Use, DWAF 1999).	4
Se	Address the problem of personal security that arises from the presence of informal dwellers and vagrants in the valley bush.	5

5.13.3 RECOMMENDED REHABILITATION MEASURES

Obj.	ECOPHYSICAL
Ea	Plant cleared areas (e.g. for routing of sewage pipeline over dunes) with indigenous dune vegetation. Reduce the number of footpaths through the riparian vegetation to one well-marked path. Introduce measures to keep incursions into the bush to a minimum.
Eb	This objective is only likely to be met if water quality entering the estuary is improved, as recommended in the generic objectives and measures (Chapter 3). In addition, leachate possibly draining from the former waste site (Reaches 25-27) into the river may pose a problem and should be investigated further, through water quality sampling and analysis. If water quality is improved, fish diversity and abundance is likely to improve markedly.
	INFRASTRUCTURAL
Ia	Odours can be reduced significantly in pump stations, using a system already in use at other pump stations in South Africa. Pressure differences are created inside the pump station, resulting in the odour being diffused back into the pipeline (du Plessis, pers.comm. 2003).
Ib	The removal of the elements of the concrete retaining wall on the right bank at the Ihlanza mouth has been agreed to in principal by BCM officials (Koekemoer, pers. comm.).
	SOCIAL/ EDUCATIONAL /RECREATIONAL
Sa	The routing of the boardwalk would be from the upper carpark near the Dolphin Hotel, directly through the present <i>Brachylaena</i> bush (some of which would have to be cleared), directly down to the estuary left bank. The boardwalk would be routed along the left (east) bank of the estuary down to the pipebridge. It would then be routed across the present pipebridge, and down the right (West) bank towards Nahoon beach. This boardwalk would ideally be constructed above the 1974 floodline and the expected high water mark. It may be constructed in shallow water in places, and will likely require pilings for structural strength. The material recommended for the boardwalk construction is "polywood" (a wood-lookalike material manufactured from recycled plastic). This is a maintenance free, waterproof, high density, non-degradable material, approved for applications where structural strength is required, and is also heavy, cannot be used for fuel, and is less likely to be stolen than wood or steel. All other access paths in this estuarine area should be closed and signs erected to inform and guide visitors. The boardwalk should serve as a nature walk and should act as both the approach and return path.

Obj.	SOCIAL / EDUCATIONAL / RECREATIONAL
Sb	It is recommended that the former pathway leading to the beach from the Dolphin Hotel carpark be closed off by greened walling or fencing, such that there would be a built and vegetated barrier between the sewage pump station (at the river mouth), which is frequently malodorous, and the boardwalk path. See Measure Ia regarding diffusion of sewage odours.
Sc	All other paths should be closed and signs erected to inform and guide visitors. Recreational clubs should be encouraged to adopt the estuary.
Sd	This objective requires that the water quality from upstream be improved to meet DWAF Water Quality Standards for Recreational Use (DWAF 1999). This is only possible if generic objectives regarding water quality and addressing of point source and non-point source pollution are met. The present sediments in the estuary are likely to be contaminated, and should be tested as they may require dredging or treatment.
Se	The issue of informal dwellers will need to be addressed with the assistance of the City Police, and a security patrol (bicycle or horseback) initiated.

5.13.4 DESIGN REQUIREMENTS

Obj	DESIGN
Ea	Design of a boardwalk alongside the left bank of the estuary, crossing over the river at the pipebridge, and continuing to the Nahoon Beach on the right bank, as recommended (Maps 5.29 and 5.30).

5.14 RECOMMENDED PLANTING PLANS

BY DEBBIE REYNHART

As stated previously, the reference state of riparian vegetation along the Ihlanza river is thought to consist of closed canopy coastal forest as is found on similar first order streams in the nearby area and in remnant patches of the Ihlanza River itself.

In rural or wilderness areas restored plant communities should be designed to represent the structural as well as compositional diversity of the reference condition along the length of the river. The Ihlanza River is however an urban river defined by its current surrounding land uses. Its urban nature places constraints on the extent to which restoration of entirely natural riparian vegetation is feasible and desirable because the ecological functions must co-exist with those of the urban environment. To this end the strategic planting of selected exotic trees is proposed in conjunction with the planting of indigenous in some sections to enhance and reinforce existing cultural themes. For security reasons and ease of maintenance it is proposed that the establishment of a middle canopy layer in Reaches 10 to 18 is restricted.

To achieve the primary aim of rehabilitation of the riparian vegetation, which is to restore some ecological functioning, it will require a significant increase of canopy cover in the riparian zone. This will contribute positively to the water quality remediation by providing shade and improving the nutrient cycle. It will also minimise the need for long-term weed control and help stabilise stream banks as well as enhance connectivity and improve corridors for species diversity and habitat. The improvement of ecological functioning in this way also results in achieving the functions of urban open space by improving aesthetics and adding value to the landscape amenity.

Since budget constraints will limit total application of vegetation rehabilitation guidelines for all reaches, it is proposed that at the least, the minimum rehabilitation actions of alien vegetation control and proper management of existing vegetation be adopted. The current rate of infestation of alien vegetation is increasing in certain reaches, and a no intervention approach in these areas (Reaches 18- 30) is likely to result in increased degradation of those areas and areas which are currently in a reasonable condition (particularly reaches 26 to 30). If protection of reaches in a good condition is a priority criteria it follows that restoration at a minimum level, should consist of an alien vegetation removal and control program. Guidelines for this may be drawn from Working for Water's current program. It should be noted that control of alien vegetation is also a legal requirement of all property owners, including private and government bodies.

The protection of existing quality vegetation (particularly large indigenous trees at the stream edge) and management (formative pruning of juveniles to speed creation of a canopy) of emergent indigenous vegetation is also essential to a more speedy restoration of a self-perpetuating indigenous riparian vegetation community.

List of considerations and guidelines for riparian vegetation rehabilitation:

- Cross compliance between programmes and land users is essential if all are to work toward a common goal. Public awareness and participation is essential for successful rehabilitation.
- Consider factors affecting forest dynamics e.g. soil types, water tables, soil compaction due to excessive traffic, etc.
- Aim to emulate forest stratification where there are different layers i.e. upper canopy, middle and understorey layers
- Plant a mix of fast (pioneer type) trees and slow-growing tree species in a manner that allows for succession, or stagger planting to produce structural variation.
- Where possible avoid abrupt changes in edge and interior vegetation.
- Retain and preserve existing geophytes so that they may serve as seed banks for later successional establishment of the species.
- Manage emergent woody indigenous vegetation to speed up creation of an upper canopy.
- If planting shade-loving species plant them in pockets in already shaded areas to serve as seed banks for later dispersal into currently exposed areas.
- Remember that not all species would be found naturally along the entire length of the river and vary planting accordingly.
- Plant appropriate plants for particular river zones e.g. emergent aquatic plants, sedges and reeds would be suitable for the splash zone near the toe of the bank, whereas plants that tolerate lower levels of inundation will need to be placed higher up the banks in the terraced zones or upper banks.
- Where particular understorey species are not likely to establish themselves due to sun intolerance, it is recommended that pockets of understorey vegetation be established in existing shaded areas.

- Consider initial maintenance requirements of plants whose roots do not reach the water table. Irrigation may be required for the first two seasons until the plants become established.
- Schedule planting of instream vegetation at an appropriate time when there is the least danger of severe detrimental inundation.
- Source plants from genetically appropriate stock if possible. This may entail contract growing of plants specifically for the project.
- Plant material installed, should be of superior quality both in size and health.
- Avoid where possible, the removal of woody indigenous vegetation. For ease of access and maintenance by land owners, an exception may have to be made for selected patches of woody climbing plants such as the Spiny splinter bean (*Adenopodia spicata*) which may need to be removed.
- Enforce legislation protecting against dumping of any kind of refuse. Provide refuse bins for public recreational use and maintain them.
- Since the establishment of riparian vegetation is not an exact science, ongoing monitoring is required to ensure that differential colonisation rates do not result in the complete exclusion of some species.

5.14.1 SUGGESTED PLANT SPECIES FOR INCORPORATION INTO THE PLANTING PROGRAMME FOR THE IHLANZA RIVER

Grasses, reeds, sedges and mesic forbs, aquatic plants:

These plants will be suitable for re-vegetation of the channel section as they will tolerate periods of inundation and resist erosion of the channel substrate once established. Care should be taken to choose plants that are suitable for the particular level of inundation and rate of flow and that they are of a suitably low growing where security is an issue. Reeds and sedges should be monitored on an ongoing basis as they should form scattered pockets rather than dense stands of impenetrable vegetation.

Mariscus congestus
Mariscus dives
Juncus kraussii
Cyperus denudatus (Winged sedge)
Isolepis cernua
Cyperus textilis
Cyperus albostratus (Forest star sedge)
Pycnus polystachyos
Eleocharis limosa

Fuirenia hirsuta
Ficinia lateralis
Zantedeschia aethiopica
Kniphofia rooperi
Nymphaea nouchalli
Adiantum raddianum

Grasses:

Stenotaphrum secundatum (Coastal Buffalo grass) (good for swales)
Dactyloctenium australe (L.M Grass)
Cynodon dactylon (Couch grass)
Oplismenus hirtellus (Basket grass) (Grows in dense shade on forest floor)
Setaria megaphylla (Broad leaved Bristle grass) (Semi- shaded areas)
Sporobolus africanus (Ratstail Dropseed)
Imperata cylindrica

Bulbs, herbaceous forbs and small shrubs:

Besides the grasses, these plants are essential to the establishment of a soil retentive understorey layer, but unlike most of the grasses, many of them prefer a shady positions and so will either need to be incorporated into existing shady areas or will have to be added to an area once canopy cover is established. Certain species such as, *Agapanthus* and *Clivia miniata* will not be suitable in all areas as they are likely to be subject to theft unless legislation regarding their protection is enforced.

Dietes grandiflora
Dietes bicolor
Commelina africana
Isoglossa ciliata
Centella asiatica
Asparagus asparagoides
Albuca sp.
Sansevieria
Haemanthus albiflos
Scadoxus puniceus
Veltheimia bracteata (near estuary)
Justicia capensis
Hypoestes aristata
Apium graveolens
Isoglossa ciliaris
Streptocarpus
Barleria obtusa
Wahienbergia rivularis
Drimyspys maculata
Plectranthus ciliatus (Speckled spur flower)
Plectranthus hadiensis (Wild purple salvia)
Asystasia gangetica (Forest foxglove)

Justicia Campylostemon (Honey Justicia)

Asparagus sprengeri

Asplenium lobatum

Pellaea africana

Agapanthus praecox

Watsonia pilifera

Crinum moorei

Hesperanthe

Cyrtanthus mackenii

Clivia miniata

Clivia nobilis

Gloriosa superba

Larger shrubs and scramblers:

These plants form a middle layer in the forest canopy along with some of the smaller trees. Thickets of these species should be retained to provide inclusion area for wildlife habitat, but new plantings should be restricted to patches particularly in sections 10 to 17 where security is an issue.

Carissa bispinosa

Dracaena hookeriana,

Turraea obtusifolia

Rhus crenata,

Plectranthus ecklonii (spur flower)

Plectranthus fruticosus

Hibiscus pedunculatus

Hibiscus calyphyllus

Metastasia muricata (Dune and estuary area)

Passerina rigida (")

Chrysanthemoides monilifera (")

Tree species:

Botanical name:

Erythrina caffra

Grewia occidentalis

Hippobromus pauciflorus

Harpephyllum caffrum

Celtis africana

Mulleitia grandis

Zanthoxylum capense

Maytenus undata

Allophylus natalensis

Davyallia caffra

Sideroxylon inerme

Ficus sur

Phoenix reclinata

Clausenia anisata

Trimeria trinervis

Common name:

Coral tree

Crossberry

Basterperdepis

umGwenya

White stinkwood

Umzimbeet

Small leaved Knobwood

Dune false currant

Kei Apple

White milkwood

Cape Fig

River palm

Horsewood

Small leaved wild mulberry

Cussonia spicata

Clerodendrum glabrum

Cordia caffra

Rhus rehmanniana

Trichelia dregeana

Podocarpus falcatus

Ficus thonningii

Tarconanthus camphorata

Vepris lanceolata

Streitzia nicotai

Ekebergia capensis

Diospyros villosa

Akocanthera oppositifolia

Cassine aethiopica

Pittosporum viridiflorum

Protorhus longifolia

Deinbollia oblongifolia

Diospyros natalensis

Euclea natalensis

Dracaena aietrifolia

Rhus chindensis

Buxus macowanii

Mimusops caffra

Euclea natalensis

Combretum erythrophyllum

Cassine tetragona

Rhus glauca

Rhus crenata

Apodytes dimidiata

Olea woodiana

Maerua caffra

Schotia brachy petala

Cabbage tree

Cats whiskers

Septe tree

Blunt leaved currant

Forest Mahogany

Common Yellowwood

Common Wild Fig

Camphor tree

White Ironwood

Wild banana

Cape ash

Common poison bush

Cheesewood

Red beech

Dune Soap berry

Small leaved Jackal berry

Dragon tree

Red currant

Red Milkwood

Guari

White pear

Forest Olive

Common bush cherry

CHAPTER 6

OUTCOMES, COMMENTARY AND CONCLUSION

6.1 OUTCOMES

The purposes of this project were:

- to plan the rehabilitation of a small degraded urban stream in South Africa, based on the Australian Stream Rehabilitation process of Rutherford et al. (2000); and
- to experience and evaluate the process, science and logistics involved in rehabilitation planning in a South African context (for the sake of future urban river rehabilitation projects).

There are a number of outcomes from this process.

6.1.1 KNOWLEDGE ON THE TRANSFERABILITY OF THE AUSTRALIAN PROCESS

To our knowledge, the completed project represents the first South African river rehabilitation plan to be based entirely on the Australian Rehabilitation method, and as such, represents a pilot trial.

The application of the planning phases (Steps 1-9 of 12) of the method has indicated that the rehabilitation process provided in the Australian Guidelines is sufficiently generic and comprehensive to be used as a basis for South African river rehabilitation projects, as long as the physical differences between Australian and South African rivers, and the different legal and social frameworks of the two countries are taken into account. Overall, the trial exercise has been beneficial, despite excluding the detailed project plan and the implementation of the suggested interventions.

The Australian method equips both the inexperienced and the specialist practitioner with a series of comprehensive, clearly motivated project Steps, each of which comprises a structured set of Tasks. It represents a sound toolkit for rehabilitation planners at all levels, and has implicit in it a series of 'checks and balances' which should eliminate the chance that major elements of the process may be overlooked. It is considered transferable to the South African context, and should be trialled in a number of situations to enable refinement and modification of elements of the process for use in both urban and rural South African river rehabilitation projects. A number of comments and recommendations regarding the method are made in Section 6.2.

The questions which arise from the experience of undertaking this project are mostly specific to the South African milieu. For example, how possible is it within the current socio-economic and legislative environment to attempt a true river rehabilitation exercise; how much support can one expect for a project in which ecological objectives are weighted similarly to infrastructural and social objectives; what are the financial and non-financial costs involved in planning,

implementation and maintenance; what problems are encountered along the way that need to be considered at a higher level, or incorporated into resource management thinking?

It also became clear that to facilitate South African rehabilitation projects, the Australian rehabilitation processes or others available from overseas (e.g. FISRWG 2000) would need to be supplemented with guidelines which provided a the context for rehabilitation within current South African law (national to local levels) and Department of Water Affairs and Forestry initiatives, including Ecoregional Classification (Thirion and Kleynhans in prep.), Catchment Management processes, classification of water resources, and Reserve Determination procedures. Other requirements include details of relevant national, provincial and local authorities; maps of their jurisdictions; directories of 'who to contact' when initiating a rehabilitation project; how to interface a project with programmes such as Working for Water and the River Health Programmer; and details of indigenous South African plants to use in rehabilitation of the riparian zone or bio-engineering applications.

6.1.2 A REHABILITATION PLAN FOR SURFACE SECTIONS OF THE IHLANZA RIVER

The rehabilitation plan for the Ihlanza River will provide the local authority (Buffalo City Municipality) and the catchment community with adequate information on which to base decisions regarding priority areas, final objectives, final designs, costings, prioritisation, project management and implementation, in consultation with specialists. This is considered a satisfactory outcome, within the Terms of Reference and the modest project budget (R160 000).

It is, however, unlikely that such a planning exercise would be easily repeated unless the budget were significantly improved. Even if community volunteers were to drive such an initiative, external funding would be required. For example, the exercise requires specialist input for a number of the steps, particularly Step 3 (Assessment of Present State). Assuming that each of seven specialists (covering hydrology, hydraulics, water quality, geomorphology, riparian vegetation, fish, invertebrates) required a minimum of a week minimum for fieldwork, analysis and reporting, this would represent a cost of up to R70 000 (excluding VAT). This is the minimum specialist input required. The time required for mapping of the river and the landscape planning, represents another high cost – in the order of R50 000. These costs exclude all project management (estimated at 100-150 days for the planning phases, at a cost of ranging from hundreds to thousands of Rands per day), meetings and discussions, information acquisition, prioritisation, development of objectives and strategies, design and costing of interventions, acquisition of conceptual designs, and documentation of the project.

6.1.3 CAPACITY-BUILDING IN URBAN RIVER MANAGEMENT

A major outcome of this project is that capacity has been built within the Project Team, the local authority and the catchment community, to consider rehabilitation of city streams within the broader context of their catchments, and as a subset of urban river management. The rehabilitation planning process has also provided a process for the successful integration of the eco-physical, social and infrastructural needs and considerations.

The intention, in urban river management, should be to balance the need for healthy waterways with the requirements of draining urban runoff, ensuring flood control, and providing sanitation facilities (chiefly sewers). Melbourne Water, a metropolitan water service provider in Victoria Australia, describes their management rationale in respect to highly modified urban streams or drainages as being designed to 'provide an asset able to meet certain criteria'. These criteria include: (i) a floodway and channel capacity able to manage flood and drainage requirements of the catchment; (ii) a sustainable and diverse physical form capable of withstanding some of the pressures generated by runoff from increased development in the catchment; (iii) a quality of water that limits impacts on downstream ecosystems (iv) an extent of vegetation cover able to satisfy stakeholders' expectations of this highly modified environment (Thompson Berrill and Fluvial Systems 1999).

6.2 THE AUSTRALIAN PROCESS: COMMENTS AND RECOMMENDATIONS

A number of comments and recommendations are pertinent regarding the nature and ordering of the process. While these may be considered project-specific, they are presented here as advice for rehabilitation practitioners using this guideline for their work in similar urban river environments in South Africa.

Firstly, a rehabilitation project such as the Ihlanza would benefit enormously from a full-time or part-time coordinator. This person would be tasked with project management and maintaining continuity within the planning and implementation phases. This individual could be tasked with a number of time-consuming tasks which require ongoing work and commitment, and are too costly to employ specialists to do. For example, relationship building, capacity building and information sharing within the community and other stakeholders. In other parts of the world, individuals have been appointed to oversee the restoration of a river system for up to a decade (Thexton, pers.comm.). Further to this, and with the experience of this project, the recommendation to local authorities would be that they appoint one individual to oversee their City's rivers. This person would be responsible for liaison between all the different (and disparate) directorates within the authority which were concerned with some aspect of the river management.

Commentary on the project process, and recommendations based on the experiences of this project, is provided for each step of the Australian process (as summarised in Appendix 1).

Prior to addressing Step 1, a draft budget and project plan should be drawn up. These will provide an early indication of the feasibility of the process and the scale at which it should be undertaken. Areas in which one is likely to underestimate the time and funds required for the project include:

- Information and data gathering, review and collation;
- Investigation of the legalities of river rehabilitation in the relevant region;
- Initial plotting of the river course using available maps, aerial photographs and Global Positioning System (GPS) instrumentation;
- Vegetation and substrate mapping;
- Identification of and interaction with relevant role players and stakeholders;
- Coordination of the project specialist team;
- Review and checking of specialist information, and importing this information into a reporting format;
- Photography and videoing of various sites;
- Objective-setting and transferral of objectives onto maps;
- Landscape planning and GIS mapping.

When preparing budgets and project plans, it is necessary to consider what specialist input is required, to add time for these individuals onto the budget, and to coordinate their sampling or survey dates where possible. This is cost effective, simplifies the process of data acquisition, and optimises information transfer and sharing. Ideally, two sampling sessions should be included: one in summer (or high flow periods) and one in winter (or low flow periods). If only one is possible, a mid-summer sample is preferable.

Once the budget and project plan have been read and approved by the relevant authorities, practitioners or lead agents, two processes can begin in parallel: The development and sharing of a vision and a goal for the project (Steps 1 and 2), and the acquisition of information pertaining to the project, including maps, orthophotos, aerial photographs, flow records, water quality data, historic photographs, anecdotes, design drawings, planning reports, etc.

The development of the Vision and the Goal (Step 1) provides the project with an initial focus, and is an important undertaking both for the specialists and non-specialists. It is critical in this step to identify what one wishes to achieve with the project: rehabilitation or remediation.

The sharing of the Vision and the Goal is a public participation-type process and could add significant time and financial costs to the project if not dealt with pragmatically. Where budgets are limited and there are no volunteers to assist with this step, it is advised that it is attempted at a later stage in the project, once there is sufficient scientific and technical information on which interested

individuals can base their comments and inputs on. In the Ihlanza Project, the goals were shared with the public with the help of media articles.

Once the information has been collected, the initial stages of mapping the river course (planform, channel width, channel depth, substrate, infrastructure) should ideally precede Step 3 (Division of the river, construction of a template of what the stream should look like, description of the present condition of the river, production of maps). Depending on the amount of background information and the quality of the mapping instrumentation and software available, this can be a time-consuming task, which is ongoing throughout the project.

It would be most useful to have the map/s in draft form as a basis for the division of the stream into reaches and segments. They would also serve as a template onto which specialists could record their site-specific information (e.g. sampling points, fixed point photographs, cross sections, areas of concern, habitat and flow types, etc.).

Step 4, the identification of the stream's main assets and problems, comprises a number of tasks which were considered difficult to perform meaningfully in the current project, in the light of the extensive degradation of the stream. This comment is of relevance particularly in highly-impacted urban stream systems, in which few of the natural or pre-impact features of the river (i.e. 'assets') remain. This makes it difficult to identify 'problems' which are defined in terms of assets. In these urban environments, Step 4 could possibly be modified to answer the question "What are the stream's ecophysical assets, and what threatens these?"

In these instances, ecophysical assets should be defined as those river features which contribute (or could potentially contribute) to the healthy functioning of the riverine and riparian ecosystem, even if these features are unlikely to have been present under natural conditions. Ecophysical threats or problems would then be defined as those features or processes that threaten the assets.

Between Step 4 and Step 5 (prioritisation), it is recommended that the Future Attainable State (FAS) be considered, on the basis of:

- The reconstructed or approximated 'Natural State'
- The Present Ecological State as determined by the specialist team
- The trajectory of change.

The FAS provides a guideline for the setting of objectives.

One is then in a position to prioritise river reaches and segments, using the principles in Step 5 as a guideline. The prioritisation matrix provided in the Australian guideline was however considered to be inadequate for the purposes of the Ihlanza River; and provided somewhat ambiguous priorities. For example, the specialist team felt that as water quality was the key limiting variable in the river, water quality remediation should be amongst the top priorities for the Ihlanza River. For this reason, Reach 2 – where the objectives included a detention basin and biological filtration system – would have been given a high priority, as an area

in which a key problem could be addressed (i.e. without water quality improvement, any other rehabilitation would be meaningless). However, in terms of the prioritisation matrix (Section 3.1.5, Table 3.1), Reach 2 emerged as the lowest priority reach for intervention.

A more complex method of assessing the numerous criteria involved in prioritisation is considered necessary. Particularly if the project or river were politically, economically or socially important, the prioritisation process provided in the Manual would need to be augmented with a procedure which took into account, and appropriately weighted, all criteria for consideration in the prioritisation exercise. A Multi-Criteria Decision Analysis (MCDA)- type tool would be appropriate for this exercise.

Step 6, the identification of strategies to protect assets and improve the stream, is appropriate at this point as it directs thinking and planning at the scale of the whole system under consideration. If one does not first plan at this level, the more detailed interventions are likely to be uncoordinated and ad-hoc.

The setting of objectives (Step 7) is a process borne in mind from the earliest stages of the project. The objectives are often in people's minds long before the project actually begins. It is a good idea to record these ideas and desires at any time during the project process, so that they can be reassessed for their feasibility during the objective-setting process. To enable one to address Steps 8 and 9, measures to meet the objectives need to be considered; conceptual designs considered, and broad-level costings supplied.

Step 8 requires an answer to the question "are your objectives feasible?". This answer is likely to be based on the broad costings, conceptual designs, legal and other constraints, and other potential negative effects of the recommended rehabilitation measures.

Step 9, the detailed design, represents the beginning of a second project management plan and requires the assistance of individuals with skills in this arena.

6.3 CONCLUSIONS

This rehabilitation planning exercise has been valuable in assessing and verifying the applicability of the Australian river rehabilitation guidelines to South African rehabilitation projects. It has also highlighted areas in need of further development or guidance within the methods and the process itself.

The project has built capacity in river rehabilitation practice in the Project Team, certain members of the catchment community, and certain officials in Buffalo City Municipality. It has helped to engender an awareness of the Ihlanza River as a continuum, an ecosystem which needs to be cared for and maintained, a corridor which could be perceived as a social asset rather than an urban drain.

The plan itself provides the local authority and the catchment community with the basis for further detailed rehabilitation project planning, prioritisation, costing, design and implementation phases for an important stream system in the City. It is hoped that the project is gradually implemented by those living in, or having authority over, the catchment; and that the river's rehabilitation potential is realised. For those living outside the catchment or the area, the rehabilitation plan serves as a case study, and may assist other rehabilitation practitioners with ideas on how to proceed with structured rehabilitation projects.

It is hoped that one of the more lasting outcomes of the project will be the increase in the coordinated focus it has provided for a number of groups, both national and local, who have to date been undertaking their actions in an uncoordinated and somewhat disparate fashion.

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