AN INVESTIGATION OF THE REHABILITATION POTENTIAL OF THE BAAKENS RIVER, GQEBERHA

PART 2: REHABILITATION SCENARIOS

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WATER RESEARCH COMMISSION

TT 910/2/23

An Investigation of the Rehabilitation Potential of the Baakens River, Gqeberha

Part 2: Rehabilitation scenarios

Report to the
Water Research Commission

by

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Laughing Waters & Associates

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This report forms part of a set of five reports emanating from WRC project no. C2022/2023-01121. The other reports are:

- An investigation of the rehabilitation potential of the Baakens River, Gqeberha. Part 1: Current state of the river. (WRC Report No. TT 910/1/23)
- An Investigation of the rehabilitation potential of the Baakens River. Part 3: Cost benefit analysis. (WRC Report No. TT 910/3/23)
- Rehabilitation Potential of the Baakens River, Gqeberha. Part 4: Recommendations. (WRC Report No. TT 910/4/23)
- Rehabilitation potential of the Baakens River, Gqeberha. Part 5: Summary Report. (WRC Report No. TT 910/5/23)

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EXECUTIVE SUMMARY

Chapter 1. Introduction

This study was commissioned and funded by the Mandela Bay Development Agency (MBDA) through a Memorandum of Understanding with the Water Research Commission (WRC).

The study aims are: to determine the present ecological state (PES) of the Baakens River, to consultatively develop a rehabilitation vision and scenarios for the river, to do a cost-effectiveness analysis on the rehabilitation scenarios, and to make recommendations regarding the feasibility of rehabilitation for the Baakens River.

This report represents the second phase of the project and is focussed on providing different rehabilitation scenarios for the river.

The rehabilitation process followed is informed by the Australian stream rehabilitation method, with reference also to the South African, British and American river rehabilitation methods.

The first step was to determine both the natural, pre-impact (reference) condition, and the current state of the Baakens River. For the Present Ecological State (PES) study, the river was divided into six reaches numbered from upstream to downstream. Four survey sites were selected in four of the reaches, and numbered in the same way. Based on these results the integrated Ecostatus (EC) per site was determined. The EC varied from an E category (29% of natural state) at the uppermost Site 1 to a C/D category (58%) at Site 2, a D category (54%) at Site 3 and a D/E category (39%) at Site 4. In contrast, the Ecological Importance and Sensitivity (EIS) scores for the sites were High for Site 1 and Very High for Sites 2 to 4. The Recommended Ecological Categories (REC) were set as a D, C, C/D and D category for Sites 1 to 4 respectively.

The next step in the process was to describe the 'assets and problems' of each reach. These are based on the PES findings and a review of available documentation. The 'assets' are described for the reference or pre-impact state only here. Upper catchment healthy seep and depressional wetlands (Reach 1) provide water storage during dry periods, groundwater recharge, flood attenuation and detention, erosion prevention and control, and supply of habitat for a range of plants and animals, including endemic plant species.

In its natural state, the river (Reaches 2 to 5) would provide habitat for biota, biomass production, biodiversity, nutrient cycling, oxygen production, carbon sequestration, water filtration, flow regulation, natural flood management, a movement corridor, and opportunity for recreational and educational activities. The estuary (Reach 6C) would deliver ecosystem services including food supply, oxygen production, carbon sequestration, water filtration, flow regulation, disturbance regulation, climate regulation, waste treatment, and scientific and recreational interest.

The 'problems' in the river provide the basis for the development of the rehabilitation scenarios. In the upper catchment (Reach 1), the seep and depressional wetlands are partly degraded due to clearing for agriculture and grazing to their edges. The area is heavily invaded with the alien Port Jackson willow. In the freshwater section of the river, Reaches 2 to 6, the most critical and urgent issue is water quality deterioration due to inflows of raw sewage from pump stations or surcharging sewers, and prevalence of litter. The diversity and abundance of indigenous fish and invertebrate biota in these sections is extremely low, reflecting this poor water quality. The middle reaches of the river (Reaches 2 and 3) are highly urbanised, with development close to

or onto the floodplain. The riparian zone in this section is cleared in places and highly invaded in others.

In Reaches 4 (Dodd's Farm) and 5 (Settlers Valley) the water quality problem persists. The river channel and riparian zone vegetation remain relatively intact, with good functionality. However, Indigenous vegetation is overgrown and poses a security hazard to recreational users. The numerous river crossings and the major weirs represent barriers to upstream fish migration. While the biota generally scored extremely low particularly in the latter reach, the endangered fish *Pseudobarbus after* (Eastern Cape redfin) was found here.

At the top of Reach 6 (6A) the major issues are water quality, alien invasives and overgrowth of indigenous riparian vegetation. In the middle section of Reach 6 (6B), the channel is gabion-lined, and lacking natural instream habitat. The right bank riparian and floodplain vegetation has been cleared, and natural flood management capability is impaired. In the lowest section of Reach 6 (6C), the estuary has been partially filled in (1860s) and built over. The remains of the channel have been narrowed and constrained into a concrete canal, with no instream or marginal habitat, and no lateral connectivity to the floodplain. These modifications have resulted in a significant reduction in flood conveyance capacity and of estuarine functionality.

Having described the assets and problems, a preliminary vision was set for the Baakens River. The initial vision is an ideal, which is likely unattainable, and this is then reworked in consultation with other stakeholders to a more practical and attainable statement. The initial vision is as follows:

The Baakens River and estuary that we envision will be a natural icon of Gqeberha. It will serve as a natural green belt and a lung for the city, offering its communities a safe and healthy escape from urban life, a reconnection to the natural world, and a place to enhance fitness and outdoor adventure skills. A network of safe walking, hiking and cycling tracks will criss-cross the Reserve areas.

The highly sensitive indigenous and endemic plant and fish species of the river will be formally protected. At the source of the river, the seep wetlands will function in good health and be protected for their habitat, biodiversity value and ability to retain water and assist in natural flood management. In the river's upper, middle and lower reaches, the river will flow clean with the largely-indigenous riparian zone and floodplain serving as a corridor for the movement of birds and small animals.

The lower river and estuary will be naturalised and reconnected to the upper reaches. It will be fringed with indigenous plants in a more functional riparian zone. The estuary will again function as a nursery area for larval fish and provide passage for migratory fish species to move from the ocean all the way up the river. It will be a clean and safe environment for recreational activity.

Chapter 2. Existing Baakens River rehabilitation initiatives

A number of studies on the rehabilitation of the Baakens River pre-date this one and bear sharing here. There is a great deal of commonality between these, but also innovative concepts which are exclusive to each. Consideration should be given to drawing on all of this work in the final rehabilitation planning exercise.

The GAPP Consortium was appointed by the MBDA in August 2014 to develop a plan for the redevelopment of the Baakens Valley Precinct. The plan sets out the vision for the study area as a vibrant, attractive and usable precinct, orientated around a dominant open space system. The intention is also to develop numerous facilities for recreation and tourism and to revitalise and provide linkages to historic buildings and venues. There are four focus areas: the Heart of the Bay, Baakens River Valley, St Georges Park and the Waterfront.

In the GAPP Consortium Plan, the **Baakens River Parkway** plan concerns the section of the river and its floodplain from the Brickmakers Street Bridge to the Port. The aim here is to provide or upgrade facilities within the existing river park area and the open space area along the banks of the river. The work will include landscaping and beautification, upgrading of parking and addition of recreational facilities.

Part of the proposal is to clear the river banks of dense alien vegetation and to implement rehabilitation measures on the canalised sections of the river and estuary. Recreational facilities include open space facilities for recreational activities including a climbing wall, bicycle path, trails, and gardens.

In terms of environmental permissions required, the final Basic Assessment Report for the Baakens Valley Precinct plan was done by Engineering Advice and Services PE in 2019, and authorised in October 2019. A renewed environmental authorisation was granted in March 2022. The conditions of approval included the requirement for the submission of a Layout Plan and Construction and Operational Environmental Management Plan covering the various aspects of the plan. As the BAR included a commitment to rehabilitation of aspects of the Baakens River, this requirement is reflected in the Environmental Authorisation.

The **Green Lung Report: Restoration of the Baakens River Valley** (2022) was commissioned by the NMB Business Chamber in collaboration with a number of partners. The Mantis Eco Group developed the plan. The report focusses on the 'redevelopment' of the Baakens Valley, and on leveraging the natural asset value of the system. It provides a series of solutions for the Baakens River in its present state. These are based on existing research, knowledge, experience and on historic studies done in the Baakens River Valley.

Three major issues are highlighted: invasive alien vegetation, sewage, and safety and security. The three themes for the initiative are: Remove, Replant, Reignite. Each is associated with a number of tasks. Under Remove, the tasks are alien vegetation removal; and addressing the sewage problem and the security threat. Under Replant, the tasks are restoration of soil health, indigenous vegetation, the river and the hydrology; nurserying of indigenous vegetation; the establishment of 3 zones; and a focus on community participation. The tasks under Reignite include the creation of a recreational zone focussed on concerts, markets, guided tours and sporting events; the conservation of natural areas (through protection); the long term goal of establishing a botanical garden; and the opportunity to use the valley for teaching and for research.

The three zones are Zone 1 (Recreational), with the pilot area being Dodd's Farm; Zone 2 (Natural/Protected) which would focus on the formal protection and conservation of natural vegetation in a series of natural areas through the valley and the establishment of a Botanical Garden, and Zone 3 (Educational), a series of educational areas to be used for formal education, research, skills development, and as nurseries for indigenous vegetation. The estimated cost of all interventions phased over a 20 year period, is R50 million.

The **Baakens River Revival Plan** (2013) is a detailed and forward-thinking landscape architecture plan focussed on the Lower Baakens River Valley. The report was authored by Rosemary Anne Buchanan (RB) and submitted in fulfilment of Degree of Masters, Landscape Architecture, University of Cape Town.

Buchanan makes effective use of graphic imagery (GIS map layers and CAD images) to present and analyse information on the upper, middle and lower catchment areas: geology and topography, hydrology and stormwater, vegetation, critical biodiversity areas, terrestrial and aquatic fauna, and natural processes.

This leads to a series of conclusions. Firstly, that habitat loss is a critical factor, and the Valley needs to have greater protection status. Development encroachment needs to be carefully monitored and pollution of the river needs to be curbed. Secondly, that floods are a real threat and a holistic approach to water run-off and bridges needs to be implemented, following principles such as Sustainable Drainage Systems (SuDS). Thirdly, that causeways and weirs should also be removed where possible as these create barriers for fish and environmental flow; alternatively, fishways should be constructed. Lastly, that river rehabilitation of the mouth needs to be implemented as part of a landscape plan for the Lower Baakens.

Chapter 3. NMB Metro and MBDA Planning Documents

There are a number of important NMB Metro and MBDA planning documents which guide development and planning decisions. They generally have a lifespan of 3-5 years.

The Integrated Development Plan (IDP) is a strategic plan for development that provides guidance on the budgeting and decision-making processes of the municipality. The executive committee of the local municipality manages the IDP process alongside the Executive Mayor. The current IDP is the fifth edition, valid 2017/18 through to 2021/22.

The Climate Change and Green Economy Action Plan (CC&GEAP) of 2015 is an official document that guides the strategic vision for the city, and is included in the IDP. It includes the identification of climate risks and vulnerabilities of the city to these risks, and proposes interventions to build adaptive capacity, climate responsiveness, and resilience to cope with these risks. While the Baakens River is not specifically mentioned in the report, the issue of flooding (which is problematic in the Baakens) is raised for specific management intervention, and catchment restoration is included in the suite of proposed interventions.

The NMB Built Environment Performance Plan (BEPP) is a planning tool to align, consolidate and focus the existing strategic planning instruments into a spatially targeted investment and implementation plan. In terms of the BEPP, the Baakens Area development planning falls within the focus on the Urban Network Strategy (UNS), Integration Zones (IZ) and Economic/ Growth nodes. Within these nodes, the CBD is seen as a Primary Hub, in which the focus of catalytic projects is on interventions including development within the defined Integration Zone (Zone 1) and assisting with private and public sector initiatives with respect to developments.

The Bioregional Plan is a spatial plan providing information on terrestrial and aquatic features critical for conserving biodiversity and maintaining ecosystem function (Critical Biodiversity Areas or CBAs and Ecological Support Areas or ESAs). It is based on the 2010 Conservation and Assessment Plan produced for the Metro.

The Spatial Development Framework (SDF) of 2015 deals with future spatial planning of the Metro at a detailed level. The intention to develop the Waterfront (Port) and Lower Baakens River is included here, and the development of the Baakens Valley Precinct is identified as one of the Catalytic Projects, shown to be viable (by 2015). The Baakens Valley is noted for its importance the Metro's most extensive corridor through fynbos habitats, and of critical importance for the continuation of ecological processes that sustain biodiversity. It is also recognised that the area provides numerous ecosystem services, playing an important role in flood attenuation, storm water management, environmental education and nature-based recreation.

The MBDA Five Year Development Plan (2018) is in alignment with all the planning documents already presented. The Baakens Area Report included in this plan deals exclusively with development planning for this area. In terms of the Inner-city Local Spatial Development Framework (not accessed as yet), the Baakens River Precinct has the following development vision: to provide an area for higher density residential development; to link the inner core to the Baakens Conservation Zone and Harbour Development; and to do careful conservation of the Baakens River and its floodplain. The proposed interventions presented in the plan include 'Environmental rehabilitation of the north and south banks (of the Baakens), including removal of alien vegetation'. The assumptions include 'Partnerships with key land and property owners and other stakeholders in the Inner-city'. One example of this being currently implemented is in the working relationship between MBDA and the NMBBC.

The stakeholders identified for the implementation of projects in the area include youth, organised business, Nelson Mandela Metro University, environmental lobby groups, NMB Tourism and its members, South End Museum and members, Wildlife and Environment Society of SA and its members, NMB Heritage Trust, sporting bodies, adventure groups, and private sector owners.

Chapter 4. Rehabilitation Scenario Planning

The next step in rehabilitation planning process for this project is to consider, on the basis of the most identified issues in the river, a number of options or scenarios to rehabilitate the river towards improved ecological health.

The scenarios presented in the following chapters arise from a process that has been underway since April 2022. This has included: gaining a broad understanding of the spatial planning context for the Metro and of MBDA's plans for the revitalisation of the South End, Baakens Valley Precinct and Baakens Parkway; a review of the available literature on the Baakens river, estuary, and catchment; a review of all other known rehabilitation plans for the Baakens; three visits to the river to walk sections of it; two days of river surveying; a visit to the South End Museum to get context; and meetings/discussions with numerous stakeholders and officials and members of the catchment community.

On the basis of what is now known of the Baakens River catchment, the main issues of concern to the ecological health of the river and its biota are considered to be: water quality deterioration, unnatural water quantity (particularly floods and base-flows); and system connectivity, channel form, and habitat availability. The deterioration in presence, abundance and condition of river biota is related to the first and last of these issues. From a social perspective the key concerns are human health, safe access and recreation, and security.

Three rehabilitation scenarios have been developed to address the key ecological issues.

Chapter 5. Rehabilitation Scenario 1: Address water quality

The current state of water quality in the Baakens is consistently poor. The water quality results presented during Phase 1 of this project reported Present Ecological State (PES) values, for Sites 1 to 4, of 64% (Category C), 67% (C), 27% (E) and 69% (C). From day to day, it may vary from these values, but Is unlikely to be better than this.

The problems arise in the main from sewage inflows into the river. These are reported on a regular basis by members of the community. The sewage is typically either direct overflow from pump stations, surcharge from manholes, or runoff from damaged or blocked sewer lines.

There are a number of organisations working to get a clearer picture of the situation and the details of the problems. At present however, the problems reported here are generic issues that apply to all pump stations (there are at least 8 in the catchment) and the catchment sewerage network.

These include the following: loss of power to pumps at pump stations (during loadshedding more severe than Stage 4); lack of backup generators and/or fuel for these; failure of pumps; vandalism to buildings – or theft of pump station pumps, and cables; lack of backup or emergency pumps; lack of screening of influent sewage at most pump stations; jamming of pump rotors by rags thrown into the system; lack of emergency sumps to accommodate sewage overflows; absence of emergency procedures; lack of adequate security; problems with procurement (for parts, etc.); non-payment of repairs (and thus repaired goods are retained and maintenance cannot proceed); inadequate staffing of pump stations; and too few inspectors of sewerage lines. According to the Executive Mayor Retief Odendaal, the budgets for maintenance and repairs of the sewerage system have hardly been spent in recent years.

There is no warning system or verification of water quality state from water quality data, as water quality data have not been uploaded to the DWS national water quality data management system (WMS) since 2019. According to local DWS, their own data have not yet been uploaded to the system.

There are also a number of areas where foreign items (e.g. glass, cement, paint, rags, packets) make their way into the sewerage system or are thrown into open manhole covers. Litter is another problem, typically flowing directly into the river from the stormwater system.

The Objectives for water quality rehabilitation are: to improve the water quality along the entire length to a sustained C category in the short term and to a B/C in the longer term; to improve Green Drop KPA status for Cape Receife WWTW to 80% by 2023; to implement water quality monitoring at the existing Baakens River sites, and reporting of data in public media; in general to reduce the health risk to visitors to the river.

The rehabilitation interventions for water quality are as follows: 1. Partner with business to address the sewage situation. 2. Commission an updated Sewerage System Master Plan for the catchment, with public participation. 3. Implement the actions as recommended in the intervention plan. 4. Employ additional staff members for line functions such as inspection of the sewerage lines. 5. Appointing trained staff to manage pump stations. 6. Ensure regular monitoring at key (existing monitoring) points along the river 7. Involve DWS in ensuring that compliance is achieved. Monitoring results should be published in popular media. 9. Install litter

traps at key stormwater runoff points in the catchment. Employ unskilled labour to clear stormwater drains daily. 10. Institute a city-wide anti-litter campaign (should be aired on television). 11. Partner with community groups to drive clean-up actions and citizen science 11. Institute a training programme for all technical staff and management, particularly those working at pump stations.

Chapter 6. Rehabilitation Scenario 2. Water Quantity: Rehabilitate Natural Flood Management capacity

The water quantity issue of immediate concern in the Baakens River is the flood flows. Floods in the catchment have historically caused deaths and major infrastructural damage, and with climate change this threat is increased. Improved management of floods and flood preparedness in the catchment are considered an urgent need. In addition, the current hydrology of the catchment (and how this differs from natural) is not well understood. Base flows are impacted by alien invasive vegetation and likely also by the increasing number of boreholes in the catchment during the drought. Real-time flow monitoring is considered necessary.

The water quantity-related problems that can be addressed by the rehabilitation interventions are: flood risk and loss of the river's Natural Flood Management (NFM) capabilities; Alien Invasive Vegetation (AIV) particularly in the upper catchment; degradation of the upper catchment seep wetlands; climate change threats; and the poor understanding of the river's current hydrology.

The objectives for the rehabilitation of water quantity aspects of the river are: to reinstate some of the river's natural flood management (NFM) capabilities; to gain a better understanding of the river's current-day hydrology through real-time flow measurement; to manage the river system for worst-case scenario in terms of climate change; and to ensure that all (but particularly, vulnerable) human communities are adequately prepared for and protected against the effects of climate change, which include the increased threat of floods.

The interventions proposed are: 1. The commissioning of a 10-20 year Stormwater Master Plan for the Baakens catchment with an emphasis on Water Sensitive Urban Design (WSUD); 2. The augmenting of the river's NFM capability through the further introduction of SuDS (e.g. rainwater tanks; swales, bioretention/biodetention ponds); 3. The clearing and ongoing management of upper catchment AIV; 4. The rehabilitation of the seep and depressional wetlands in the upper catchment; 5. The proposal that no further development be permitted in the upper catchment area and that formal protection of this area be applied for; 6. The clearing of AIV in the lower river and estuarine reach (Reach 6); 7. The restoration of floodplain function in the lower river; 8. The initiation of real-time flow gauging at minimum of one site in the middle Baakens.

Chapter 7. Rehabilitation Scenario 3: Improve Connectivity, Channel Form and Habitat

This intervention is focussed on the lower portion of the river from the Brickmakerskloof Bridge to the mouth of the river at the Port. This section, Reach 6, is further divided into Reaches 6A, B and C, representing river, river-estuarine interface, and estuary respectively.

In this section of river, longitudinal (ocean--estuary-river-wetland) and lateral connectivity (river-floodplain) and habitat availability have been reduced or lost due to the alteration of channel form (canalisation of the lower section) and the clearing of instream and marginal habitat and much of the marginal and riparian vegetation on the right bank. Longitudinal connectivity in the river has been further reduced by the presence of several instream barriers across the river in the form of low-level crossings and weirs, particularly upstream in Settlers Park and Dodd's farm areas.

The results of this have been a loss of estuarine functionality (particularly the larval fish nursery), a decrease in instream and riparian biodiversity; loss of the migration corridor for catadromous fish and for and a significant reduction in NFM capability in this reach.

The proposed interventions include: 1. The installation of fishways on man-made barriers to upstream fish migration; 2. The clearing of AIV and thinning of all indigenous vegetation on the right bank Reaches 6A and B; 3. The naturalisation of channel morphology, increase in channel cross-sectional area, and reinstatement of instream, marginal and riparian habitat in Reaches 6 B and C; and 4. The possible introduction of floodplain features such as flood channels in Reach 6B and C.

Chapter 8. Stakeholder Engagement

The proposed stakeholder engagement for this project was limited to a single meeting with identified stakeholders, to present and discuss project outcomes and rehabilitation options, actions and costings, and to engage with the Metro and community in discussion on which actions may be viable to initiate the shift of the selected sites/areas in the direction of ecological functionality, more natural conditions, and best recreational opportunities.

However, as the project unfolded it became clear that a single meeting with stakeholders would not provide adequate interaction, particularly regarding perceived issues, and it was agreed that the approach should rather be a sequence of engagements throughout the project. While this approach is superior it is extremely time consuming and not all stakeholders were contactable.

The stakeholders who were identified and contacted or engaged with during the course of the project (via email, cell phone, or online/real-time meetings) include: MBDA, NMB Metro (Infrastructure and Engineering, Public Health); local Department of Water and Sanitation; Nelson Mandela Bay University (Prof. Nadine Strydom, Mr Adrian Grobler), Private Enterprise (NMB Business Chamber, Engineering Advice and Services PE, Urban Dynamix, Hive Ecosystems, Mantis Group, Rose Buchanan Landscape Design), Civil Organisations (WESSA, Algoa Bay Ocean Stewards, Community Crime Awareness, Civil Society Coalition), Historian and Author Dean McCleland, and active community members (Ms Candy Boonzaaier, Mr Johan Gerryts, Ms Ellen Paasche, Mr Gary Koekemoer). There is ongoing communication via phone and other media with a number of these groups and individuals.

The value of this approach is that it has provided a platform for communicating with individuals and organisations who are deeply committed to the City and to the future of their natural

environment, and the Baakens River system in particular. They have been helpful in assisting with ground-truthing the river, providing local context, assisting with historical background and present day information, and being willing to discuss the practicalities of proposed rehabilitation interventions.

It is clear however that Stakeholder participation is a slow process that must continue throughout the rehabilitation planning and decision-making phases. It is not the same as consultation. The ability of a number of parties representing different interests to work together in a common direction definitely requires the building of relationships and trust, and this can only be achieved through regular interaction, and eventually the structuring of a clear plan and objectives, and assigning of roles.

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ACRONYMS, ABBREVIATIONS, NOMENCLATURE

approx.	Approximately
BGIS	Biodiversity GIS
DHSWS	Department of Human Settlements, Water and Sanitation (historic name)
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (historic name)
DWS	Department of Water and Sanitation (current name)
EA	Environmental Authorisation
EC	Ecological Category
EIS	Ecological Importance & sensitivity
FRAI	Fish Response Assessment Index
GIS	Geographical Information System
ha	hectares (10 000 m^2 or 0.01 km^2)
IHAS	Integrated Habitat Assessment System
IHI	Index of Habitat Integrity
IZ	Integration Zone
km^2	square kilometres
mamsl	metres above mean sea level
MBDA	Mandela Bay Development Agency
mcm	Million cubic metres
MIRAI	Macroinvertebrate Response Assessment Index
mm	Millimetres
m^3/s	cubic metres per second
m^3/a	cubic metres per annum
na	not applicable
NMBBC	Nelson Mandela Bay Business Chamber
NMBM	Nelson Mandela Bay Metro
NWA	National Water Act
PAI	Physico-chemical Assessment Index
PES	Present Ecological State
REC	Recommended Ecological Category
spp.	several species
VEGRAI	Vegetation Response Assessment Index
WRC	Water Research Commission
WR2012	Water Resources of South Africa, 2012
WWTW	Waste Water Treatment Works

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1 INTRODUCTION

1.1 BACKGROUND TO THIS STUDY

The Mandela Bay Development Agency (MBDA) is a special purpose development company which receives its mandate from the Nelson Mandela Bay Metropolitan Municipality (NMBM) in the Eastern Cape city of Gqeberha. The MBDA has entered into an agreement with the Water Research Commission (WRC) to facilitate water-related studies in areas in which information is needed for development decision-making by the MBDA. In the case of this project, the information requirements relate to the Baakens River catchment.

The MBDA sought a study which would provide information on the current condition of the Baakens River in Gqeberha, in terms of its water quality, fauna and flora, and assess the feasibility and cost effectiveness of rehabilitating areas of the river. The Baakens River occupies a central position in the geography, life and heart of the city. The river and estuary have, since the early days of settlement (1820s) been subjected to a suite of impacts, particularly in the lower reaches and estuary. In spite of this, the Valley still retains significant biodiversity and natural-capital value, and is home to a catchment community that is passionate about improving its condition, and protecting what is left.

A Memorandum of Understanding (MOU) was signed between the WRC and the MBDA to facilitate this and other research. The study falls under WRC Key Strategic Area (KSA) 2, Water Resource Management and Ecosystems, Thrust 3: Water resource and ecosystem protection and utilisation, and Programme 2: Rehabilitation and conservation.

Laughing Waters and Associates were awarded the project and commenced work in April 2022.

The study aims are:

1. To determine, using accepted current South African methods, the current ecological state of the Baakens River at four sites (Deliverable 1, completed June 2022).
2. To develop a rehabilitation vision and different rehabilitation scenarios for the river, in consultation with key stakeholders (Deliverable 2).
3. To do a cost-effectiveness analysis on the rehabilitation scenarios (Deliverable 3).
4. To make recommendations regarding the feasibility of rehabilitation for the Baakens River (Deliverable 4).

This report represents the second phase of the project (Deliverable 2), and is focussed on providing different rehabilitation scenarios for the river. The approach to this was:

1. To determine the rehabilitation needs for the river, based on the outcomes of the current state analysis, the problems identified, and in consultation with key stakeholders.
2. To develop a broad scale rehabilitation vision for the catchment with the inputs of the key stakeholders.
3. To develop three rehabilitation scenarios for the river.

1.2 A NOTE ON TERMINOLOGY

River 'rehabilitation' and 'restoration' are terms embracing a wide variety of activities, all of which have the common purpose of returning to the riverine system some level of natural physical and ecological functionality. In recent decades, the term 'river rehabilitation' has been used to refer to the practise of a returning a river ecosystem towards its natural pre-impact state, where the expectation is that not all elements of the original ecosystem will be recovered, as this is likely not possible. The term 'river restoration' has been used to communicate the intention to return the river to a totally recovered natural ecosystem state (e.g. Rutherfurd et al. 2000, Nuruzzaman 2017).

Currently, however, the tendency is to refer to both of these activities under the banner of 'restoration'. That this terminology is adopted in the naming of the globally-recognised Society for Ecological Restoration (SER), and the 2021-2031 United Nations Decade of Restoration, somewhat reinforces this. This may raise semantic arguments but, for now, is simply now a matter of fact. 'Restoration' is the term used by and in media, and it is increasingly understood by non-academics, which is critical for the expansion of the field.

Despite this, for the purposes of this study, it is felt to be more accurate to use the term **'rehabilitation'** to clarify the intention to return ecological form and function wherever possible, while acknowledging that it is unlikely to be possible to return to the original condition of parts of the Baakens system, particularly the lower reaches and the estuary.

More specific use is made of the more descriptive terms in throughout the report. There are many other terms now in use within the rehabilitation/restoration spectrum. Much of the environmentally-driven work in highly modified urban streams is termed 'enhancement' or 'naturalisation' (Gordon et al. 2004) or, more recently, 'renaturing' or 'rewilding'. For the sake of clarity the common terms in use are tabulated below with a description of how they are likely to apply in the bigger picture of returning function to an ecosystem.

Table 1.1 Additional terminology in the field of restoration or rehabilitation

Term	Description and Reference
Enhancement	River enhancement is typically used in exactly the same context and with the same meaning as 'restoration', often both terms are used together. Habitat enhancement is the process of increasing the suitability of a site as habitat for some desired species (Nature 2022).
Naturalisation or renaturing	These terms generally apply in urban situations where the natural aspects of a river have been degraded or significantly altered. The intention here is to return elements of natural form and ecological functionality to the system, without the aim of restoring it to pre-impact state.
Rewilding	The assisted recovery of an ecosystems, focusing on natural processes and typically including the planned reintroduction or reinforcement of animal or plant species (especially keystone species or apex predators) into habitats from which they have disappeared or been depleted, in an effort to increase biodiversity and restore ecosystem integrity (SER 2022).
Remediation	Remediation typically refers to a focussed effort to remedy a particular issue in, or unwarranted impact to, an ecosystem – often pollution in a river. Remedial actions are those which are possible and should have clear effects, and include emergency interventions.
Revival	Revival generally refers to the 'bringing back to life' of some aspect of an urban ecosystem or social system which has been lost. It is typically applied in an urban context. The South Precinct revival is a good example of this (and includes the rehabilitation of the river).

1.3 THE REHABILITATION PROCESS

The rehabilitation process followed in this study is based on that of Rutherfurd et al. (2000a, Vol.1), with additional reference to the methods presented by Day et al. (2016), the River Restoration Group UK (1997, 2020) and various other sources (individually referenced). The decision was taken to present one methodology rather than the several available, for the sake of simplicity, and to present the process with which the Project Leader is most familiar. This is in no way an indication that other processes are considered less sound or comprehensive.

The process of Rutherfurd et al. (2000a) achieves a good balance between technical considerations and practical issues. It involves 12 broad steps (Figure 1.1), each of which involves a number of detailed Tasks. As it is outside of the scope of this project to follow the entire process and the sequence shown, the steps included and the sequencing is recorded in Figure 1.1 as numbered blue circles. Importantly, this project represents the beginning of a process, and a great deal more work would be required to actualise rehabilitation of the Baakens River.

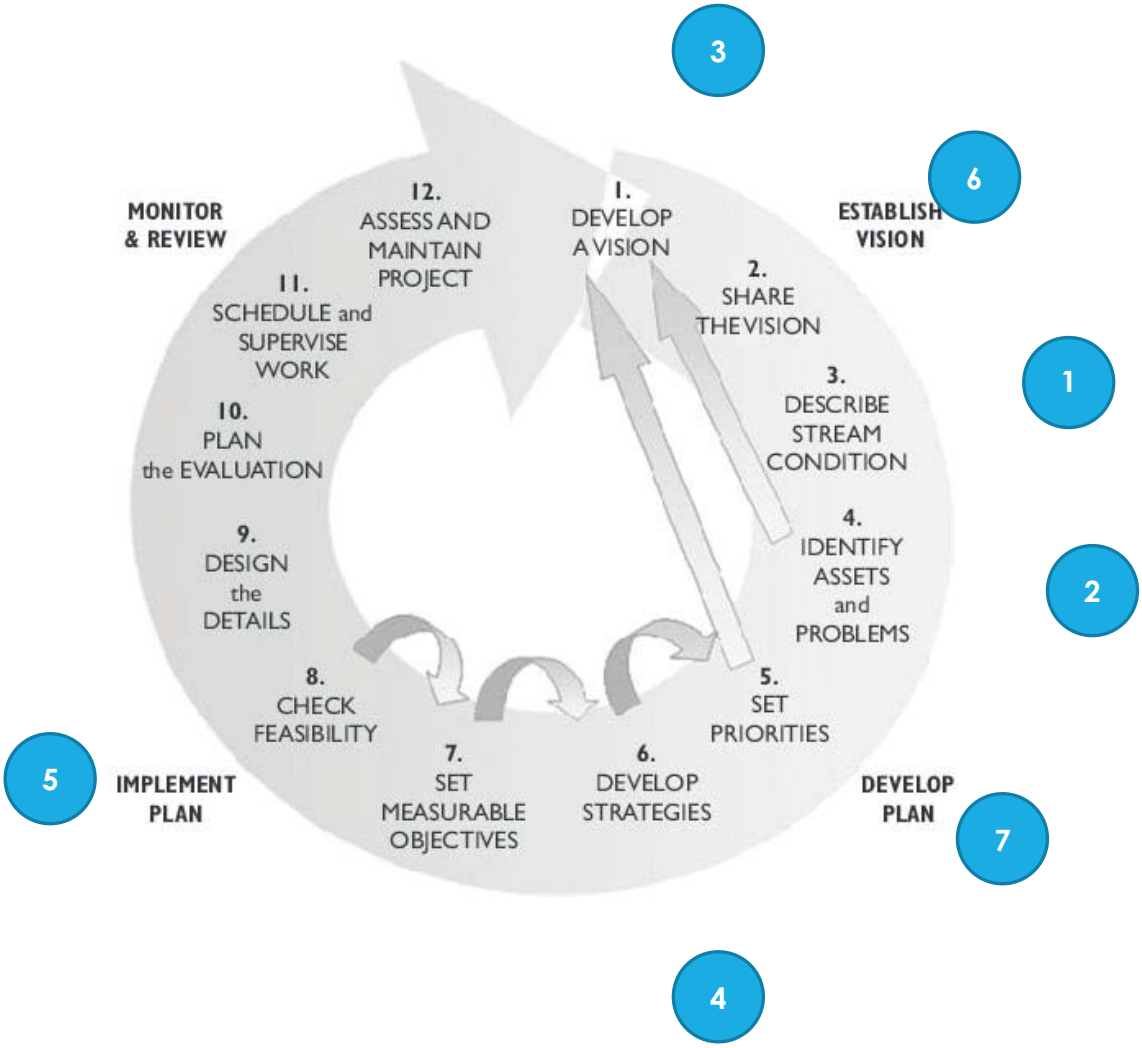


Figure 1.1 A graphic summary of the 12 Step river rehabilitation process of Rutherfurd et al. 2000. Numbers in blue circles represent the sequencing in this study

1.4 A DESCRIPTION OF RIVER CONDITION

In the first phase of this project, the Present Ecological State (PES) of the river was determined at four sites within six reaches along the 23 km Baakens River (see Figure 1.2). Studies were done to determine the PES of the water quality, riparian vegetation, fish and aquatic macroinvertebrates. These results were then used in a specialist workshop to determine the Ecostatus (overall condition) for each site, as well as the Ecological Importance and Sensitivity (EIS) and the Recommended Ecological Category (REC) for each site. The results were presented in Part 1 of this series (Uys et al. 2022a) and are summarised in Table 1.2 and Table 1.3.

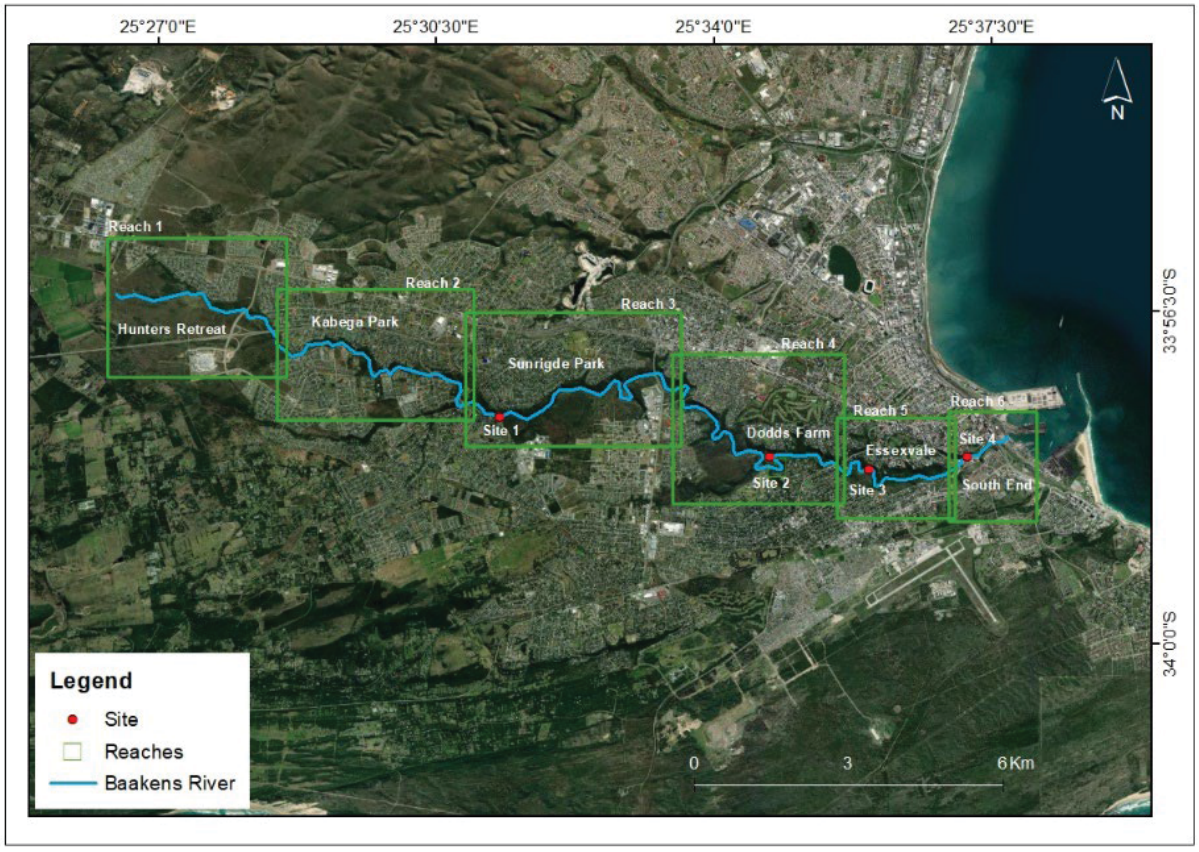


Figure 1.2 The division of the catchment into six reaches, and the four sampling sites

The PES results are presented in Table 1.2. These are a summary of Present Ecological State (PES) percentages, Ecological Categories (ECs) and confidence values out of 5 (Conf) for each of the four sites, for water quality (WQ results), riparian vegetation (RV results), fish and macroinvertebrates (Invert results).

The PES and Ecostatus categories and their applicable percentage ranges (relative to reference or natural condition) are:

- A: near natural (>89% to 100%)
- B: largely natural (> 80% to 89%)
- C: moderately modified (> 60% to 79%)
- D: largely modified (>40% to 59%)
- E: seriously modified (>20% to 39%)
- F: critically modified (<20%)

Table 1.2 Present Ecological State results for the four sites along the Baakens River (WQ – water quality, RV – riparian vegetation, Invert-invertebrates)

REACH	SITE	WQual	EC	Con	RipVeg	EC	Con	Fish	EC	Con	Invert	EC	Con
3	**1**	64.1%	C	3	13.7%	F	3	44.2%	D	2	48.9%	D	2
4	**2**	66.5%	C	3	66.7%	C	4	45.3%	D	2	43.5%	D	2
5	**3**	26.5%	E	4	62.0%	C	4	59.0%	C/D	2	14.5%	F	2
6	**4**	68.8%	C	3.5	35.9%	E	3	46.3%	D	2	40.9%	D/E	2

The Ecostatus (integrated PES) result per site are presented in Table 1.3. These are the Ecostatus percentages (Eco %) and associated Ecological Categories (EC) together with the Ecological Importance and Sensitivity values (EIS), site Trajectory (Traj; Neg – negative), and Recommended Ecological Category (REC). In the case of an Ecostatus of E or lower, remediation is considered a requirement.

Table 1.3 Ecostatus and EIS Results for the sites together with Trajectories of change and RECs

REACH.	SITE	Eco %	EC	EIS	Traj	REC
1	**-**	**-**	**-**	HIGH	**-**	**-**
3	**1**	29.2%	E	HIGH	Neg	Remediation
4	**2**	57.8%	C/D	VERY HIGH	Neg	C
5	**3**	53.8%	D	VERY HIGH	Neg	C/D
6	**4**	39.8%	D/E	VERY HIGH	Neg	D

1.5 IDENTIFICATION OF ASSETS AND PROBLEMS

The natural-state (reference condition) assets of the river, and the present-day problems are summarised in Table 1.4 and Table 1.5.

1.6 SETTING AN INITIAL VISION FOR THE RIVER

The setting of an initial vision was based on our studies of the catchment, from the process of reconstructing a template of likely natural or reference state; the determination of current state and major problems (Uys et al. 2022); and on broad engagement with MBDA and many other stakeholders. It was felt to be important to set a first-level vision to guide the process of identifying rehabilitation interventions.

Once there is a picture of the river in its natural pre-impact state, the changes imposed on the catchment during the last 150 years, and the present day state, the vision can be developed, initially as an aspirational statement based on what is desired rather than what is possible. The preliminary vision is an ideal, and is then reworked in consultation with stakeholders to a more practical and attainable statement.

The initial vision is as follows:

The Baakens River and estuary that we envision will be a natural icon of Gqeberha. It will serve as a natural green belt and a lung for the city, offering its communities a safe and healthy escape from urban life, a reconnection to the natural world, and a place to enhance fitness and outdoor adventure skills. A network of safe walking, hiking and cycling tracks will criss-cross the Reserve areas.

The highly sensitive indigenous and endemic plant and fish species of the river will be formally protected. At the source of the river, the seep wetlands will be functioning in good health, and these and the remaining rocky outcrops will be protected for their functions, habitat and biodiversity value. In the river's upper, middle and lower reaches, the river will flow clean with a largely-indigenous riparian zone and floodplain serving as a corridor for the movement of birds and small animals. The highly sensitive indigenous and endemic plant and fish species of the river will be formally protected.

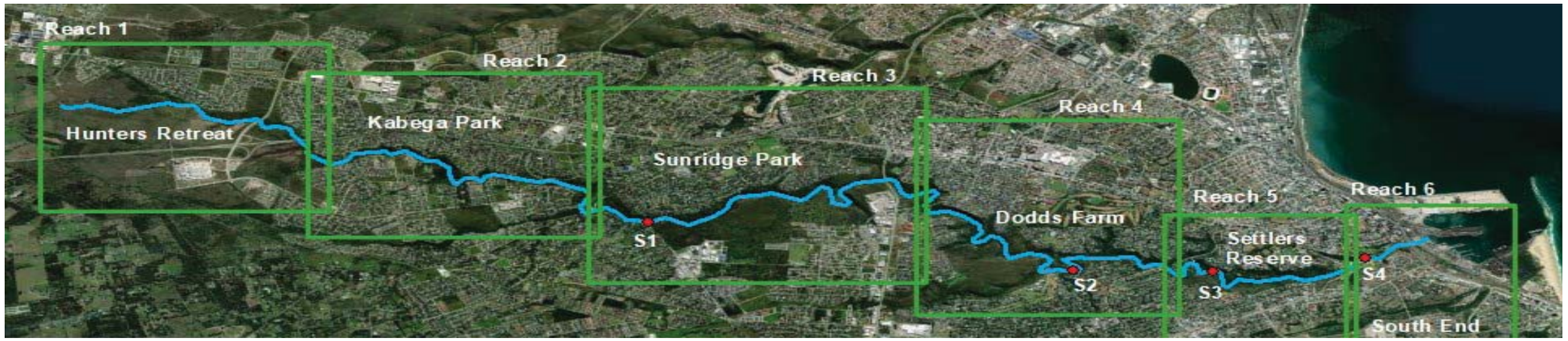
The lower river and estuary will be naturalised so that functionality can be restored and it will be fringed with indigenous estuarine plants. Migratory fish species will once again be able to move from the ocean up the river. The estuary will be a clean and safe area for recreational activity.

1.7 NATURAL-STATE ASSETS AND PROBLEMS: PRESENT-DAY DEGRADED ASSETS

Table 1.4 A brief description of the river assets under natural conditions

	REACH 1	REACH 2	REACH 3	REACH 4	REACH 5	REACH 6
	HUNTERS RETREAT	KABEGA PARK	SUNRIDGE PARK	DODD'S FARM	SETTLERS PARK	VALLEY ROAD
	WETLANDS, ENDEMIC PLANTS	RIVER	RIVER	RIVER, DODD'S FARM	RIVER, SETTLERS PARK	ESTUARY
NATURAL STATE: ASSETS	In this upper catchment there are numerous seep and depressional wetlands. Under natural conditions, and when functioning optimally, these wetlands provide a range of ecosystem services: water storage during dry periods, groundwater recharge, flood attenuation and detention, erosion prevention and control, supply of habitat for a range of plants and animals. The fynbos plant species of special concern (SSC), the Honeybush (*Cyclopia pubescens*) occurs in association with the seep wetlands and rocky outcrops in the area. This, together with numerous other plant SSCs, as well as the wetlands and rocky outcrops, provide this reach with high biodiversity, high ecological importance and sensitivity, and high protection value.	The river in these reaches represents a natural corridor and green lung. The water quality is unimpacted. The instream habitat is chiefly bedrock, boulder and cobble, and the river has a riffle-run-pool morphology. The riparian zone and floodplain are well connected to the channel. The riparian vegetation varies from Bethelsdorp bontveld (Albany thicket bioregion) in the lower reaches to Algoa Sandstone Fynbos in the middle and upper reaches. The ecosystem services supplied by the healthy river, riparian zone and floodplain would include: habitat for a diverse fauna (including rare fish species, invertebrates, birds, reptiles and amphibians), biomass production, biodiversity provision, nutrient cycling, oxygen production, carbon sequestration, water filtration, flow regulation, flood attenuation, a movement corridor, and healthy open space for recreation, adventure sport, outdoor and scientific research and education, spiritual gatherings, and events (e.g. concerts, markets).				The lower river, estuarine interface and estuary would under natural conditions be a dynamic system, with a healthy fauna and well vegetated floodplain. It would provide the following ecosystem services: food supply, oxygen production, carbon sequestration, water filtration, flow regulation, disturbance regulation, climate regulation, waste treatment, and scientific and recreational interest.

Table 1.5 Degraded Present-Day Assets per Reach, Baakens River



	REACH 1	REACH 2	REACH 3	REACH 4	REACH 5	REACH 6
	HUNTERS RETREAT	KABEGA PARK	SUNRIDGE PARK	DODDS FARM	SETTLERS PARK	VALLEY ROAD
	SEEPS, DEPRESSIONAL WETLANDS	RIVER	RIVER	RIVER	RIVER	RIVER, ESTUARY
PROBLEMS: PRESENT DAY DEGRADED ASSETS	Seep and depressional wetlands in this upper catchment area are degraded due to clearing, grazing, and recent large-scale development (Bay West Mall). There is the threat of further development, particularly in the form of large residential complexes. As a result of the farming and development in the catchment, and the loss of wetland functionality, there is reduced NFM capability. There is extensive litter, likely from stormwater inputs and pedestrian traffic. Numerous people appeared to be making their homes in the bush (Site visit May 2022). Trajectory with no interventions: Negative	The major issues here are extensive urbanisation of the catchment, substantial increase in hardened surface, development into the floodplain, severe water quality deterioration as a result of sewage spills directly into the river from Hawthorne Ave pump station (inter alia), large-scale invasion of riparian vegetation by AIVs, loss of riparian zone and floodplain integrity, and the presence of instream barriers. Trajectory with no interventions: Negative	The right bank, riparian zone and floodplain have historically been cleared for small-scale farming. There is extensive encroachment of invasive alien vegetation (juvenile and well established Eucalypts, Port Jackson willow, Pines). Development continues in this reach, coupled with an increase in hardened surface, a decrease in infiltration and an increase in storm runoff. Natural flood management (NFM) capability is reduced. Water quality is reportedly consistently poor due to regular inflows or raw sewage from the Woodlands and Mangold Park sewage pump stations. Trajectory with no interventions: Negative	As much of the land in Reach 6, Dodd's Farm, is protected from development and naturally vegetated, the riparian and floodplain vegetation in this reach is relatively intact, and incidence of alien invasive vegetation is relatively low. The vegetation is however very overgrown and needs clearing. Major threats in this reach are water quality deterioration as a result of sewage spillage (at the weir), threats to human health, declining biodiversity, loss of amenity and infrastructure value (due to disuse and lack of maintenance and management of structures), and safety and security for visitors. The continual presence of members of community groups such as the Community Crime Awareness (CCA) group and Fat Tracks mountain bike club, and the monitored high-level security camera, assist greatly in addressing security. Trajectory with no interventions: Negative	The major threats in this section are severe water quality deterioration (representing sewage inputs from upstream Mangold Park and Essexvale pump stations) representing a health threat to human users and to biota. Indigenous vegetation is overgrown and poses a security hazard to recreational users. There are vagrants living in the overgrowth. The numerous river crossings and the major weir in this reach represent barriers to fish migration. Reserve infrastructure has been vandalised and represents a safety hazard. Trajectory with no interventions: Negative	Reach 6A. Major issue is water quality, alien invasives and overgrown indigenous riparian vegetation. Reach 6B: Channel gabion-lined, lacking natural instream habitat, right bank riparian and floodplain vegetation cleared. NFM capability severely reduced. Reach 6C: Estuarine wetland floodplain cleared and largely developed. Estuarine channel filled in (1860s) and partially developed. Remains of the channel have been narrowed and constrained in a concrete canal. Loss of flood conveyance capacity. Loss of all instream habitat, marginal and riparian vegetation and floodplain functionality. Loss of connectivity to ocean, river and floodplain. Loss of estuarine functionality. Trajectory with no interventions: Negative

2 EXISTING BAAKENS RIVER REHABILITATION INITIATIVES

2.1 INTRODUCTION

In the past decade there has been a great revival of interest in the historic, cultural and ecological importance of the Baakens Valley, and its relevance to the wellbeing of the City. This is partly due to the MBDA plans to revive the South End area of the city. The South End was one of the early residential areas of Port Elizabeth, a vibrant multicultural and cosmopolitan community supported by services and commerce, and referred to as 'the District 6 of Port Elizabeth' and 'a way of life' (Munro 2017). The area abutted the south bank of the Baakens River and estuary. It was destroyed during the 1960s by forced removals by the former South African nationalist apartheid government, under their 1950 Group Areas Act.

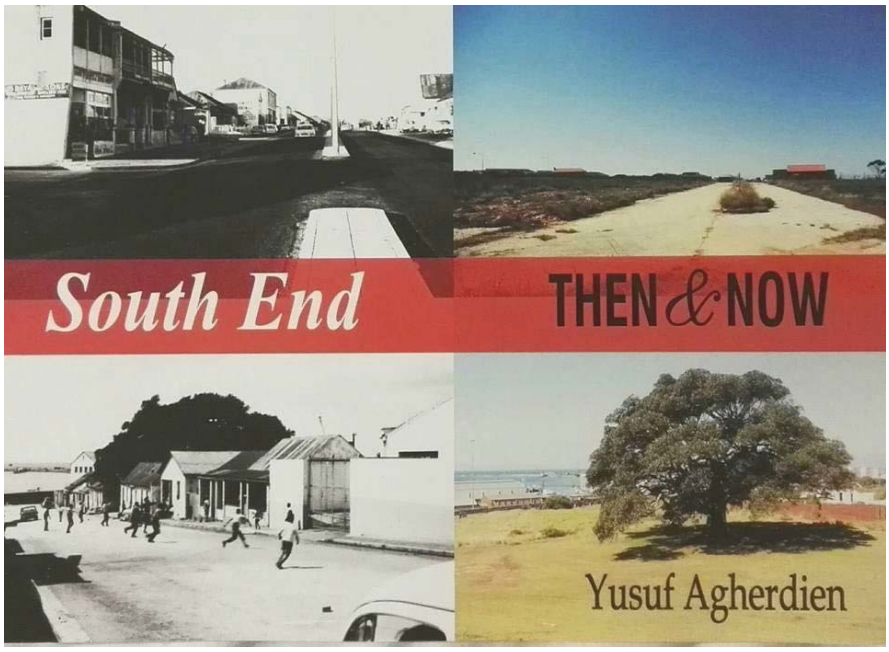


Figure 2.1 Cover of a book recalling the South End area

The South-End revival under the management of the MBDA has been underway for some years, with the restoration of the Tramways Building and St Peter's church, and the construction of the pedestrian bridge over the Baakens River all having been completed.

The remainder of the MBDA'S South Precinct Development Plan focusses on the construction of mixed-use developments in the cleared South End area, the reintroduction of safe and vibrant recreational areas and adventure facilities, and the rehabilitation of the Baakens River.

The study reported here is one of a number of studies commissioned to investigate this rehabilitation process. A number of other studies on the rehabilitation of the Baakens River pre-date this one. There is a great deal of commonality between these, and some innovative ideas which bear sharing. The rationale for including a summary of each here is to expose the reader and decision makers to this existing work, to acknowledge the ideas in each, and wherever possible to attempt to work alongside these initiatives, while avoiding duplication of effort.

Consideration should be given to drawing on all of this work in the final rehabilitation planning exercise. The effective rehabilitation of a river is a decades-long process requiring leadership, partnership and relationship. The more collaborative the planning, engagement and the management of such a process, the more likely it is to succeed, as many actions can be undertaken simultaneously through the catchment if well managed. This approach is also likely to appeal to the larger community who will participate in the rehabilitation process, and ultimately become the custodians of the process and the healthy river system.

It is hoped that in the case of the Baakens River, the intention to collaborate will result in partnerships between the various organisations and individuals responsible for the rehabilitation planning work done to date.

2.2 MANDELA BAY DEVELOPMENT AGENCY (MBDA)

Figure 2.2 The renovated Tramways building alongside the Baakens Estuary, offices of MBDA.

The MBDA was established as a municipal entity in 2003 by the Metro with the support of the Industrial Development Corporation (IDC).The MBDA's mandate is to serve as a trans-disciplinary agent in the implementation of urban regeneration in Nelson Mandela Bay's inner city. According to the SDF (2015), the aim of this was to promote economic and tourism development against the backdrop of urban renewal. The philosophy of the MBDA is to create well-researched, community centred, catalytic infrastructure projects and services through public sector investment, in order to attract private sector investment and create a more diverse economy.

Within the CBD Cluster of projects in the MBDA mandated area, is Integration Zone 1 (IZ1), which refers to PE Central Business District (CBD) and Newton Park. The Baakens Valley Precinct Plan is one of three catalytic projects Identified for this CBD area (2016-2020 IDP and BEPP; EASPE 2020).

The Baakens Valley Precinct is divided into four focus areas, each supporting new and integrated uses: the Heart of the Bay, Baakens River Valley, St Georges Park and the Waterfront. In each of the four focus areas, a number of priority projects are to serve as catalysts for private sector investment and development.

A key component of the overall vision of this project is reviving and redeveloping the South End, as already discussed.

2.3 BAAKENS RIVER PRECINCT REDEVELOPMENT PLAN

The GAPP Consortium was appointed by the MBDA in August 2014 to develop the plan for the redevelopment of the Baakens River Precinct. The plan sets out the vision for the study area as a vibrant, attractive and usable precinct, orientated around a dominant open space system. In addition to the mixed-use development planned for the South End Precinct, the intention is also to develop numerous facilities for recreation and tourism and to revitalise and provide linkages to historic buildings and venues such as the St Peters Church.

Part of the process is the identification of key catalytic projects, such as major infrastructure, open spaces/ street spaces/ water/ landscaping or buildings that will have a major impact on the image of the precinct and waterfront.

The intention is to support mixed uses including residential use, while restoring and conserving valley ecosystems and biodiversity. The plan also focusses on preserving and restoring the rich heritage of the area, and optimising its economic benefits. It aims for a positive return on investment for the public and private sector. Public participation was considered an important part of the planning process, and meetings were held at each phase of the planning process.

2.3.1 Open space planning

The open space planning element of the study involves rehabilitation of natural open space areas, landscaping of active open space areas, and **rehabilitation of some river elements** (e.g. addressing bank erosion, removal of broken weir structures, and construction of upstream fishways to improve ecological functioning). Various landscaping interventions are proposed to replenish the ecosystem and allow the natural biodiversity to flourish.

The open space network in the plan creates a 'pedestrian' green belt and links through the city, adding to connectivity and linkage to strengthen movement and economic activity. It is well connected and forms the largest component of the site, which includes the ‘valley walls’ and the associated vegetation. The proposed land use and movement are perceived to support this network.

The proposed Baakens River Parkway is a major intervention required for the residents of Gqeberha and the new housing proposed in the valley. The Baakens River Parkway plan concerns the section of the river and its floodplain from the Bridge Street Bridge to the Port.

The aim here is to provide or upgrade facilities within the existing river park area and the open space area along the banks of the river, which will include landscaping and beautification, upgrading of parking and addition of recreational facilities (e.g. tables, benches, walkways) to enhance the area for public use and safety.

The proposal is to clear the river banks of the dense alien vegetation and to implement rehabilitation measures on the canalised sections of the river and estuary (EAPSE 2020). Recreational facilities include open space facilities for recreational activities including possible amenities such as a climbing wall, pump track, bicycle path, gardens.

According to the GAPP (2014) report, **Phase 1** of the Baakens River Park would include cleaning up the park, providing grassed areas, lighting and pedestrian/cycle ways through the park. In **Phase 2**, a larger waterbody would be created in the park and additional landscaping including a children's play park and children's centre would be developed. **Phase 3** would require the extension of the park to the west of Bridge Street linking to Settlers Park, including an amphitheatre in the existing quarry. The aim was to develop a major park that is used by all the residents of the Metro.

The concept plans for the Lower Baakens Precinct and the Parkway are shown in Figure 2.3 and Figure 2.4. The design elements are listed here.

- **Landmarks** are design features that act as focal points, meeting places, terminal points of vistas and assist in orientation. The landmarks proposed and identified directly communicate the importance of culture. Most of these are monuments/heritage zones and/or recreational spaces that have the capacity to hold cultural and sports events. Included among these are an amphitheatre planned for development in the quarry in Settlers Park (see Figure 2.3) and the Bridge Street Bridge.

- **Gateways** define the entrances and exits to an area and mark the transition between them. Two are proposed: the entrance from the Waterfront into Lower Baakens River on lower Valley Road, and at the T junction between Upper Valley Road and Bridge Street.

- **Views and vistas** can be established to direct views towards specific features or lead people to sites of importance or interest. These are mostly in the valley.

- **Nodes** are concentrations of activity and facilities that provide the focal points of the districts within which they are located. Two nodes are planned in the valley: the interface between Lower Valley Road and Baakens Street, which is anticipated as a hub of activity and an attraction to tourists, with a mix of activities, and the Valley node, where a new park reception is proposed along with an upgrade and encouraged re-use of industrial buildings.

- **Paths** assist people in orientating themselves and leading them between key points. The principle pedestrian paths are the links through the open spaces, while the urban pedestrian paths support and activate environment for both vehicular and non-motorised transport.

- **Edges** separate districts from one another, define the site boundaries and define public from private spaces. The valley walls are important as natural edges. Active and passive edges are envisioned around the Precinct site, through changes in land use, roads and landscaping techniques. This gives the districts a more confined space to nurture their respective identities.

2.3.2 Environmental Assessment and Authorisation

In terms of environmental permissions required, the final Basic Assessment Report (BAR) for the Baakens Valley Precinct plan (Engineering Advice and Services PE 2019) was first authorised in October 2019. This authorisation lapsed but was reapplied for and granted in March 2022. In terms of the renewed authorisation, a period of 48 months from 3 February 2022 has been granted to commence with the development programme, failing which the authorisation lapses and the environmental studies will have to recommence.

The conditions of approval, issued in 2019 and relevant to the renewal include the submission of a Layout Plan and Construction and Operational Environmental Management Programmes (CEMPr and OEMPr) covering the various aspects of the plan. As the BAR included a commitment to rehabilitation of aspects of the Baakens River, this is reflected in the Conditions of Environmental Authorisation (EA), which require, inter alia:

3.3.3 *Detailed designs of all structures envisaged to effect rehabilitation/restoration of the Baakens River inclusive of the two proposed fishways are to be submitted to the Department for approval/endorsement prior to such structures being put in place. Furthermore, rehabilitation and restoration of the Baakens River to be undertaken with the Rehabilitation Plan contemplated in Condition 3.4.2.2*.

And that the OEMPr make provision for:

*3.4.2.2. A **rehabilitation plan** that addresses rehabilitation of the Baakens River as addressed in this Environmental Authorisation and the FBAR (Final Basic Assessment Report).*

*3.4.2.7 A comprehensive **storm water management programme** including special measures that may be necessary to ensure that stormwater from residential units is managed and controlled to prevent damage to or pollution of the Baakens River and Estuary.*

Figure 2.3 A conceptual plan of the Lower Baakens Precinct and Baakens Parkway (GAPP Consortium 2014)

Figure 2.4 The conceptual plan of the GAPP Consortium (2014) lower Baakens Precinct Plan and Parkway

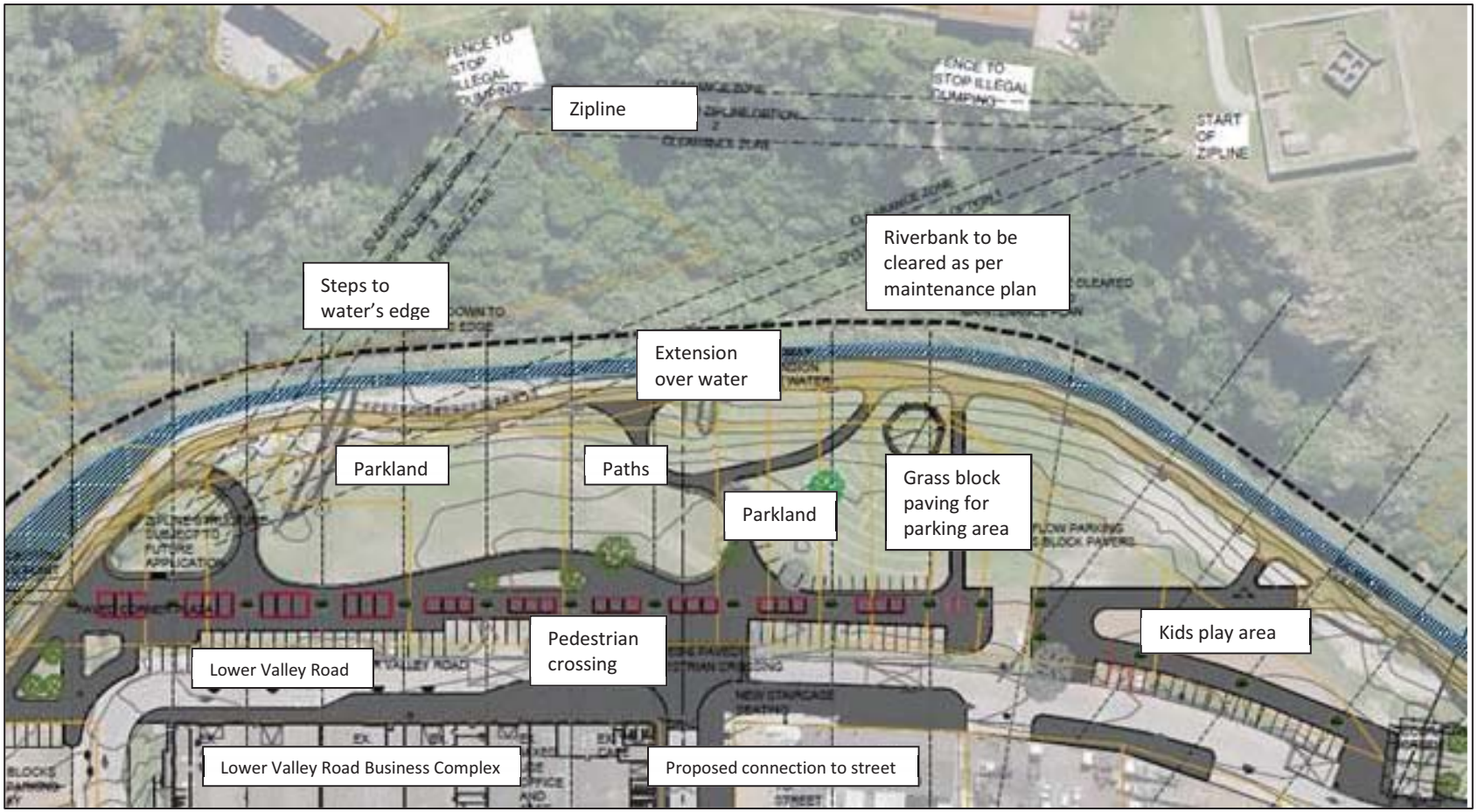


Figure 2.5 The GAPP 2014 Plan for the Baakens Parkway

Figure 2.6 A slide from an MBDA Presentation on the Baakens Parkway, showing some of the envisioned designs.

Figure 2.7 Images of Greenpoint Park, one of the design inspirations for the Baakens Parkway.

2.4 PROJECT GREEN LUNG

Figure 2.8 The Green Lung Report by the Mantis Group

The Green Lung Report: Restoration of the Baakens River Valley (Mantis 2022) was commissioned by the NMB Business Chamber in collaboration with GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), NatureS (Natural Resources Stewardship Programme), and Ezethu Development Trust.

The report focusses on the 'redevelopment' of the Baakens Valley, and on leveraging the natural asset value of the system. It provides a series of solutions for the Baakens River in its present state. These are based on existing research, knowledge, experience and historic studies done in the Baakens River Valley. Three major issues are highlighted, with eight critical problems which need be addressed:

Invasive alien vegetation

- Presence of alien invasive vegetation (the three of concern being Port Jackson willow, black wattle and bluegum);
- Biodiversity loss and degradation;
- Fire hazard due to alien vegetation;
- Improper harvesting of trees causing accelerated regrowth;
- Unsustainable efforts towards rehabilitating the river valley;
- Flood risk (due to stormwater pollution and debris choking bridges and causeways).

Sewage

- Sewage leaking constantly from the city's major sewage line which runs down the length of the Baakens River and contaminating the river and the sea.

Safety & Security

- An increasing number of robberies, rapes and assaults make the area unsafe for the local communities. The report refers to the river being the location for various opportunistic crimes over recent years. This is attributed to its isolation, thick vegetation cover in some spots,

multiple entrance and egress points, insufficient lighting and the lack of security presence in the valley. The crimes being reported in the Valley include, but are reportedly not limited to, opportunistic theft, house robberies in the fringe areas of the valley, organized poaching, assault, and the illegal removal of indigenous vegetation. The report also refers to vagrants living within the Valley.

The authors recommend that redevelopment project be governed by a steering committee consisting of representatives from key stakeholders identified. The capital investment in the project is estimated to be in the order of R47.5 million (2022 figure). Numerous businesses have reportedly shown interest in investing. The process aims to be labour-intensive, and to serve as a major employment creator. The redevelopment of the river would tie-in with the South End revival plan, which is under the jurisdiction of the MBDA, and with the plan to redevelop the Waterfront area (recently again under discussion). The river valley would provide a venue for large sporting events, along similar lines to Iron Man but with more of an adventure-bent (e.g. running, mountain biking, ultrasport events). In the longer-term the aim would be to create a 'Kirstenbosch-like' botanical garden as a venue for markets, music concerts, picnics and recreation, in a portion of the valley.

The three themes for the redevelopment initiative are: **Remove, Replant, Reignite**, and each has a number of themes and tasks.

Remove

- **Alien vegetation:** Restoration of soil health, indigenous vegetation, the river system, hydrology and natural filters. Establishment of an indigenous nursery.
- **Sewage:** Ensure the sewage maintenance plan is followed and implemented.
- **Security threat:** Reignite the Eco-Guards development plan. Re-establish the Mountain Patrol Unit in the Valley. Use technology and apps within the valley. Increase footfall.
- **Natural /Protected Areas:** Linking tourist hubs through natural passage; preserving natural landscape; reducing the carbon footprint of the city; having protected pockets throughout the Valley. The long-term goal is to establish a botanical garden.
- **Education:** School groups, field trips, research base for students. Platform for conservation education, use of technology in the Valley, linking with existing applications.

Replant

- **Alien invasive vegetation:** restoration of soil health and indigenous vegetation; replanting (and establishment of indigenous nursery; restoration of hydrology and natural filters; safety and security. An attempt to promote the success of SMEs and other eco-business ventures in the valley would result in increased employment, improved standard of living and a more active valley, which may well reduce crime in those areas. Increase footfall into the valley.
- **Zone establishment:** recreational zone, natural/protected zone, educational zone.
- **Community engagement:** community participation; plan to increase footfall into the valley.

Reignite

- **Recreational zone:** This focusses on concerts, markets, guided tours, sporting events. Leisure, linking with existing initiatives. The Baakens as a tourism asset.
- **Natural /Protected Areas:** Linking tourist hubs through natural passage; preserving natural landscape; reducing the carbon footprint of the city; having protected pockets throughout the Valley. The long-term goal is to establish a botanical garden.
- **Education:** School groups, field trips, research base for students. Platform for conservation education, use of technology in the Valley, linking with existing applications.

The philosophy is that once the clean-up of the valley begins, this will 'open a doorway as to what is possible within the grounds of the Valley' and presumably entice further similar initiatives. For this reason, the study focuses on three physical zones within the valley (Figure 2.7). While the intention is that these should be controlled activity nodes, they are also considered to be fluid through the valley (connected) rather than distinct areas.

Zone 1: Recreational areas (Pilot area: Dodd's Farm)
The recreational areas will be dedicated to recreation and commercial activities such as those which already exist in the Lower Valley area, including Bridgestreet Brewery and the Tramways Building area. Dodd's Farm is envisioned as a pilot area. The plan includes physical developments (structures such as an amphitheatre for concerts and events, and designated areas for pop-up markets) and focussed activities (trails for mountain biking, hiking and running). The benefits of this are seen to be the concentration of activity and accessibility, the control of footfall (the mechanism for this is not detailed), protection of the vegetation; and provision of a secure environment for community.

Zone 2: Natural areas (throughout catchment; focus on Settlers Valley)
This is a fluid zone throughout the catchment. Natural areas and pockets will be dedicated to the protection and preservation of the natural vegetation and will be situated throughout the valley. As further means of seeking protection for the Valley two proposals are made: firstly, the creation of a smaller-scaled version of a Botanical Garden, and secondly, the classification of certain areas of the valley as Protected or as Conservancies. Benefits include the protection of the natural vegetation, controlled footfall (minimal entry – although this is not detailed any further), and minimal to no disturbance to natural vegetation (trails, etc.). The protection and the minimal disturbance aspects are not detailed any further. Bird hides are planned at intervals through the catchment (presumably along the Guinea Fowl Trail).

Zone 3: Educational areas
The report suggests that education plays a large part of the future of the Baakens Valley. The plan proposes that dedicated educational areas are created through the Valley, run in parallel to the protected and recreational areas. These areas can be used for education (school trips), research, skills development, training, guided tours, and as localities for nurseries for indigenous vegetation. Benefits include practical education, nature conservation, dedicated research areas, dedicated areas for training and skills development.

2.4.1.1 Implementation

Rehabilitation is usually considered at the scale of decades rather than years (Rutherfurd et al. 2000). The Green Lung: Baakens Rehabilitation plan proposes that implementation actions will have a 20-year horizon.

Years 1-5 Priority and Impact Restoration Programme
All proposals to be actioned, with a priority on redressing the sewage issues, the clearing of AIV throughout the catchment, the management of floods and fire hazards, and upgrading the overall security of the catchment.
Years 6-10 Estimated follow-up restoration programme
This is a period of follow-up on all restoration actions.

Years 10-20 Estimated management and maintenance of restoration actions
By this time the major priorities are expected to be achieved, but actions will be ongoing and maintenance will be critical during this phase.

2.4.1.2 Job Creation

The report focusses attention on employment creation, estimating that the major actions will result in the creation of some 735 jobs. These are categorised per action.

2.4.1.3 Partnering

There is a strong emphasis on partnering with existing initiatives and forging new beneficial linkages. The existing initiatives include numerous adventure applications (apps) already being used in the catchment (e.g. the trail app Trailforks, the sports app Strava, the app for geocaching), and groups who already use the valley extensively (e.g. Fat Tracks MTB Club). The intention is to revive social events such as evening markets in the lower section of the valley, and to involve local businesses in the ongoing life of the valley. There would be numerous commercial opportunities also arising from the works required and the sports and social eventing that is possible in the valley.

2.4.1.4 Costing

The costs of the actions included in the report amount to just under R50 million, which includes a R20 million contribution to the repair and upgrade of the sewerage system, an injection of R15 million to the AIV clearing, and an input of R5 million to security and safety. The remainder of the budget is focussed on the upgrades required to re-establish Dodd's Farm as a safe and vibrant nature-oriented community hub and venue (potentially a future botanical garden). The estimated revenue to be generated from the project is calculated at up to R1.56 million annually.

2.4.1.5 A Framework

The report contains recommendations for the development of a Framework with set guidelines regarding removal of AIVs, methods for removal, species to plant, methods for ongoing maintenance, and how to volunteer and participate in the overall rehabilitation efforts. A marketing drive is necessary to create awareness of the Valley (which is found to be lacking), of the many initiatives underway to reinstate the Valley as a safe, healthy natural urban area, and of the opportunities to link or partner with these. These processes should be managed by a Management Steering Committee. This MSC would oversee a group of Task Teams, each focussing on a particular aspect of the initiative – for example any of activities addressing the three key issues or within the key zones.

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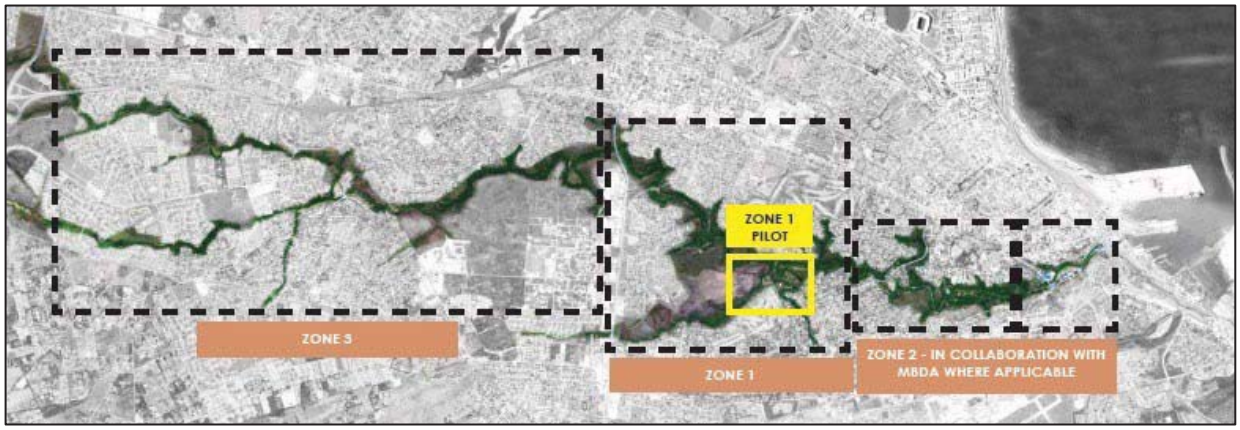

Figure 2.9 The proposed three zones of Project Green Lung: Baakens Restoration.

Figure 2.10 The proposed development of Dodd's Farm in Pilot Phase 1.

2.5 THE BAAKENS RIVER REVIVAL PLAN 2013

This is a detailed and forward-thinking landscape architecture plan focussed on the Lower Baakens River Valley. The report was authored by Rosemary Anne Buchanan and submitted in fulfilment of the Degree of Masters, Landscape Architecture, Department of Architecture, Planning and Geomatics, University of Cape Town, in September 2013. It is uncertain if copies of the thesis were distributed to MBDA or NMB Metro, however these have been made available to the MBDA by this project team, with permission of Ms Buchanan (Buchanan, pers. comm. 2022).

The first section of the work covers the theoretical frameworks for urban landscape design and development. The approach taken by Buchanan was one of 'Landscape Urbanism', which proposes a unity of the disciplines of architecture, landscape architecture, urban design, urban planning and landscape planning. Sources of inspiration for the design ideas were referred to and include landscape architect Elizabeth Meyer, who proposed the need for aesthetics and beauty in sustainable landscape architecture. Buchanan documents the numerous landscape architectural approaches which are the influences behind her plans for the river and estuary.

She states: 'It is clear that the ecological processes of the site need to be understood in terms of the functional as well as the experiential and formal opportunities. By drawing on these opportunities the design can be opened up to aspects such as process and change as well as the possibilities to integrate it into the urban and social processes. (…) The design will not attempt to mimic or restore ecology, but will rather create a new ecological basis which is designed and purposefully constructed. In this manner a new urban ecology can be formed'.

This is an interesting perspective and, in the lower section of the river (Reach 6) aligns with the aims of this WRC project, to determine the feasibility of restoring a more natural and functional ecology to the lower river, acknowledging that it is not possible in this section to restore natural form.

Buchanan's planning is meticulous and is based on a sound understanding of the basic biophysical template of the natural system, so it represents a useful resource. Buchanan makes effective use of graphic imagery (GIS map layers) to present and analyse summarised information on the upper, middle and lower catchment: geology and topography, hydrology and stormwater, vegetation, critical biodiversity areas, terrestrial and aquatic fauna, and natural processes.

This leads to a series of conclusions for each section of the river, some of which are presented in Figure 2.11:

- Habitat loss is a critical factor in the Valley and the Valley needs to have greater protection status. Development encroachment needs to be carefully monitored and pollution of the river needs to be curbed. However, activation of the Valley needs to take place and access points as well as the potential of the Lower Baakens need to be developed as a means to draw people into the Valley.

- Floods can no longer be addressed in the current 're-building of infrastructure' manner, but a more holistic approach to water run-off and bridges needs to be implemented. One solution to this problem is to implement Sustainable Urban Drainage Systems (SUDS) methods in Gqeberha and to create stormwater retention and cleaning areas. In this manner more water will be absorbed into the ground, the run-off will be slowed down and the pollution of the river will be reduced.

- Causeways and weirs should also be removed where possible as these create barriers for fish and environmental flows. Bridges with footings outside of the riparian zone are preferable. Where this is not possible, fishways (particularly in Settler's Park) should be constructed.

- River rehabilitation of the mouth needs to be implemented as part of a landscape plan for the Lower Baakens. Aspects such as re-establishing the river surface gradient and the riparian zone are critical for the functioning of the river.

From these Conclusions and the map shown in Figure 2.12, it is evident that the greatest area needing intervention is the Lower Baakens. The proximity of this area to the inner city and the potential waterfront makes it an ideal site for a precinct analysis and design proposal. The remainder of the Buchanan report focusses attention on a concept design for the lower Baakens River.

2.5.1 Buchanan's Lower Baakens Framework Plan

Buchanan (2013) writes: 'The rehabilitation of the river in the Lower Baakens forms the basis for the precinct framework. (…) there is the potential to demolish structures in the flood plain, widen the river channel and re-establish riparian vegetation. Excavation of the rubble fill in the river (as put there during the early 20th century) can be removed in order to deepen the channel and open it to tidal processes. Excavated material can be used to create landforms.'

She makes the point that lessons learnt from Berrizbeita (2009) indicate that attempting to return a river back to its natural state is not appropriate for an urban context. Rather a 'second nature' should be created through 'deliberate and physical human nature' and in places a 'third nature' may even be appropriate in areas where 'a specific intention is imposed in a quest to create a sense of beauty and aesthetic pleasure'. Despite being 'manufactured', these interventions are ecological in their aim, but incorporate the urban and social context.

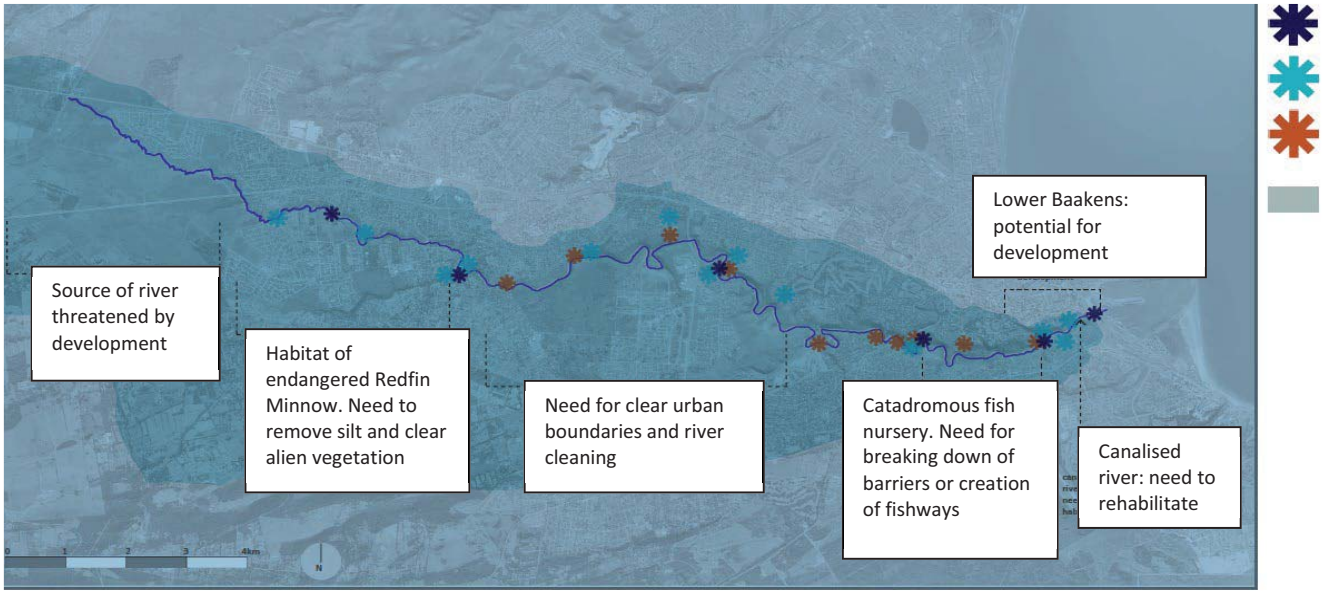

Figure 2.11 Some of the Buchanan (2013) conclusions overlaid on a plan view of the Baakens catchment. Blue star: Floodwater to be addressed; Turquoise star: Areas suitable for stormwater cleaning; Brown Star: Access Points that need to be celebrated. Source: Buchanan 2013

Conceptually the revival plan is envisioned as a combined urban and natural landscape having two nodes of activity; the city/waterfront node and the community/valley nodes, connected by a riverfront park. The nodes created gateway spaces for the waterfront and the valley respectively, while drawing people from the city centre and the suburbs. The connecting riverfront park responds 'to the imperatives of ecology, indeterminacy and phenomenology', allowing for the landscape urbanism approach of integration of the city and the landscape while providing for a number of recreational activities.

At the mouth of the river the plan includes a number of activity nodes. At the edge of the city a tourist node is envisioned, involving re-use of existing buildings, activating their edges through new structures and creating a direct city to water link. Tourist functions are further created through boat moorings for tour boats and the creation of public space enlivened with public art. Corresponding to this node is the creation of a waterfront fishing node on the fishing pier. In this way, the proposed functional activities of the waterfront can be combined with commercial tourist needs, for example through fish restaurants and a market space in the re-commissioned warehouse.

On the south bank of the river mouth the site would be extended into the waterfront through commercial functions, combined with ecological functions within the tidal zone. A cultural node would be created through the Tramways building (which was intended to function as an office and conference centre, as it does now) and the siting of a new South End Museum (this is complete and open to the public), thereby restoring the social need for memory is restored. This node would also responds to the tourist node and draw tourists to the south bank and into the park.

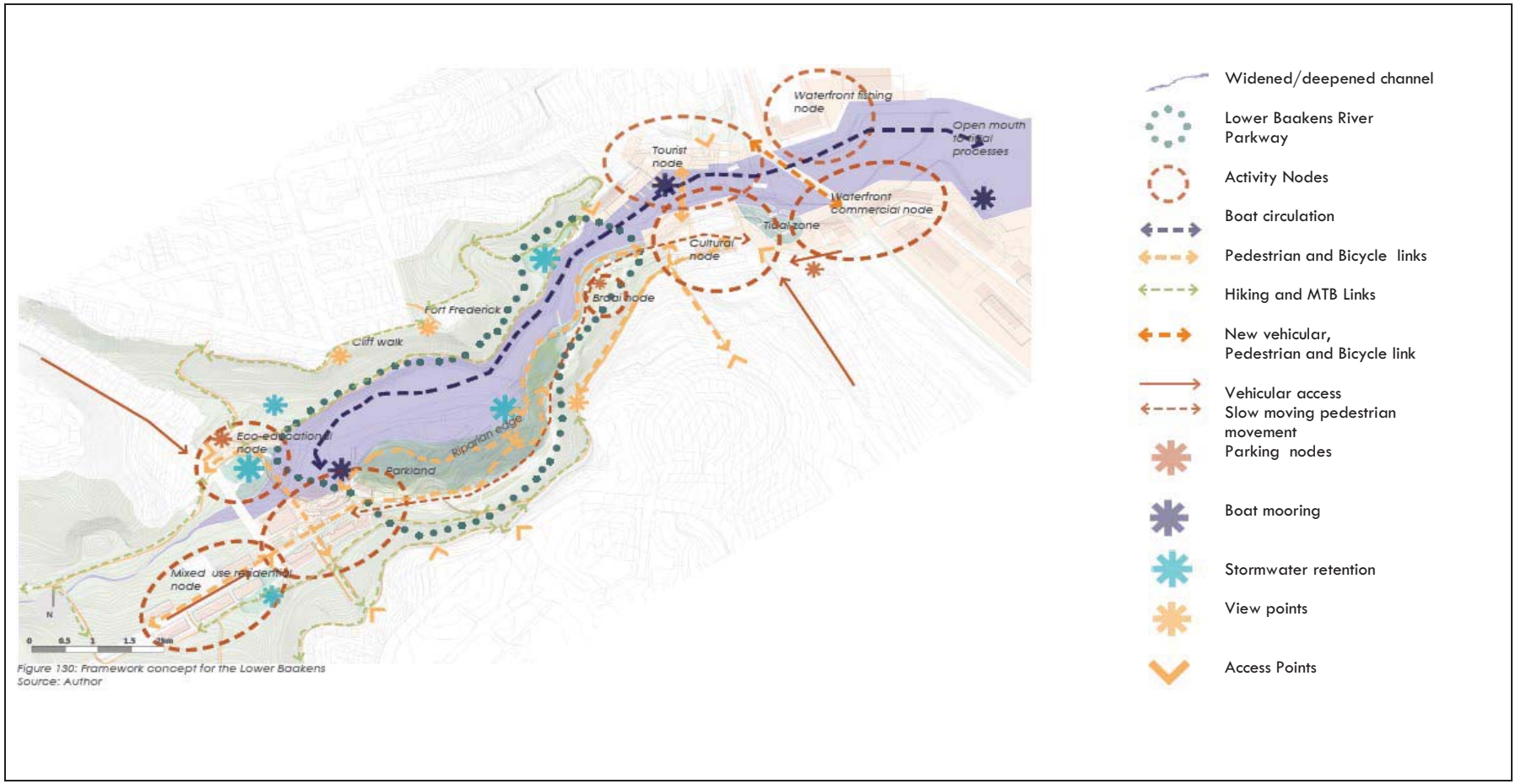

Figure 130: Framework concept for the Lower Baakens
Source: Author

Figure 2.12 Buchanan's conclusions on the Baakens River. Blue star: Floodwater to be addressed; Turquoise star: Areas suitable for stormwater cleaning; Brown Star: Access Points that need to be celebrated. Source: Buchanan 2013

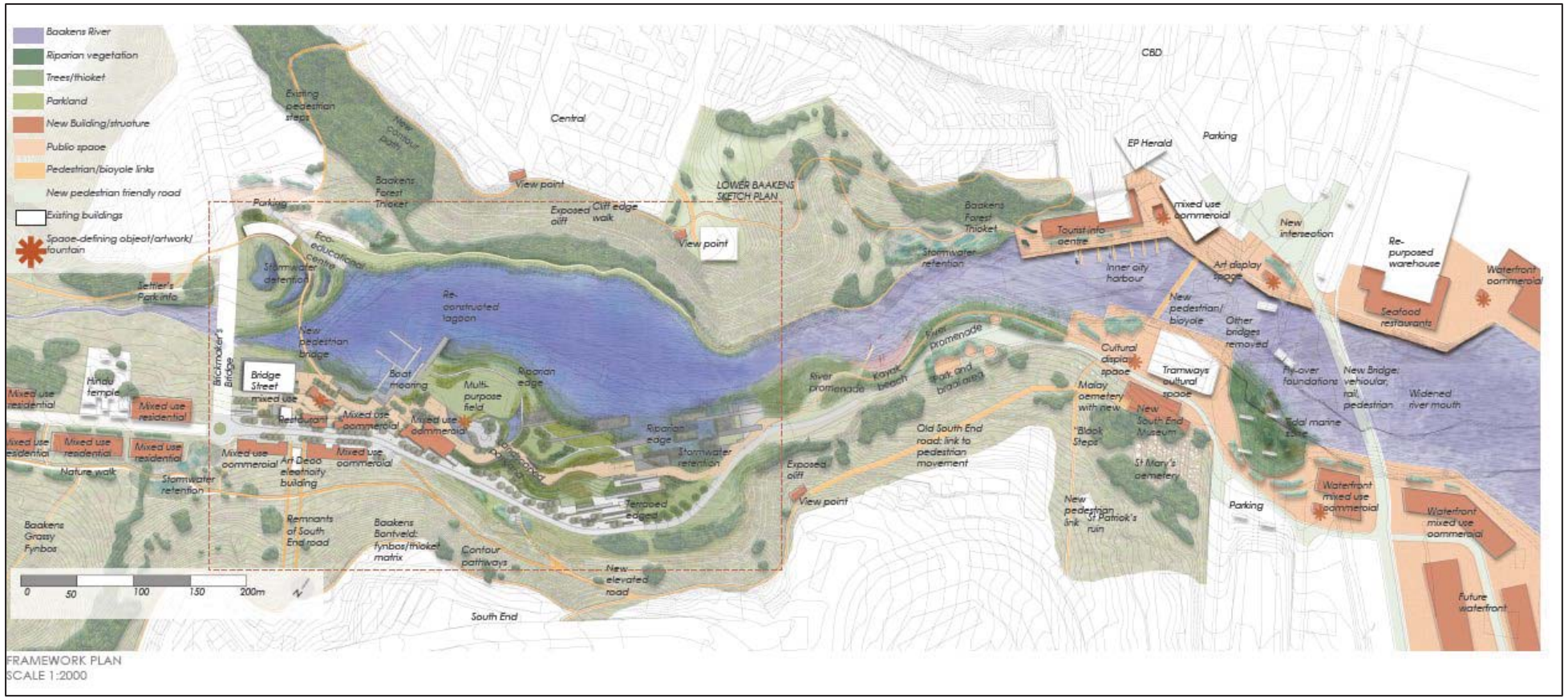

Figure 2.13 Buchanan's (2013) more detailed conceptual plan for the Lower Baakens Valley. Source: Buchanan (2013)

2.6 PROPOSED REMEDIAL ACTION FOR THE BAAKENS RIVER ECOSYSTEM (STRYDOM 2014)

This is an important recommendation made by Professor Nadine Strydom of Nelson Mandela University, in 2014. Professor Strydom is an Advisor to this project and has also been consulted in this regard during the study. Her detailed commentary regarding proposed remedial action for the Baakens is considered highly relevant and is presented in Text Box 2.1.

Text Box 2.1 Extract from a report on the status of the fish of the Baakens River (Strydom 2014)

Proposed Remedial Action for the Baakens River Ecosystem

In 2004, a framework for conserving the city of Port Elizabeth's biodiversity was established by the local municipality and WESSA (Lear, 2013), this initiative appears to have largely overlooked the continued functioning of Baakens River for fishes and does not factor in rehabilitation of the former estuary. The Baakens River is in need of immediate intervention in order to prevent further species declines.

The Baakens River and Estuary are highly modified environments at present. This is largely due to shallow canalisation of the lower reaches. Despite the recent National Biodiversity Assessment 2011 (Van Niekerk & Turpie 2012) of the lower Baakens as an estuary, the shallow canal and persistent freshwater flow impedes the upstream penetration of seawater on the incoming tide, as occurred historically in the lower Baakens, and the use of the lower reaches by estuarine fishes and marine fishes dependent on estuaries is limited. The historical nursery value of the lower Baakens has been severely impacted by anthropogenic modification. Currently, rare fishes, albeit low numbers, are still encountered in this section of the lower Baakens River, one of which is a potentially new fish species. Only three individuals of the genetically unique (Swartz 2005), endangered redfin, *Pseudobarbus afer,* were found in over a four month sampling period. The population of this species is under threat of local extinction unless drastic measures are taken.

A project is planned to improve the aesthetics of the Lower Baakens area and improve the functionality of the river/estuary, with the hope of attracting more people to the valley and promoting sustainable use thereof. It is proposed that improving the current environment to enhance ecosystem resilience and biodiversity persistence will serve to improve ecotourism and use of the inner city landscape as well as provide an opportunity to rehabilitate the lower Baakens River. Unfortunately, river ecosystems should be managed as a whole ecosystem and not partitioned in piece meal rehabilitation efforts. Problems currently facing the future of fish health in the Baakens affect the entire system and these include alien fishes, pollution and siltation. Currently, it is legislated that threats to endangered species and threats to ecosystem health need to be mitigated (National Environmental Management: Biodiversity Act 10 of 2004).

Proposed Remedial Action for the Baakens River Ecosystem (Continued….)

Remedial action along the entire length of the Baakens River needs to be undertaken prior to rehabilitation of the lower reaches. These are:

1) An immediate eradication program, focused on an annual basis, to remove excess alien mouthbrooders, and possibly also Tilapia, from the river course to create niche space for indigenous species, particularly the Eastern Cape Redfin. This can easily be achieved through passive gear like fyke nets or by means of electrofishing.
2) Major improvement in piping infrastructure to prevent sewage leaks into the Baakens River, which currently results in eutrophication of the system.
3) Cleaning up of choked river channel, removal of invasive plants and reintroduction of rocky riffles to promote redfin breeding along the river course
4) Public awareness campaign to prevent dumping of water-borne and solid waste as well as aquarium fishes in the river
5) The absence of appropriate fish ladders along the river course severely impedes the natural migration of catadromous fishes. Bok (1997) proposed remedial action in this regard to the City of Port Elizabeth and this has still not happened. Anthropogenic alteration has resulted in reduced river functionality for migratory fishes.

With reference to lower Baakens rehabilitation plans, careful consideration of rare and endangered fishes as well as the renewal of estuarine functionality needs to be made. (…)

The lower Baakens River, seaward of Bridge Street, was historically a small estuary and is still listed as an estuary in the latest National Biodiversity Assessment 2011 (Van Niekerk & Turpie 2012). The current status quo where the lower Baakens has been altered into an artificial river course is an ecosystem and conservation loss for Port Elizabeth (Gqeberha *Ed*).

It is highly recommended that the lower section of the Baakens River be rehabilitated to its natural small estuary status to fulfil biodiversity conservation initiatives. This, in effect, means that the existing channel needs to be widened and deepened along with the additional creation of small embayments along the margins of the area, preferably with suitable submerged aquatic vegetation to serve as shallow refugia for lower-river, estuarine and marine-dependent non migratory fishes. The details of which can be provided at a later stage.

Finally, it should be noted with utmost importance that any rehabilitation of the lower Baakens will require that rare fishes, namely the fishes from the Family Gobiidae, *Awaous aeneofuscus* (Freshwater goby) and *Stenogobius ?polyzona* and the fish from the Family Eleotridae, namely *Eleotris fusca* (Dusky sleeper) currently occurring in the lower Baakens area will need to be professionally removed unharmed and relocated to above the construction zone or housed in suitable aquaria for later release. This will require careful planning and actions by fish specialists in conjunction with conservation authorities.

Strydom, 2014

3 PLANNING FRAMEWORKS

There are a number of important NMB Metro spatial planning documents which guide development and planning decisions. They generally have a lifespan of 3-5 years. They are included here in brief. The detail provided is that which is relevant to the Baakens River rehabilitation and the validity of this in light of the City's own planning objectives and performance areas. The list of documents bears witness to the many years of complex spatial planning that haves preceded the proposed developments in the Valley (and particularly the lower Baakens).

3.1 THE INTEGRATED DEVELOPMENT PLAN (IDP)

The IDP is a five-year strategic plan for development that provides guidance on the budgeting and decision-making processes of the municipality. The executive committee of the local municipality manages the IDP process alongside the Executive Mayors. The Municipal Systems Act requires that that the municipality consults with the public when it develops and reviews its IDP.

The third edition of the current IDP was adopted in June 2019 and remains valid until the end of 2021. It refers to the six Key Performance Areas (KPAs) of local government:

1. Basic Service Delivery and Infrastructure Development.
2. Spatial Development Framework.
3. Local Economic Development.
4. Municipal Transformation and Organisational Development.
5. Good Governance and Public Participation.
6. Financial Sustainability and Viability.

The Baakens Valley Precinct development planning falls under KPA 1.

The long list of **Strategic Objectives** includes the following which are of relevance to the Baakens conservation of the Baakens River Valley and the restoration and revival of the lower portions of the river and estuary:

(a) Facilitate and **promote infrastructure led growth**, development and Tourism.
(b) Execute existing design and **implement new projects that competitively differentiate Nelson Mandela Bay as a destination city** for business, tourism and investment – including through strategic partnerships.
(c) Provide **infrastructure that improves the safety of communities** and visitors.
(d) **Improve the safety and security** of Nelson Mandela Bay communities.
(e) Spatial and built developments that **promote integrated neighbourhoods, inclusive communities** and a well-connected Nelson Mandela Bay.
(f) Promote the health and well-being of all communities through the **spatially equitable provision of social infrastructure.**
(g) Provide effective general environmental and public health services.
(h) Develop an environmentally friendly sustainable city through proactive planning, **conservation of resources, and natural and built environments**.

The IDP includes the NMBM Climate Change and Green Economy Action Plan (CC&GEAP) of 2015.

3.2 NMB CLIMATE CHANGE & GREEN ACTION PLAN 2015 (CC&GEAP)

The CC&GEAP (2015) is billed as an official document that guides the strategic vision for the city. It includes the identification of climate risks and vulnerabilities of the city to these risks, and proposes interventions to build adaptive capacity to cope with these risks.

The intention of the CC&GEAP is to shape climate responsiveness and resilience (CR&R) in municipal services (BEPP 2020/21). The CC&GEAP has been included in the NMBM IDP since 2017.

While the Baakens is not mentioned explicitly in this plan, the intention to include **catchment restoration** in climate-change response interventions is included, as is the recommendation to **encourage rainwater harvesting** (this would assist with flood damage mitigation in the lower Baakens River). The intervention programmes are shown in Figure 3.1 – the focus on catchment restoration, water conservation (rainwater harvesting), disaster risk management, and renewable energy are of particular interest.

Figure 3.1 The intervention programmes proposed in the CC&GEAP

3.3 NMB BUILT ENVIRONMENT PERFORMANCE PLAN (BEPP)

The BEPP is a planning tool to align, consolidate and focus the existing strategic planning instruments into a spatially targeted investment and implementation plan. This is intended to assist the city to achieve more equitable, inclusive and sustainable growth. This growth must happen in a spatially transformed city that overcomes imbalances of the past and accommodates growth and redevelopment.

According to the current BEPP: 'in terms of the city, the ecological systems and vegetation cover provide a multitude of ecosystem services. Due to diverse and convergent biomes, the potential for the metro areas to act as natural carbon 'sinks' and perform optimally as water purification systems and runoff retention is great. Open spaces are important to prevent the 'heat island' effect within urban areas.'

The NMB Metro's budget was strongly committed to the Built Environment Performance Plan (BEPP) urban network strategy and previously disadvantaged areas.

In terms of the BEPP, the Baakens Area development planning falls within the focus on the Urban Network Strategy (UNS), Integration Zones (IZ) and Economic/ Growth nodes. Within these nodes, the CBD is seen as a primary hub, in which the focus of catalytic projects is on interventions including: Development within the defined Integration Zone (IZ1), assisting with private and public sector initiatives with respect to developments; implementation of the Integrated Public Transport System (IPTS) which provides for linkages between the IZs and the wider city.

3.4 NMB BIOREGIONAL PLAN 2014

The Bioregional Plan is an important, though somewhat outdated, spatial plan providing information on terrestrial and aquatic features critical for conserving biodiversity and maintaining ecosystem function (Critical Biodiversity Areas or CBAs, and Ecological Support Areas or ESAs). It is based on the Conservation and Assessment Plan produced for the Metro in 2010 (SRK Consulting 2010).

The plan provides a map of biodiversity priorities and accompanying guidelines to inform land-use planning, environmental assessment and authorisations, and natural resource management. The statement is made that 'It is important to note that the conservation assessment was developed in a manner that attempts to minimise potential conflict between biodiversity and other forms of land-use to the greatest extent possible'.

In terms of maintaining biodiversity processes, it is noted that 'All the mainstem rivers of the Nelson Mandela Bay area need to be safeguarded in order to meet conservation targets for freshwater systems, as all have unique signatures'. The tributaries too are targeted for conservation actions in order to achieve the targets set. At the time of this Bioregional report being written, the Baakens mainstem was assessed as being 'intact' (no longer!), however its 8 tributaries were 'no longer intact'.

Included in the plan was the recommendation that all Critical Biodiversity Areas (CBAs) must be managed for the biodiversity processes and incorporated into the protected area system. The Baakens CBAs are shown in Figure 6.9. The Baakens Valley ranked 6th out of 28 identified prioritization sites for implementation of the Conservation Plan, and extension of the protected area network (specified areas in the Valley).

The plan provides management guidelines for all CBA areas which include wetland types, river reaches, estuaries and catchments. The overarching guideline is 'Keep in a natural or near natural state'. These guidelines are included as **Appendix 1.**

3.5 NMB SPATIAL DEVELOPMENT FRAMEWORK 2015

The municipality's envisaged SDF spatial vision is to, by 2030, turn Nelson Mandela Bay into a Metropole that is **socially and economically inclusive, an environmentally sustainable city, with integrated human settlements – a place of opportunities where people can live, study and participate in the growth of the city.**

The SDF deals with future spatial planning of the Metro at a detailed level which is not of special relevance to this project. Although the SDF is now somewhat outdated, it is worth noting that the intention to develop the Waterfront (Port) and Lower Baakens River was already made by this time. The proposed development plans are summarised in the SDF as follows:

'*There has been recent focus on plans to develop the Waterfront at King's Beach area. Transnet have agreed to move the oil tanks in 2016 and the manganese ore facility to the Coega IDZ in 2019. In the port planning for the port post-relocation, Transnet has agreed that a portion of land will be set aside for a marina/commercial development and this portion will not fall under the strict port security controls.*

A Steering Committee comprising of Transnet, the MBDA, NMBM and the ECDC is currently working to ensure there is a well formulated Master Plan to determine the extent and depth of retail, residential, office, leisure/ entertainment/ tourism development as well as a Master Plan that can be implemented over time. ***The Port / Baakens precinct between the Port and the Bridge Street Brewery as part of the broader Waterfront Development plan is envisaged to become a new tourism/leisure/entertainment precinct and it will be a further catalyst for the redevelopment of the area over time for non-industrial purposes.***

The development of the Baakens Valley Precinct is identified as one of the Catalytic Projects and has been through a preliminary viability assessment by the DBSA Project Preparation Facility which has concluded that the project is viabl*e.' (SDF Page 200).*

The **Spatial Development Concept** of the SDF provides strategic guidance for the spatial restructuring of the metropolitan area. It is based on a system of interrelated and integrated spatial elements which together make up the desired spatial development form for the municipal area. These spatial elements are made up of nodes, networks, surfaces, integration zones, etc. (SDF 2015).

The Baakens Valley is noted for its importance as an ecological corridor in the Metro, and deserving of 'special mention': '*It is the Municipality's most extensive corridor through fynbos habitats and is of critical importance for the continuation of ecological processes that sustain biodiversity. The area also provides numerous ecosystem services, playing an important role in flood attenuation, storm water management, environmental education and nature-based recreation'* (SDF 2015).

Listed with the Proposed Strategic Policy Interventions are the CBD Revitalisation and Urban Renewal through the recycling of land, and buildings, including derelict Transnet land in Harbour

Precinct; and the creation of City Improvement Districts (CID's) to focus efforts into specific areas such as the Baakens Valley Precinct. The Precinct (lower river) is seen to have commercial potential if derelict land can be developed. The Baakens is also included as a Catalytic Project in IZ1 of the SDF Urban Network Strategy (IZ1 includes the CBD, Newton Park and 2010 Stadium). The mandated area of the MBDA is within this IZ which is seen to hold significant potential for inner city revitalization, with projects like the Lower Baakens Catalytic Project.

Of relevance to the Baakens Rehabilitation Study is the following. In terms of the SDF, the Baywest area along the N2 was recognised as a **regional node** due to the magnitude of the projects taking place (at that time – 2015). The N2 Development/Bay West project included a super-regional shopping centre, a mixed-use residential development (8000 residential opportunities), and a 400 000 m² development of high-tech warehouse, offices, a motor city, and light industrial area. The development of the Baywest Mall and the ancillary developments/services was seen as an anchor that would stimulate developments in the immediate vicinity, i.e. opportunity to promote intensification of residential densities, light industries, etc. within ±2 kms of the node. The Baywest area was one of six Integration Zones (IZ6), with the following rationale:

The potential, capacity and significance of the Baywest/ N2 Node as catalyst for intensified integrated and mixed use development at scale, has contributed to the inclusion of the larger development area of this node as a sixth Integration Zone (IZ6). This integration zone holds the potential to attract private sector investment in the development of the node/ zone which should be harnessed because of its potential to be a significant generator of rates income.

While this spatial planning outlook may have changed in the intervening years (this has yet to be established), these proposals regarding the Baywest/N2 Node are significant in terms of the recommendations made in this report, which include a recommendation for formal protection of this area.

3.6 MBDA FIVE YEAR DEVELOPMENT PLAN 2018

This is the Development Agency's own 5-year Strategic Plan, commencing 2018. As discussed, the MBDA is an implementing agent for projects and events which align with the IDP, BEPP, SDF, Local Spatial Development Plans (LSDF), zonation plans, and precinct and policy plans as developed by the various departments of the Metro, or identified through MBDA's own research and consultation (see Figure 3.3).

Mission To become a knowledge-based development agency that seeks to achieve social, spatial and economic transformation in the Nelson Mandela Bay

Vision To develop an iconic world class ocean city showcasing its diversity, culture, heritage and environment

Strategic Objectives 1. To pioneer and implement people-centred catalytic programmes, 2. To create spaces that inspire and transform the Nelson Mandela Bay, 3. To develop and promote a creative culture in the Nelson Mandela Bay.

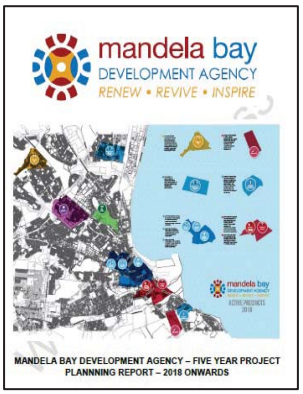

Figure 3.2 The Mission, Vision and Strategic Objectives of the MBDA

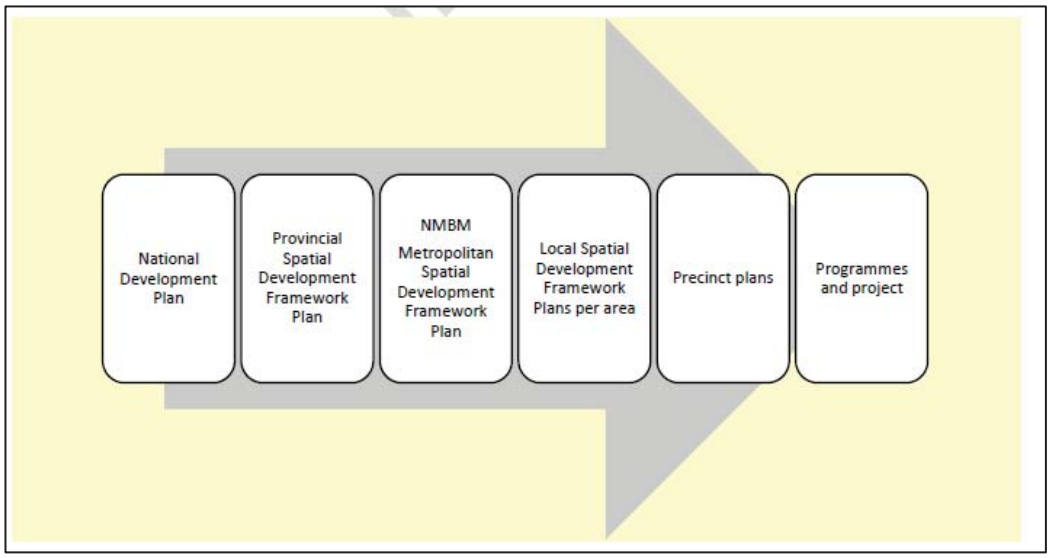

Figure 3.3 The various planning layers informing spatial development, programmes and projects within the MBDA

The projects within the designated areas of MBDA align with these documents and their objectives; and the desired outcome of all projects align with the NMBM's mission, vision, and strategic objectives (

Figure 3.2), and the six pillars or foundations on which the development priorities are hinged: Well Run City, Opportunity City, Inclusive City, Caring City, Safe City, Forward-thinking City.

The MBDA Projects are clustered around five Precinct areas, one of which includes Gqeberha Central (CBD), Baakens Valley, and Happy Valley. The Key Objectives per area for projects include: Master and Precinct planning, infrastructure development, fundraising, research and development, partnership development, maintenance and operation, and marketing and activation. The focussed elements are catalytic and include targeted multi-sector interventions, area management facilities management and partnerships and research.

The Baakens Area Report included in this Development Plan deals exclusively with development planning for this area, and cites the inclusion of the Baakens within the key planning reports. The development of the area falls within the IDP Key Performance Area 1 (Basic Service Delivery), and aligns with three of the six pillars: the safe city, the inclusive city and the forward-thinking city.

In terms of the BEPP report, there is a focus on the Urban Network Strategy (UNS), Integration Zones and Economic/ Growth nodes, of which Gqeberha CBD is seen as a Primary Hub, and in which the focus of catalytic projects is development interventions. In terms of the SDF, the Baakens is named as one of the Urban Renewal projects.

In terms of the NMBM Inner-city Local Spatial Development Framework (which is referred to in this Five Year Plan, but could not be accessed as a full report), the Baakens River Precinct has the following Development Vision:

- Providing an area for higher density residential development, supported by sustainable entertainment, employment, and public transportation provision;
- Linking the inner core to the Baakens Conservation Zone as well as the Harbour Development;
- Carefully conserving the Baakens River and its floodplain.

The Development Guidelines include mixed-use zones (non-intrusive, recreational and offices), special residential areas, and conservation zones and corridors (Baakens River Valley Reserve and Harbour precinct).

The stakeholders identified for the implementation of projects in the area include youth, organised business, Nelson Mandela Metro University, environmental lobby groups, NMB Tourism and its members, South End Museum and members, Wildlife and Environment Society of SA and its members, NMB Heritage Trust, sporting bodies, adventure groups, private sector owners, etc.

The 'Problem Analysis' for the Baakens area includes:

- The Baakens River precinct is a under underutilised parcel of land in the heart of the inner-city area.
- The river is very polluted by broken sewers that occur upstream.
- The precinct is prone to severe flooding from time to time.
- There are limited resources within the NMBM to upgrade the land and improve the infrastructure.
- The single sector economic focus on urban regeneration is not adequate in dealing with the transformation of the area.
- There are limited tourism opportunities that have been developed.
- The green heritage of 23 km of pristine river frontage has not been exploited to its maximum.

None of the listed objectives in the LSDF speak directly to the rehabilitation of the river, but they do include objectives relating to increasing tourism. The Interventions listed do however include 'Environmental rehabilitation of the North and South Bank (of the lower Baakens), which includes removal of alien vegetation'. Included in the Assumptions list is 'Partnerships with key land and property owners and other stakeholders in the Inner-city'. One example of this being currently actioned is the working relationship between MBDA and the Mandela Bay Business Chamber in regard to the Baakens River.

4 PLANNING OF THE REHABILITATION SCENARIOS

4.1 THE PROCESS OF DEVELOPING SCENARIOS

The development of the rehabilitation scenarios arises from the following broad process:

1. A review of the available literature on the Baakens river, estuary, catchment and the surrounding areas. These include historic studies on the river; scientific, engineering, planning and other reports (some of which were commissioned by the Metro or the DA), archived literature, news and online reports, blogs and other sources;
2. A broad understanding of the development prospects for the river, particularly in its lower reaches. This has been developed based on exposure to the various initiatives discussed in Chapter 3, on Nelson Mandela Bay Metro's development programme, and on the MBDA's plans for the revitalisation of the South End Precinct. The latter has, in turn, been acquired from all available documentation, interaction with the MBDA and the Mandela Bay Business Chamber, a visit to the South-End Museum, discussions with historian Dean McCleland, and extensive review of literature and popular articles regarding the river and its history.
3. Ongoing discussions with (or observation of activities within) with MBDA, local government officials, and the catchment community, engaging both one-on-one and in various online or popular WhatsApp forums.
4. Focussed time spent in the catchment with the specialist team over the period of 2 days in April 2022, 6 days in May 2022, and another 3 days in November 2022. This included driving the catchment and stopping to walk various sections of the river reaches, specialist surveys of the four sites for riparian vegetation, fish, invertebrates; results of the analyses of these data (PES, EIS and Ecostatus Report, Uys et al. 2022); workshopping of present ecological state results and initial development of rehabilitation scenarios.
5. Meetings online and in person with numerous stakeholders both in Gqeberha and online to discuss issues and considerations (see Stakeholder Engagement, Chapter 8).

4.2 MAJOR ISSUES AROUND WHICH TO DEVELOP SCENARIOS

On the basis of what is now know of the Baakens River catchment, there are seven major issues of immediate concern to the ecological health of the river, and to the communities wishing to make use of the river or its catchment: **water quality, water quantity (floods), system connectivity (lateral and longitudinal), channel form (lower river), biodiversity, habitat, and safety for recreational access**.

4.3 THE THREE SCENARIOS

The ecological issues which are considered most urgent for the city to address, which align best with the MBDA Baakens Precinct Development plans, and which best compliment the recommendations of the Mantis Group Report (2022) have been shaped into three scenarios for rehabilitation. For each scenario there are a number of proposed interventions which will assist in achieving the objective set.

Scenario 1: Address water quality deterioration catchment-wide
Scenario 2: Manage water quantity (floods) and the river's natural flood management (NFM) capability
Scenario 3: Re-establish system connectivity, naturalise channel form and improve habitat.

4.4 SCENARIO WRITE-UPS

Each of the three rehabilitation scenarios is written up to include the following:

- An introduction or a description of the Baakens River current state;
- A brief description of the problems associated with this issue;
- The rehabilitation objectives (these are considered preliminary);
- A suite of possible interventions to contribute towards achieving the objectives.

It is important to note that the scenarios and the interventions are conceptual in nature at this stage. This is the early stage of a rehabilitation project, and detailed design is only considered once further work has been done to assess the proposed interventions (see Figure 1.1).

5 SCENARIO 1: ADDRESS WATER QUALITY DETERIORATION

5.1 WATER QUALITY CURRENT STATE

The term 'water quality' encapsulates the physical, chemical, biological and aesthetic properties of water, which determine its fitness for a variety of uses and for protecting the health and integrity of the aquatic ecosystems (Evans et al. 2021).

The Present Ecological State of the water quality in the Baakens River at the four study sites (1-4) was assessed as a **C category** (moderately modified) at Sites 1, 2 and 4, and an **E category** (seriously modified) at Site 3. The applicable percentage ranges for these categories were presented in Section 1.4.

5.2 WATER QUALITY: PROBLEMS

In recent months the water quality situation in Gqeberha has become extremely serious, and the water quality PES may have deteriorated from the reported values in May 2022. There are regular reports of raw sewage being discharged directly into the Baakens River (Loyiso 2022, Algoa Bay Ocean Stewards 2022). The effects of this continuous pollution on the river biota is considered by catchment community members to be a form of 'ecocide'.

The issues arise mainly from sewage inflows into the river and dumping and washoff of litter. Addressing these issues should be viewed as a **top priority for the Metro** as the riverine system is rapidly losing the capacity to support biota, and is becoming a threat to human, animal and plant life. The rehabilitation interventions therefore are not considered an option but a legally-mandated requirement of the Metro. If water quality is not attended to in the short-term, there is limited value in rehabilitating other riverine aspects.

The National Green Drop Report (2022) reports that the Metro Green Drop score decreased from 81% in 2011 to 56% in 2022. The Driftsands Collector Sewer (the treatment site for sewage collected in the Baakens River catchment) and the Cape Recife Wastewater Treatment Works (WWTW, where wastewater is treated and treated effluent is discharged into sea via a marine pipeline), achieved a Key Performance Area (KPA) rating of 73% versus 91% in 2011.

The publicly available Metro's Sewerage Master Plan is dated 2009. This has reportedly been updated, but any such updated document is not available to the public and could not be sourced by this Project Team despite a number of attempts. In the absence of such a document or a current situation analysis it is difficult to pinpoint the areas in which there are specific issues, and for this reason the water quality issues is dealt with here as a generic, catchment-wide problem. It is beyond the scope of this project to do detailed investigations of specific problem areas, and the need for a Situation Analysis is included here as a priority.

The Metro has 'Wastewater Risk Abatement Plans' (WRC 2011) which *'provides a practical approach to the management of the entire wastewater system from catchment through treatment to the receiving environment and end users in order to provide an effective means of consistently, responsibly and sustainably ensuring the safety of wastewater treatment and its by-products. The wastewater risk abatement plans are implemented through practical risk management based on scientific best practices and supported by appropriate monitoring, management and good communication.* These do not speak to planning or intervention however.

The problems described in Section 5.2 are those determined during fieldwork, discussions with Community groups and Controlling Authorities, online presence on community watch groups, and review of published reports and articles.

5.2.1 Problem: Maintenance

According to Mayor Retief Odendaal, posting specifically on the sewage issues in Gqeberha (Facebook Post 14 November 2022, Text Box No. 1), 'over the past couple of years the metro continued to spend, on average, less than 1.8% of its total budget on maintenance and repairs. This severe neglect has now finally caught up with us and it will be a mammoth task to get our infrastructure back on track'.

The photographs accompanying this post indicate that some of the pump stations in the Metro have been ransacked for the pumps and major external power cables have been stolen (this is reportedly also a common issue in the Baakens catchment).

5.2.2 Problem: Sewage pump stations

Pump station faults of various types also result in random dysfunction and sewage spills into the river. Many pump stations in the catchment are in urgently need refurbishing and upgrading of infrastructure, capacity, pumps or all of these; maintenance and skilled management. This problem is receiving high-level and ongoing attention of the current Executive Mayor, Retief Odendaal, together with his Executive Committee and the Multiparty Coalition; in partnership with the Nelson Mandela Bay Business Chamber, who are assisting with expertise and the identification of interventions required, inter alia (see Text Box 5.1).

The broad problems that have been reported with the pump stations in the catchment are presented here. As no information was forthcoming from the Metro despite numerous requests via formal email, supported by letters of request from the MBDA and phone calls, the problems presented here, and the generic interventions recommended, have been distilled on the basis of:

- Review of documentation available: Metro documents, the Green Drop Report (2022), journal papers, news articles, social media posts;

- Interaction or scanning of community-driven social media groups (e.g. Algoa Bay Ocean Stewards), following posts in this regard on social media (Facebook, Instagram);
- Discussions held with landowners, community members and activists, municipal staff, and contractors to the Metro (present on site at time of sampling).

Some of the (generic) problems at the pump stations in the Baakens catchment, as far as can be established from community members and other sources, are as follows:

- **Vandalism:** Pump stations are regularly vandalised, equipment and cabling is stolen and in some instances buildings are destroyed. This represents a high cost for Council.
- **Lack of adequate security:** the security at the pump stations is reportedly poor. There are no high-level cameras and no guards.
- **Pumps fail:** during loadshedding worse than Stage 4, power to the pump stations is lost, and raw sewage runs directly into the river. Apparently there is no emergency protocol for this situation.
- **Generators:** While some pump stations do have generators, in some instances these are not functioning and in others they have been vandalised or stolen.
- **Pumps also malfunction for other reasons:** such as a lack of parts to repair them, and poor procurement processes;
- **Lack of backup pumps:** The majority of pump stations are reportedly running on the main pump and there is no backup pump.
- **Screening** of influent sewage is not being done at all pump stations, many stations apparently do not have screens at all. Numerous issues are associated with this. Larger items in the sewage stream (e.g. rags, other foreign objects) are not screened-out and can damage pumps or block the sewerage system down-slope. Operators apparently do not have anywhere to throw these rags when they are removed.
- **Emergency sumps:** There are (reportedly) no emergency storage sumps at the pump stations. The intention behind these structures is that they are able to store wastewater unable to be conveyed in the sewerage system, over a period of 6 hours. hey do have associated problems: if not evacuated (by a honeysucker) they are a source of odour and possible ill health. Design would need to accommodate this.
- **Emergency procedures are apparently absent** or dysfunctional: during emergencies (i.e. non-functioning pumps) there is no procedural plan to prevent sewage overflow. This overflow should be regularly extracted by pumping from the sump with a 'honeysucker'. This is not being done as there are no longer any contracts in place to facilitate this (this has been verified by two sources).
- **Contracts with honeysuckers businesses have expired**: While there were formerly contracts in place for emergency services at pump stations during times of power outages or pump failure, these contracts have reportedly expired.
- **Parts procurement:** This is reportedly one of the biggest issues holding up efficient maintenance of the sewage stations.

- **Lack of payment:** Apparently another issue is the lack, or tardiness, of payment to the businesses contracted to fix and maintain pumps and other parts. As a result, these items are retained until payment is made.
- **Poor staffing:** there are reportedly not adequate staff to allocate a trained individual to each pump station. The track inspection function for the Metro is reportedly understaffed and at minimum one additional trained, competent track inspector is required for patrolling of the sewer lines and reporting on issues.

5.2.3 Problem: sewerage system

According to community members, there are a number of hot-spots in the catchment (not listed here) where foreign items such as plastic, glass, clothing, glue, paint, cement, sanitary items including nappies, blankets, tips, rags and packets are flushed, or physically thrown into, the sewerage system. These items typically cause blockages in the system and can result in surcharge of raw sewage into the river.

It is also common in urban areas that residents route their stormwater into the sewerage system. During storm events this results in the system exceeding capacity and surcharging (from open or damaged manholes) sewage into the river during high rainfall events. It is likely that large items such as those listed previously also make their way into the sewerage system this way.

As a result of the drought experienced in recent years in Gqeberha, many of the sewerage pipes and manholes have also been physically damaged due to plant roots physically 'breaking in' to find water. These roots have to be physically removed, which requires intensive labour.

5.2.4 Problem: Litter

Litter is another perpetual problem in the Baakens River, with community members and groups taking action themselves to collect waste at stormwater egress points (see Text Box 5.2). Litter that is not collected as part of normal city clean-up function tends to collect at stormwater drains and can be washed into the system during rainfall events. It is important to note that not all community lay the blame on the Metro, many recognise their own role in the problem and propose that they avail themselves of the opportunity to address it.

Text Box 5.1 A Facebook post by Mayor Retief Odendaal regarding the sewage infrastructure of the Metro.

FACEBOOK POST

by Mayor Retief Odendaal, Executive Mayor, Nelson Mandela Bay

14 November 2022

The Metro is facing an unprecedented crisis with regards to sewerage infrastructure. Years of insufficient budget for maintenance and repairs of the existing sewerage infrastructure coupled with the fact that most capital funding has been directed to drought mitigation and water augmentation projects have resulted in the near collapse of our sewerage infrastructure.

Our waste water treatment plants are not functioning properly, most of our sewerage pump stations have serious challenges and in certain areas sewerage pipelines have collapsed.

Making matters exponentially worse is the fact that the metro currently does not have a contract in place for sewer cleaning by contract plumbers. This is as a result of some tender irregularities that were discovered.

My colleague and MMC for Infrastructure and Engineering, Cllr Dries van der Westhuyzen, has been working around the clock to facilitate emergency maintenance work where possible.

The NMB Business Chamber has now reached out to us to assist the municipality in dealing with the impending crisis. They have already facilitated inspections of much of our sewerage infrastructure by experts in the field.

Over the next couple of days the NMB Coalition Government will make pronouncements on the following:

1) Emergency contracts for sewer cleansing and maintenance;

2) The establishment of a possible public-private partnership with the NMB Business Chamber to assist in the fast tracking of emergency repair work to sewerage, bulk and other infrastructure.

3) The shifting of budget to fund the emergency repair work and/or the maintenance work.

Over the last couple of years the metro continued to spend, on average, less than 1.8% of its total budget on maintenance and repairs. This severe neglect has now finally caught up with us and it will be a mammoth task to get our infrastructure back on track.

The new coalition government will prioritise spending on maintenance and repairs of all existing infrastructure so that we can get NMB working again. I am aware of the backlog in sewer problems across the metro and hope that we shall soon be in a position to proactively address most of the bigger challenges which we are facing.

Enjoy your Sunday! #getNMBworkingagain.

Executive Mayor Retief Odendaal



Text Box 5.2 A Community Member's Facebook post regarding litter collection in the Baakens. (The name of the community member has been removed)

FACEBOOK POST

Community Member X is at Baakens Valley.

November 3 at 9:38 PM · Port Elizabeth ·

In only 2 weeks we have removed 15 bags of litter from the Baakens River in Gqeberha.
All of this was collected in 2 days (once a week) from 1 spot where a stormwater canal flows into a small tributary of the main river. Our nets aren't even stopping all the litter! Imagine how much litter is entering our rivers every time it rains!
This waste is coming from our streets. We are the problem. We can't blame foreign ships or other people this time. Let's stop litter at the source!
Many parts of South Africa are prone to droughts. It has so many ramifications but we can also use it to our advantage. We have more time to remove litter from the streets before it can enter the water systems. Prioritize clean cities!

5.3 WATER QUALITY OBJECTIVES

The initial water quality objectives are:

- To address current sewage issues in the catchment (pump stations, sewage lines, manholes) and to augment systems for future predicted loads,
- To improve water quality in the Baakens River catchment (whole river) to a sustained C category for the full length of the river in the short-term (1-5 years) and to a B/C category over the longer term (5+ years);
- To achieve Green Drop KPA status for Cape Recife WWTW of 80% by 2025;
- To implement monitoring of physico-chemical water quality in the river on a monthly basis and biomonitoring on a quarterly basis, and reporting in public media;
- To reduce health risk to people visiting / utilising the river valley to zero.

5.4 WATER QUALITY: REHABILITATION INTERVENTIONS

5.4.1 Water quality intervention: Sewage Situation Assessment and Management Plan

It is beyond the scope of this Project to identify the repairs, maintenance and upgrades required to each pump station and to the sewerage network in the Baakens Valley. The maintenance and management of all components has been poor and this has led to a failure of the entire system. The first step to remediating this situation would be to commission a full Situation Assessment and Sewage Management Plan for the catchment. This should be done by qualified Sanitation Engineers. A Public Participation Process should be a core component of this study. The Intervention Plan should be phased over 5 years, to be fully budgeted so that it can be absorbed into the next budget cycle and included in the next IDP.

Responsible Party: NMB Metro

5.4.2 Water quality intervention: Implement recommendations of the Plan

Phased implementation of all remedial measures identified in the aforementioned Situation Assessment and Intervention Plan. This will include urgent repairs, upgrades, modernisation and expansion of pump stations. All pump stations should have emergency sumps and generators installed, as a basic requirement with the current load-shedding situation.

Responsible Party: NMB Metro

5.4.3 Water quality intervention: Institute training of staff and management

All technical staff and management operating in the sanitation environment should undergo further education and training to ensure competence in all aspects of system operation, particularly that of the pump stations. In addition, a mentorship programme would serve to extend this training into the more practical sphere of pump station and WWTW operation and maintenance.

One training aid of relevance may be the SEWPUMP tool of Jacobs et al. (2015). This was developed in South Africa in 2015 as part of a project to: (i) aid operators with sewage pump problem identification so as to help understand and identify problems at sewer pump stations, (ii) facilitate communication between pump station operators and technical management, and (iii) provide for basic training regarding sewage pumping and related problems that could be used

by individuals for self-study and by managers to facilitate training. It was intended that the outcomes of this project would aid a municipality and their engineering consultants to better understand the working of a sewage pump station and the related problems. The authors of the associated report (2015) concluded that 'the expectation of a maintenance free sewage pump station should be replaced by empowerment'.

5.4.4 Water quality intervention: Manage litter

Install litter traps at key stormwater points in the catchment, backed up by a maintenance and management plan to ensure that these are regularly cleared. Launch a city-wide anti-litter campaign with rich media presence, along similar lines as the highly effective 1970s 'Zip it in die Zibi' campaign.

Responsible Party: NMB Metro in collaboration with Media specialists, Business and Community

5.4.5 Water quality intervention: Implement and maintain monitoring

- Continue water quality monitoring at existing points in the catchment plus 1-2 more sites upstream of these. Ideally new monitoring points should be downstream of sewage pump stations.
- Upload data and interpretation for both monitoring exercises to Metro websites within a week of sampling.
- Prepare a response plan for water quality in the environment which does not meet the DWS Water Quality Guideline Recreational Standards (DWAF 1996).

Responsible Party: NMB Metro, DWS

- Implement biomonitoring of fish and invertebrates at the four sites in this study twice to three times annually.
- Data and interpretation for both monitoring exercises to be uploaded to DWS, Metro websites and the Freshwater Biodiversity Information System (FBIS) within one week of sampling.

Responsible Party: Department of Water and Sanitation

5.4.6 Water quality intervention: DWS involvement and monitoring

The Department of Water and Sanitation (DWS) needs to play an active role in ensuring its Green Drop (2022) recommendations are implemented and compliance is achieved. Regular monitoring of the river at the DWS monitoring points should be reinstituted as a matter of urgency. Biomonitoring for fish, plants and invertebrates is critical to record the trajectory of the system in terms of the effect of water quality on biodiversity. Transparency is also required with the publication of the metro rivers' water quality and biomonitoring test results in public media (the website results are inaccessible to many).

Responsible Party: DWS

5.4.6.1 Water quality intervention: Foster community action

Community clean ups or appointment of clean up crew for catchment cleaning (different sections daily) or task river rangers with this function.

Responsible Party: Community Groups and Ratepayers

6 REHABILITATION SCENARIO 2 – MANAGE WATER QUANTITY

6.1 INTRODUCTION

In the context of this study, water quantity refers to the amount of water moving through the river system at a given time or place, more commonly referred to as flow or discharge (volume of water per given time), and measured in metres cubed per second ($m^3.s^{-1}$).

While the water quantity issues of concern to the greater Metro area are both droughts and floods, in the Baakens Valley, the main water quantity concern is the floods. Historically, floods in the catchment have caused numerous fatalities and major infrastructural damage (see Uys et al. 2022 Chapter 2), and with climate change this threat is increased. Improved management of floods in the catchment is considered urgent (e.g. SRK 2014), and was recently raised as a focus area in a meeting between the MBDA, the NMB Business Chamber and this project team (see Chapter 8).

Although flood management is typically an engineering and disaster-management function, here it is considered a rehabilitation intervention in the sense that much of the natural flood management (NFM) capability of the river has been lost and needs to be gradually returned to the system. The rehabilitation interventions designed to address the water quantity issues in the catchment focus on ways in which to return some of this NFM capability; on measures to mitigate flood threats; and on means of developing an understanding of natural and current baseflows.

6.2 WATER QUANTITY PROBLEMS

6.2.1 Problem: Floods

The NMB Metro Bioregional Plan (2014) states that 'The Baakens River Valley, which forms an east-west corridor through the urban expanse of the municipal area … is the municipality's most extensive corridor through fynbos habitats and is of critical importance for the continuation of ecological processes that sustain biodiversity. The area also provides numerous ecosystem services, **playing an important role in flood attenuation, storm water management**, environmental education and nature-based recreation'.

While this should be true, the river system has been substantially impacted by urban development, and much of the river's ability to naturally manage flood flows has been compromised.

Historically, and in more recent years (1908, 1968, 1981, 2006, 2015), major floods in the catchment have been responsible for human fatalities and major damage to urban infrastructure (bridges, roads, buildings) and personal property (houses, cars, furniture). In terms of fatalities, the 1968 flood claimed the lives of at least five people and 30 or more were rescued. There were nine confirmed fatalities in the 2006 floods.

Records indicate that in the Great Flood of 1968, precipitation of 428 mm was recorded over a six hour period. The flood was estimated to have a 1:200 year recurrence. Fourteen years later, in 1981, precipitation of 224 mm was recorded over a 24-hour period. The latter flood was estimated to have a larger than 1:100 year recurrence.

In the 2006 flood, precipitation of 201 mm was recorded over a 39 hour period. The peak flood discharge at the Lower Valley Road bridge was 525 $m^3.sec^{-1}$ (Iliso 2007). The lower part of the catchment is the most vulnerable area during floods as this is where the river is constrained, there is a great deal of development, and the flow is cumulative from the upper catchment. Humans, infrastructure and homes in this area are most at risk. In this section, the predicted peak flows for a 1:50 year flood were modelled as 300 $m^3.s^{-1}$ and for a 1:100 year flood, as 567 $m^3.s^{-1}$ (SRK 2014).

By 2007, the effect of urbanization and development of the Baakens catchment area was estimated to have increased the Probable Maximum Peak Flood (PMPF) by more than 100% relative to the pre-development state (Iliso 2007). Extensive development has occurred since 2007, suggesting that this increase would now be in excess of 100%. The inference is that floods are likely to be higher than predicted, and that major management interventions should be under consideration.

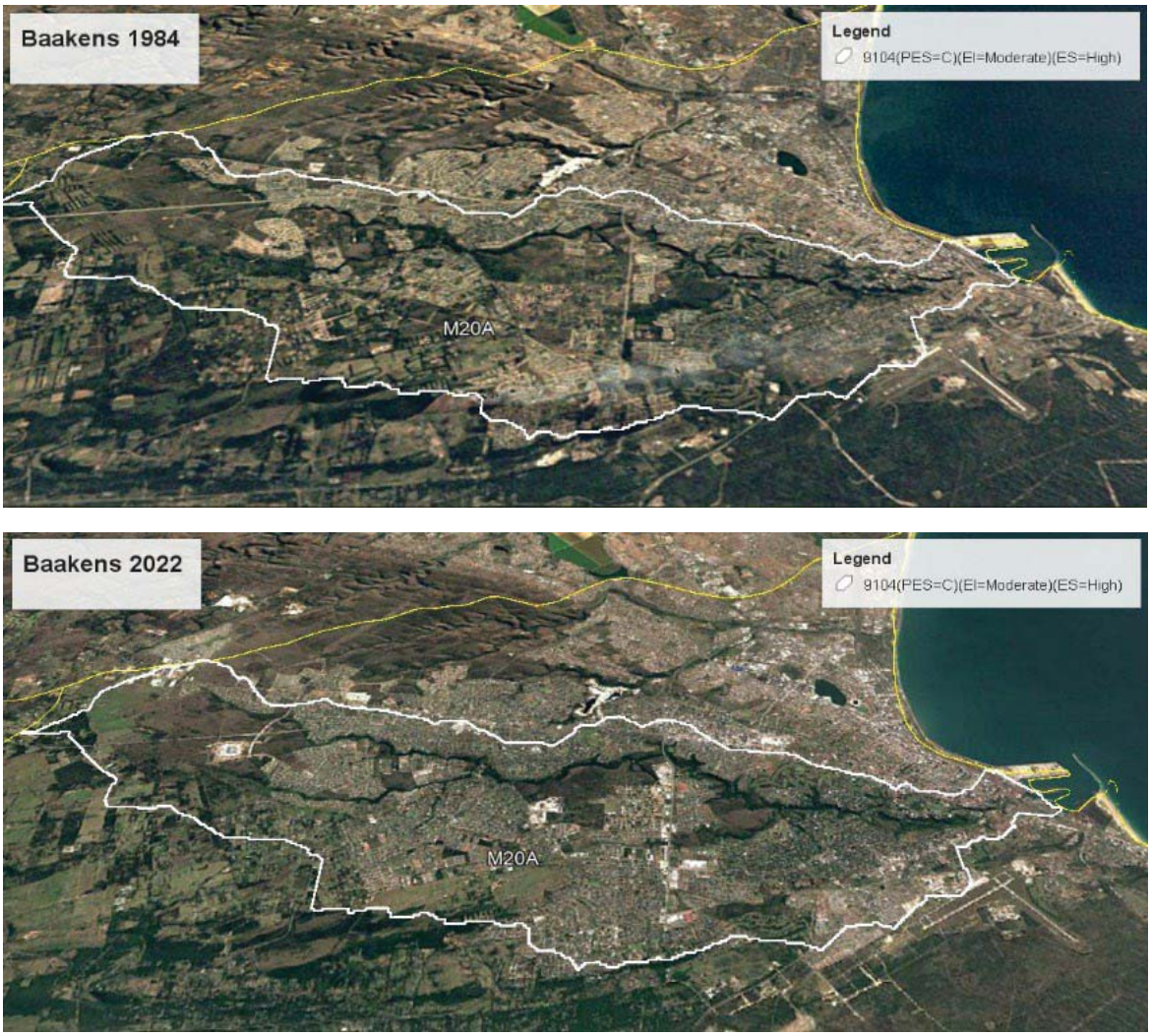

Figure 6.1 Google Earth © Aerial Imagery showing the extensive increase in urbanised area of the Baakens catchment over the past 38 years (1984 to 2022)

6.2.2 Problem: Loss of Natural Flood Management (NFM) capabilities

In the Baakens, NFM capability has been significantly reduced. These changes are attributed to, inter alia:

- Extensive urban development in the catchment which has resulted in a major increase in hardened surface, a reduction in infiltration of precipitation to groundwater, and a major (unquantified) increase in stormwater runoff.
- The extension of the hydrological network due to the construction of paved areas, roads, bridges and river crossings. There are at least ten bridges and multiple stream barriers (low-level crossings and weirs) in the 23 km of the Baakens River.
- Clearing of, and development in, the floodplain, in many instances resulting in a loss of floodplain function and the partial severance of the important channel-floodplain connection.
- Further changes in the river's longitudinal and lateral connectivity (source-to-sea and channel-to-floodplain respectively).
- The unmanaged spread of alien vegetation in the catchment, much of which is invasive. In particular the alien vegetation in the uppermost catchment (Port Jackson willow) has impacted the functionality of the upper catchment wetlands.
- Loss of vegetation cover due to agriculture and urbanisation. This has also resulted in changes to soils, including a reduction in their water retention and infiltration capacities. Runoff has increased even in grassed areas due to both the increase in hardened surfaces (including the soil), and likely loss of soil organic matter.
- The severe restriction of the lower river as the result of infilling and canalisation which began in the 1860s. Finally, this section of natural river and estuary was replaced with gabion-lined or concrete canals in order to increase available land. This represents a significant loss of channel capacity for high-flow and flood conveyance. Flow width (and likely depth) has been significantly reduced, instream and marginal habitat has been lost to reduce channel roughness, and the channel has been straightened to allow for an increase in flow velocity.
- Further modification of the river mouth as a result of several bridges being built across it.

6.2.3 Problem: Alien Invasive Vegetation (AIV)

By James MacKenzie

The dense stands of alien invasive vegetation (AIV) in various parts of the catchment also contribute to reduced biodiversity value and NFM capabilities (Uys et al. 2022). According to Grobler (2012), 23 alien species were recorded in the Valley as early as the 1970s (Olivier 1977). In many areas, these species had already largely replaced the indigenous vegetation and become the predominant vegetation (McCallum 1981, Grober 2012). In the upper parts of the catchment, in the Fynbos area, Port Jackson (shown in the following picture) is invading vitally important hillslope seepage wetlands and unchanneled valley bottom wetlands. AIV is a significant user of both groundwater and water stored in the river bank, and significantly degrades biodiversity value.

The most common and well-known species currently occurring in the Baakens River valley are declared weeds (Category I) and ornamental invaders (Category III) under the Conservation of Agricultural Resources Act No.943 of 1983 and Amendments R280 of 2001. These include the Category I weeds *Acacia cyclops* (Rooikrans)*, A. longifolia (*Long-leaved wattle*), A. mearnsii (*Black wattle*), A. saligna* (Port Jackson Willow), *Eichhornia crassipes* (water hyacinth), *Hakea drupacea* (Sweet Hakea), *Lantana camara* (Lantana), *Opuntia ficus-indica* (Sweet Prickly Pear), and *Sesbania punicea* (red sesbania), and the Category III weeds *Eucalyptus lehmannii* (Bush Yate) and *Pinus halepensis* (Aleppo pine; Heunis 2000; Olivier 1977; WPCSSA 1965). A comprehensive plan to remove and manage the AIV was reportedly produced by Working for Water several years ago (Buckle, pers. comm. 2022).

There are four categories of AIV:

Category 1a: Invasive species which much be combatted and eradicated. Any form of trade and planting is prohibited.

Category 1b: Invasive species which must be controlled and wherever possible, removed and destroyed. Any form of trade or planting is strictly prohibited.

Category 2: Invasive species or species deemed to be potentially invasive, in that a permit is required to carry out a restricted activity. Category 2 species include commercially important species such as pine, wattle and gum trees. Plants in riparian areas are assigned Cat 1b.

Category 3: Invasive species which may remain in prescribed areas or provinces. Further planting, propagation or trade is however prohibited. Plants in riparian areas are assigned Cat 1b.

Our own studies (MacKenzie in Uys et al. 2022) indicate that while the clearing of the alien vegetation in the entire catchment may be necessary over the longer-term, the areas that are likely to yield best ecological returns in the short-term are the upper catchment in the area of Hunters Retreat, and the lower catchment from Settler's Valley to the estuary. The upper catchment area is extensively invaded with Port Jackson willow, and this has resulted in degradation of seep wetlands in this less-developed part of the catchment.

6.2.4 Problem: Upper catchment seep wetland degradation

As discussed in the Current State Report (Part 1 of this series, Uys et al. 2022a), the most extensive wetland in the catchment is the Baakens estuary, which is in a highly modified current state, and measures rough 13 Ha according the wetland delineation in the new wetland map No. 5 (National Biodiversity Assessment 2018).

There are also notable unchanneled valley bottom wetlands and hillslope seepage and depressional wetlands in the headwaters of the catchments. These occur in Algoa Sandstone Fynbos vegetation and provide critical habitat for one of the last remaining populations of the Eastern Cape endemic plant *Cyclopia pubescens* (Honeybush, pictured right), a critically endangered shrub that is a seep wetland specialist. At least 80% of this species' habitat was already transformed as a result of urban expansion, agriculture and alien plant invasion by 2012 (Grobler 2012). Further urban expansion will have threatened at least two remaining subpopulations, and alien invasive plants are present in the locality of three subpopulations (Raimondo et al. 2011).

The unchanneled valley bottom wetlands in the catchment are critically threatened (CR threat status in National Biodiversity Assessment database 2018) and are poorly protected, while the seep and depressional wetlands in the headwaters and upper catchment are vulnerable (VU threat status in the NBA database, 2018) and are also poorly protected.

The following Table shows the current extent of wetland types in the Baakens River catchment. Data are according to the new wetland map (2018), but upon closer investigation, these are clearly underestimates of wetland extent.

Wetland Type	Area (Ha)
Channelled Valley Bottoms	2.264
Depressional Wetlands	11.017
Estuary	12.914
Flats	7.844
Seepage Wetlands	9.908
Unchannelled Valley Bottoms	12.816
Total	56.763

Besides than their intrinsic natural value, which should be sufficient in itself, these seep wetlands provide ecosystem services in the form of natural flood management (flood attenuation), retention of precipitation, baseflow conservation, infiltration capacity, filtration (water purification) and biodiversity value. The degradation and loss of form and functionality in both upper and lower catchment wetlands as a result of the impacts mentioned has resulted in a severe reduction in these important natural functions.

6.2.5 Problem: Climate change

Climate change predictions were modelled for NMB Metro by the South African Weather Services (SAWS) in 2015 using downscaled models of global climate change models. Local future climate

scenarios were described for 2025-2056 (near term) and for 2056-2095 (long term) and were calculated relative to the baseline of years 1973-2015. The outcomes are summarised in Table 6.1.

Table 6.1 Climate change projections for Nelson Mandela Bay (2015)

NELSON MANDELA BAY'S CLIMATE THREATS		
	Change in temperature patterns	More hot days and heat waves, higher minimum temperatures and lower temperature cold spells, higher average temperature
	Change in rainfall patterns	Decrease in average rainfall and number of rainfall events, but increase in rainfall intensity
	Change in drought patterns	Increase in frequency of drought
	Change in flood patterns	Increase in intensity (e.g. 1:100 year flood will increase in magnitude
	Change in fire patterns	More frequent fires
	Sea-level rise	58-78 cm rise in sea level
	Change in storm surge patterns	Higher probability of extreme storm surges
	Change in wind patterns	Strengthening of easterly winds, weakening of westerly winds

The outcomes of the risk assessment which accompanied the NMB Metro climate study (2015) were as follows:

'Increased drought is anticipated to be the greatest risk to society. This is the highest priority for management of possible threats. Drought risk is almost double in magnitude the importance of the next highest rated risk. There will be changes in rainfall patterns, with increased unpredictability. Drought and erratic rainfall hazards will impact the entire population of the municipality and are 4 and 2x greater risks than the other concerns.

Temperature changes, flooding and wind changes tend to be locality-specific, as do changes to fire and storm surge patterns (…) '

In planning for present and future flood management, there is a need to factor in the unpredictable increase in flood parameters (return interval, peak flows, duration and frequency) which are likely to result from climate change, to design measures in such a way that the uncertainty associated with climate change is accommodated, and ensure that the design specifications exceed current 'expected' flood parameters. Updated climate change predictions are also advised.

6.2.6 Problem: Poor understanding of the river's current hydrology

Floodline studies have been based on modelled rainfall data, and have largely focussed attention on high flows and floods (e.g. Iliso 2007, SRK 2014). Thus the base-flows and intermediate-sized flows in the catchment are poorly understood, both in their natural or current state. Baseflows are the 'template' of the river ecosystem functioning and even though these are no longer 'natural', it is important to have information on these flows as they are part of the basis for determination of environmental flow requirements for rivers.

To our knowledge, the alteration to natural base-flows in the Baakens results from, inter alia:

- Increased urban development and concomitant increase in hardened surfaces (decreased infiltration to groundwater);
- Loss of functionality of upper catchment wetlands;
- Likely draw-down of groundwater due to installation of boreholes in the catchment for domestic supply;
- Water use by alien invasive vegetation (transpiration losses);
- Inputs of grey-water and brown-water (domestic waste water which has its source in other catchments) in the form of sewage spills into the system;
- Rainwater harvesting (increasingly encouraged as a means of increasing self-reliance and reducing flood risk, see Muir 2022).

Flood hydrology in the Baakens River is directly or indirectly affected by the following:

- Climate change (predictions of higher peak flows and more frequent flooding).
- Increased urban development and resulting increase in hardened surfaces (decreased infiltration to groundwater). Associated extension of the hydrological network of the catchment (introduction of new flow paths in the form of roads and bridges).
- Historic clearing of riparian zone and floodplain vegetation for agriculture (upper catchment) and for urban development (middle and lower catchment).
- Colonisation of riparian zone and floodplain in places by alien invasive vegetation.
- Reduction in flood attenuation functionality of upper catchment due to vegetation clearing and grazing, and to alien vegetation invasion of upper catchment.
- Loss of channelled valley bottom wetlands, which would serve as natural flood detention systems, in the middle catchment.
- Major modification (narrowing and hardening) of the natural channel and loss of instream habitat in the lower river and estuary.
- Major restriction of channel width (loss of flood conveyance) in the lower river and estuary due to infilling and canalisation.

6.3 WATER QUANTITY REHABILITATION: OBJECTIVES

On the basis of the problems listed, the following are the broad objectives in regard to water quantity:

- To reinstate some of the river's natural flood management (NFM) capabilities through a sequence of rehabilitation actions, following the principles of Water Sensitive Urban Drainage (WSUD).
- To protect the NFM capability of the upper catchment wetlands and floodplain against further development.

- To incorporate additional mechanisms to assist in flood management capability (e.g. flood detention systems, sustainable urban drainage systems or SuDS).
- To gain a better understanding of the river's current-day hydrology based on real-time flow measurement and other data.
- To manage the river system and the surrounding urban catchment for worst-case scenario in terms of climate change.
- To ensure that all (particularly, vulnerable) human communities are adequately prepared for, and protected against, the effects of climate change including increased frequency of floods.

6.4 WATER QUANTITY INTERVENTIONS

6.4.1 Water quantity intervention: Stormwater Master Plan

An updated Stormwater Master Plan is required for the Baakens catchment. This study should be along similar lines to the one done in 2013 for part of the Metro by Jeffares and Green Consulting Engineers and Environmentalists (du Toit 2013). The new SWMP should focus on WSUD implementation and SuDS interventions as described in Section 6.4.2.

Updated floodline studies are required as input to this plan (these are to be commissioned in 2023, David, pers. comm. 2022). The hydrological studies as recommended in Scenario 2 (Section 6.4.9) should also be consulted during this process.

Environmental studies will be required in order to obtain authorisations from Department of Environment Affairs and Department of Water and Sanitation).

6.4.2 Water quantity intervention: Aid recovery of Natural Flood Management

Recovering some of the NFM capability to a catchment encompasses any measures which work with natural processes to manage flood risk and improve or restore the natural flood attenuation functionality of the riverine system (European Commission, undated). Restoration of this capability in urbanised rivers has become an active field of study with its own guidelines (Environment Agency 2017, Text Box 6.1). Many of the interventions listed in this Scenario will assist indirectly with the recovery of NFM functionality in the catchment.

Historically flood risk was managed by increasing the speed of water downstream through engineering straight channels, and reducing friction with the replacement of natural banks with concrete channels. However in London, urban density generally increases downstream. Also the proximity of buildings result in significant constraints in the maintenance and adaptation of artificial channels to cope with projected increase in frequency and severity of storms due to climate change.

With increased storminess, there is a move to slow water upstream to reduce flood peaks downstream. This approach is entitled Natural Flood Management, where natural processes are used to reduce the risk of flooding, through slowing water. Examples of Natural Flood Management techniques include restoring bends in rivers, restoring floodplain, and changing the way land is managed so soil can absorb more water.

Natural flood management is most effective as part of a catchment approach where peaks from different tributaries can be managed and the combination in benefits of smaller projects better understood. Natural Flood Management not only reduces flood risk it can also achieve multiple benefits for people and wildlife, helping restore habitats, improve water quality and contribute to making riverine ecology more resilient to the impacts of climate change.

Catchment Partnerships in London, 2020

Text Box 6.1 New approaches to flood risk management

6.4.3 Water quantity intervention: Improve stormwater management with WSUD and SuDS

What are WSUD and SuDS?

Text Box 6.2 A brief description of the rationale behind WSUD and SuDS

Stormwater management in the urban areas of South Africa has, and continues to, predominantly focus on collecting runoff and channelling it to the nearest watercourse. This means that stormwater drainage currently prioritises quantity (flow) management with little or no emphasis on the preservation of the environment. The result has been a significant impact on the environment through the resulting erosion, siltation and pollution. An alternative approach is to consider stormwater as part of the urban water cycle, a strategy which is being increasingly known as **Water Sensitive Urban Design (WSUD)** with the stormwater management component being known as **Sustainable Drainage Systems (SuDS)**. SuDS attempt to manage surface water drainage systems holistically in line with the ideals of sustainable development. The aim is to design for water quantity management, water quality treatment, enhanced amenity, and the maintenance of biodiversity. In so doing, many of the negative environmental impacts of stormwater are mitigated and some benefits may in fact be realised.

Armitage et al. 2013

SuDS are, broadly, constructed systems designed to increase infiltration of rainfall or runoff, to slow and detain flood flows, and/or to provide water filtration and removal of pollutants. There are a number of different options for SuDS structures. Systems appropriate to the Baakens

catchment include swale systems, dry infiltration beds, bioretention and biodetention wetland ponds, and flood channels (see Figure 6.6).

Under optimal circumstances these systems should be designed to integrate into their environment and behave as ecosystems. Preferably they include indigenous plantings and some level of wetland functionality.

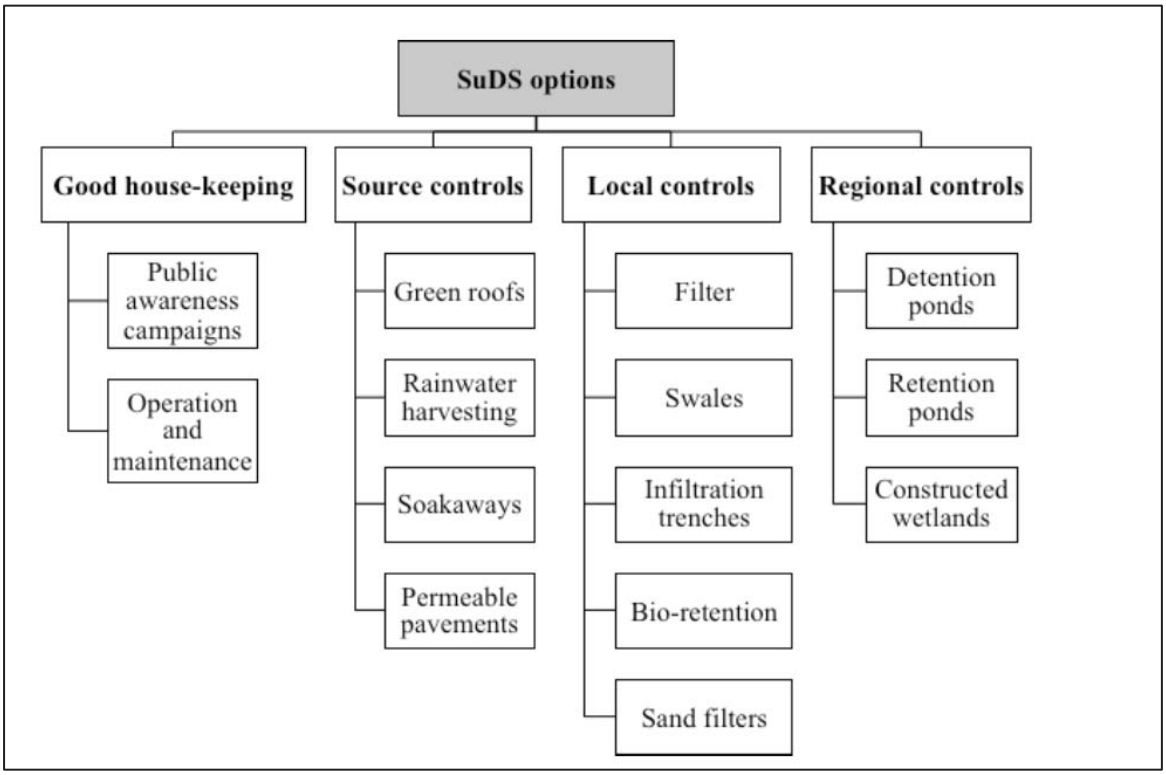

Figure 6.2 Grouping of SUDS options from the South African SUDS guidelines (Armitage et al. 2013)

Implement SuDS in the Baakens Catchment

In order to reduce the undesirable impacts of stormwater runoff from developed areas of the catchment, it is recommended that further WSUD and SuDS principles be applied to the stormwater management of the Baakens catchment. This is necessary catchment-wide, but particularly at current stormwater concentration points which still represent flooding threats.

The major flood threat 'hotspots' in the Baakens for 1: 50 or 1:100 year floods were modelled by SRK in 2014[1]. At the time, and most likely still, they were those road crossings which had insufficient hydraulic capacity, and existing developments within these floodline levels.

[1] Note that this floodline study is now outdated as there has been significant further development in the catchment. A new floodline study will be commissioned in 2023 (David, pers. comm. 2022).

The study indicated that 23 crossings have insufficient hydraulic capacity for these size floods: The Port area; Walmer Boulevard (6 bridge crossings); Bridge Street Bridge – Brickmakerskloof; Chelmsford and TargetKloof bridges; 3rd Avenue, Newton Park; Kragga Kamma/Circular Drive (only 1:100 flood risk); Riverstone Road, Kabega; Fortuna Way, Parsonsvlei; Juno Crescent, Parsonsvlei; Reserve Road, Parsonsvlei; Troy Avenue, Parsonsvlei; AG Visser Road, Overbaakens; William Moffett Drive, Overbaakens; Circular Drive, Lorraine; Orleans Street, Woodlands; Kabega Road, Glenroy Park; Devon Road Sherwood; and Luneville Roads, Lorraine.

The existing developments that were listed by SRK (2014) as being potentially affected by the 1:50 and 1:100 year flood events, were:

Commercial Areas:	Commercial Industrial-lower Baakens River area and the Harbour Area
Recreational Areas:	Settlers Park, 9th Avenue Walmer
Residential areas:	Essexvale; the lower part of the Walmer-Target Kloof area; 8th Avenue and St Johns Avenue, Walmer; certain parts of Circular Drive; Southern parts of Parsonsvlei; upper parts of Church Road (northern side); Lower edges of Pine and Oak Roads, Overbaakens area; Circular Drive/Carrington area; lower edges of Lemorne and Montagne Streets in Lorraine; Brymore suburb; and the lower edges of the tributary in Sherwood.

These areas may have been attended to in the intervening years, while other areas may have become more problematic. All areas of current flood risk should be detailed in the Stormwater Management Plan, and flood management and mitigation measures provided.

Bioretention and biodetention systems

Biodetention and bioretention systems are landscaped depressions or shallow basins used to slow and treat stormwater runoff and to assist in slowing floods in urban areas. There are many types of systems, varying in functionality, design complexity, and cost. The main difference between a detention basin and a retention pond is the presence or absence of permanent water. A **detention, or dry, pond** has an orifice that is level with the bottom of the basin, and does not have a permanent pool of water. All the water runs out between storms and it usually remains dry. A **retention basin or pond** has a riser and orifice at a higher point, which enables it to retain a permanent pool of water, and it has the appearance of a pond (Wessler Engineering 2022). The stormwater percolates through the system and in the process is also treated by a number of physical, chemical and biological processes. A wide range of pollutants, such as suspended solids, nutrients, metals, hydrocarbons, and bacteria can be removed. The slowed, cleaned water is allowed to infiltrate the soil or is directed to a nearby stormwater system or back to the river. Designs for two different types of bioretention systems are shown in Figure 6.4 and Figure 6.5. It is also possible to design a combined system with a permanent shallow wetland element (see Figure 6.5) which is kept full either by within-year high flow events or by pumping of river water into it.

Additional bioretention facilities should be considered for areas upstream of stormwater concentration points, or high flood-risk areas in the Baakens catchment. These multi-purpose systems can be designed as a multi-stage, multi-function facility, providing both flood detention and ecological value (New Jersey 2009). One such system is proposed for the Settlers Valley close to this study's Site 1 (Figure 6.3).

NOTE: The dangers associated with stormwater retention facilities which have permanent ponding is that they can pose as a drowning hazard in an urban environment. For this reason, they are best installed in areas where public access not possible. In areas where access is possible, such as Settlers Valley, these systems should be designed with safety features (e.g. shallow even at maximum depth; gravel base, large stepping stones, wooden walkways, lifesaving equipment).

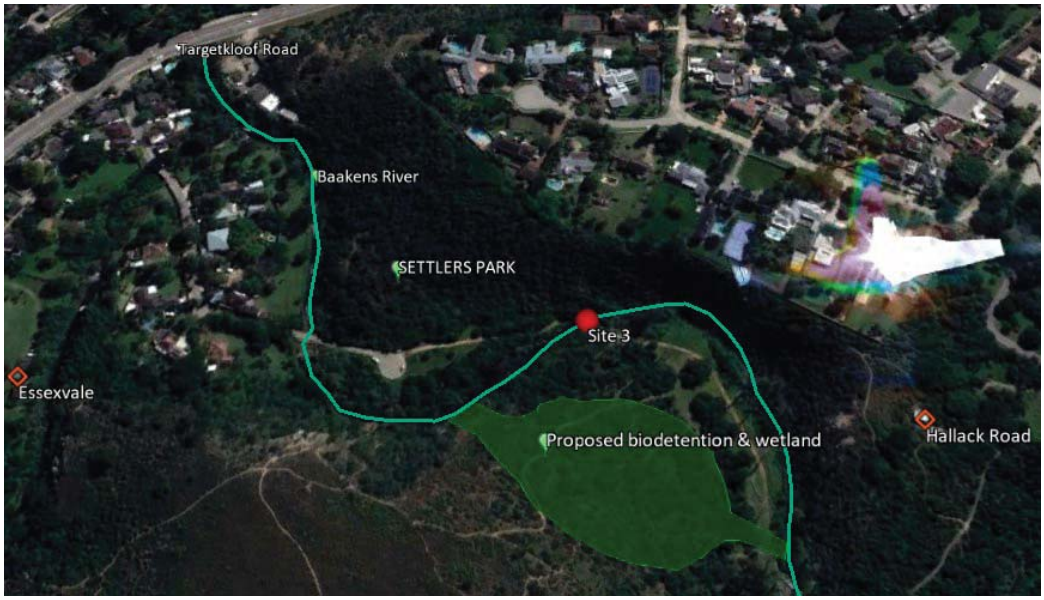

Figure 6.3 An optional location for one of the proposed bioretention ponds with a wetland component, downstream of an area demarcated as a flood hazard zone of the catchment. Within the Settlers Reserve. Note: The total surface area illustrated here is 14,000 m^2

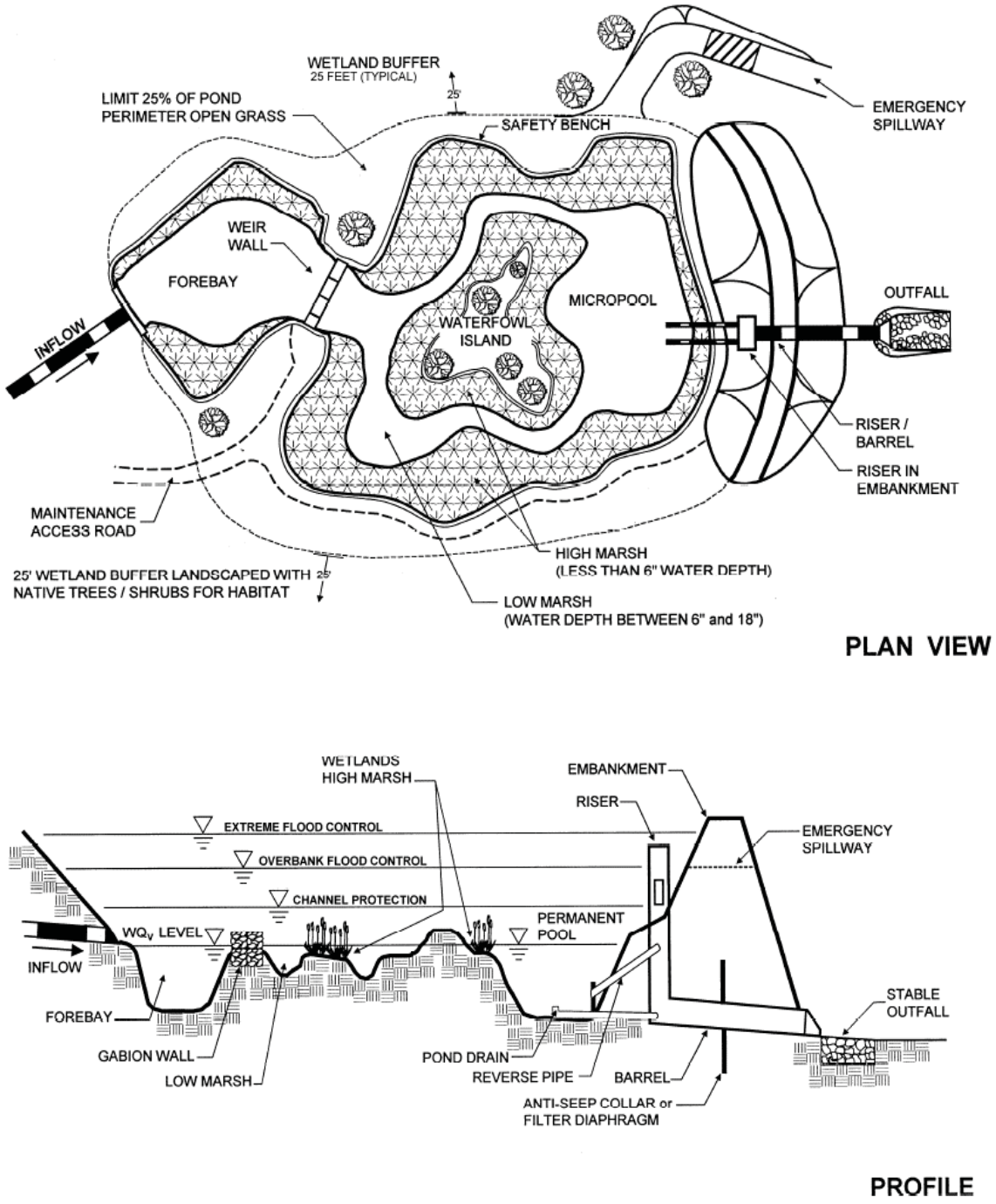

Figure 6.4 Stormwater wetland detention facility in plan and profile view (EPA 2009)

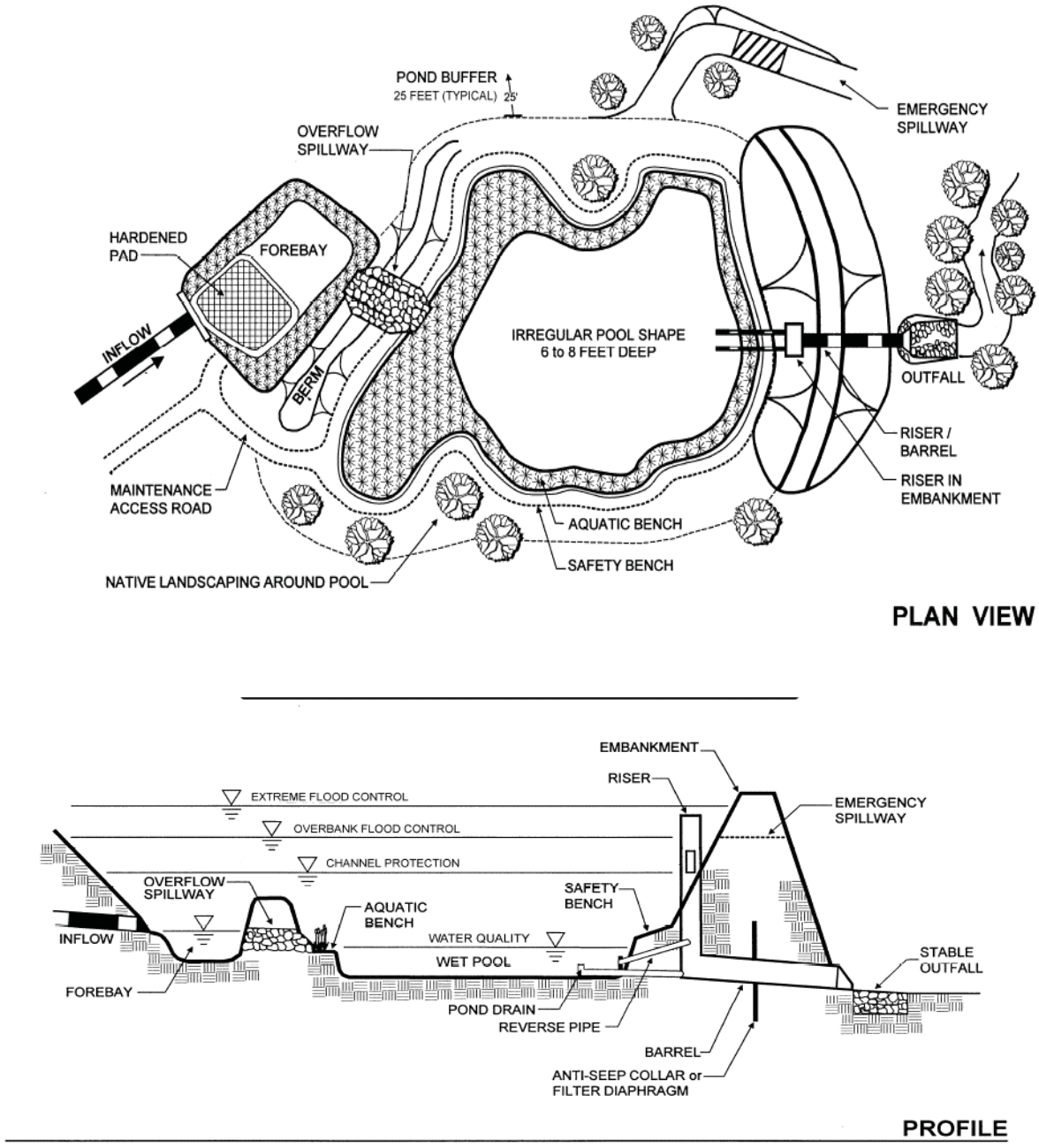

Figure 6.5 Stormwater Wetland Pond Schematic (EPA 2009)

1. Constructed Wet Pond (bioretention system)

2. Constructed swale

3. Constructed stormwater detention system immediately after flooding

4. Storm water detention system (naturalised)

Figure 6.6 A number of Sustainable Drainage Systems[1] of relevance to the Baakens catchment

6.4.4 Water quantity intervention: Clear and manage upper catchment AIV

This intervention measure applies to the uppermost catchment upstream of the rocky gorge, within the fynbos area where the seepage, depressional and unchanneled valley bottom wetlands occur. This intervention is aimed at mitigating the water quantity (high flow) issues and improving biodiversity in this area.

The area is heavily infested by dense stands of Port Jackson Willow (*Acacia saligna*) which cover extensive areas along the hillsides and main channel, and have begun to encroach on wetland areas. Port Jackson Willows were brought to the Cape in 1848 to help stabilise loose coastal sand on the Cape Flats but the species has since become a serious invader in South Africa and a threat

[1] Sources: 1,2. https://developersguide.njfuture.org/bmp/ 3. Photo by Edee Daniel, Flickr https://www.flickr.com/photos/eddeedaniel/14935297681 4. A detention pond reduces stormwater peak flows while supplying a sump with stormwater used for irrigation at the Falls PnP, Roodepoort. Photo by D. Ellis. http://www.uwm.uct.ac.za/

to fynbos ecosystems. Port Jackson resprouts from the collar when cut down or burnt, which can result in even higher densities, and seeds remain in the soil for up to 50 years.

The most effective method for their removal and management appears to be ringbarking of adults, which results in plant death, and pulling by hand (weeding) of seedlings. For success it is recommended to couple detailed planning with known best practices over time frames that are relevant to the problem species (in this case 10-15 years minimum). A broad outline for planning alien clearing operations is provided in Appendix 2.

NMB Metro to outsource to Working for Wetlands, Working for Water, or Private

6.4.5 Water quantity intervention: Restore upper catchment wetlands

The upper-catchment AIV clearing should be coupled with restoration actions required on the upper catchment seep, depressional and unchanneled valley bottom wetlands (Figure 6.7), either under the planning and management of a dedicated and trained Metro team, or under Working for Wetlands management.

This intervention measure applies to the Baakens catchment upstream of the rocky gorge, within the Fynbos area where the seepage, depressional and unchanneled valley bottom wetlands occur. Before wetland restoration is undertaken the following studies or actions are required:

Wetland delineation: The current delineation (van Deventer et al. 2018) underestimates the actual area and extent of wetlands (see Figure 6.8 for example). As such, the process should commence with a wetland specialist to conduct and map wetland delineation in the upper catchment.
Wetland PES assessment: wetlands require on-site assessment of present ecological state (PES) using WetHealth or WET Instream Habitat Index.
Wetland protection improvement: this upper catchment area in which many of the wetlands occur needs improved protection from further impacts (clearing, agriculture, development) in terms of legislation and management (see Section 6.4.6).
AIV clearing and maintenance: (this item is covered above in the previous intervention).
Wetland consideration/ management / restoration: should occur in conjunction with stormwater management, to prevent incision of wetlands. Delivery of stormwater to wetland and riverine areas should not be accelerated (refer to intervention options in section below).
Assessment of rehabilitation measures required: It is important to assess where wetland rehabilitation is required. As many of the upper catchment wetlands do not appear to be highly degraded (at desktop study level), it is likely that the following actions will be adequate to return wetland function: AIV removal and management (see above); improved wetland protection; promotion of health of marginal zone riparian vegetation which will enhance water purification.

NMB Metro in partnership with Working for Wetlands, SANBI, or Private

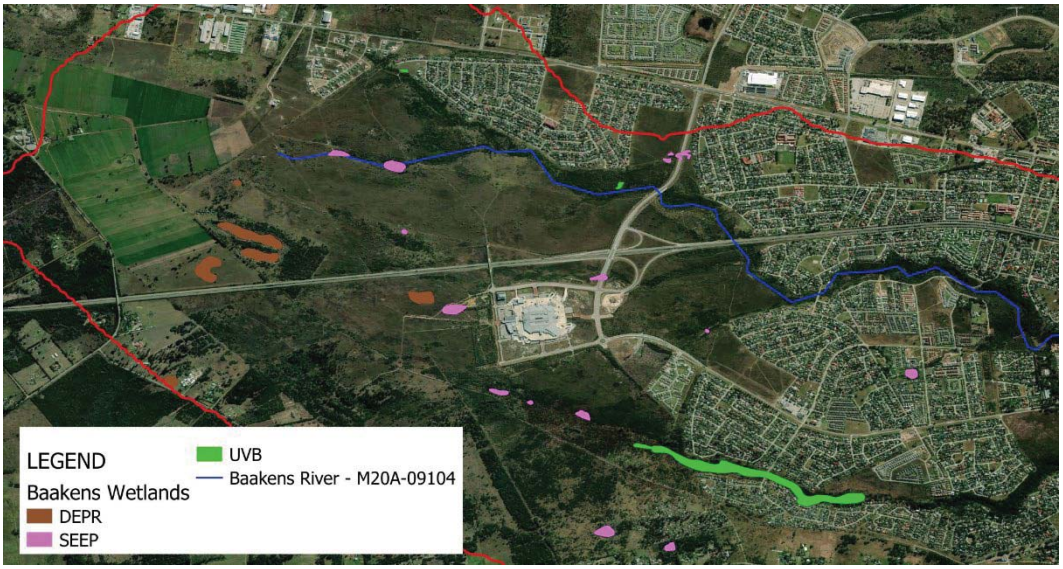

Figure 6.7 Map showing wetland hydrogeomorphic (HGM) types in the upper Baakens catchment (wetland delineation and typing from National Wetland Map 5, 2018). DEPR – depressional wetlands, SEEP – seep wetlands, UVB – unchanneled valley bottom wetlands

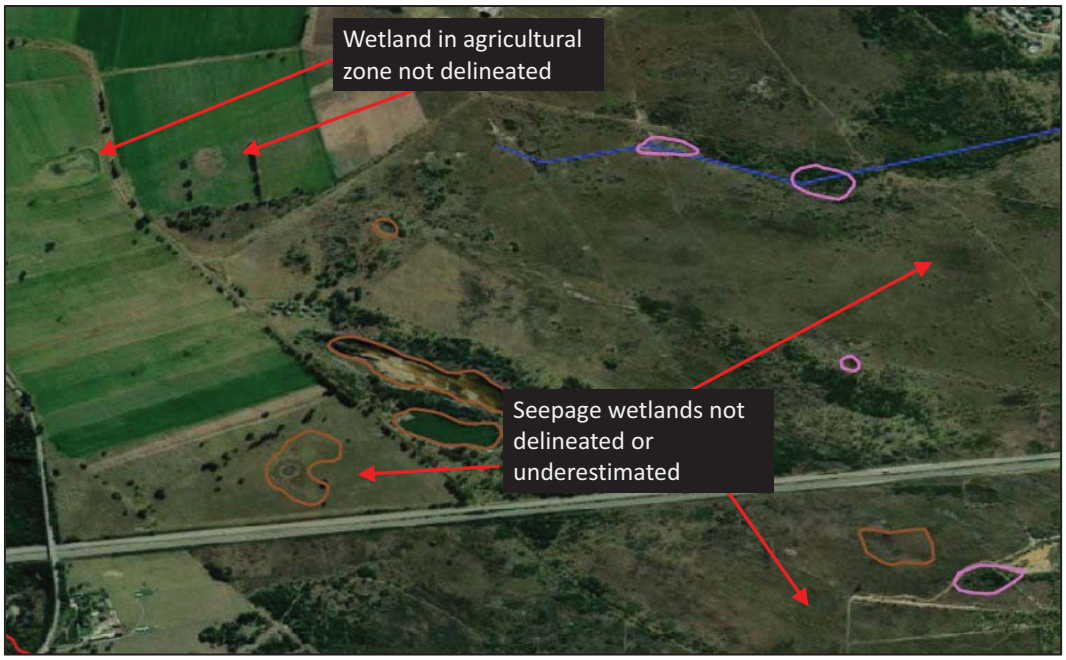

Figure 6.8 Visual evidence of underestimation of wetland delineated area. – cf Bing maps to NBA, (van Deventer et al., 2018) wetland delineation.

6.4.6 Water quantity intervention: Apply for formal protection of upper catchment area

The Baakens catchment includes numerous Critical Biodiversity Areas (CBA), defined as: any land or aquatic site required to meet pattern, process, or biodiversity targets.

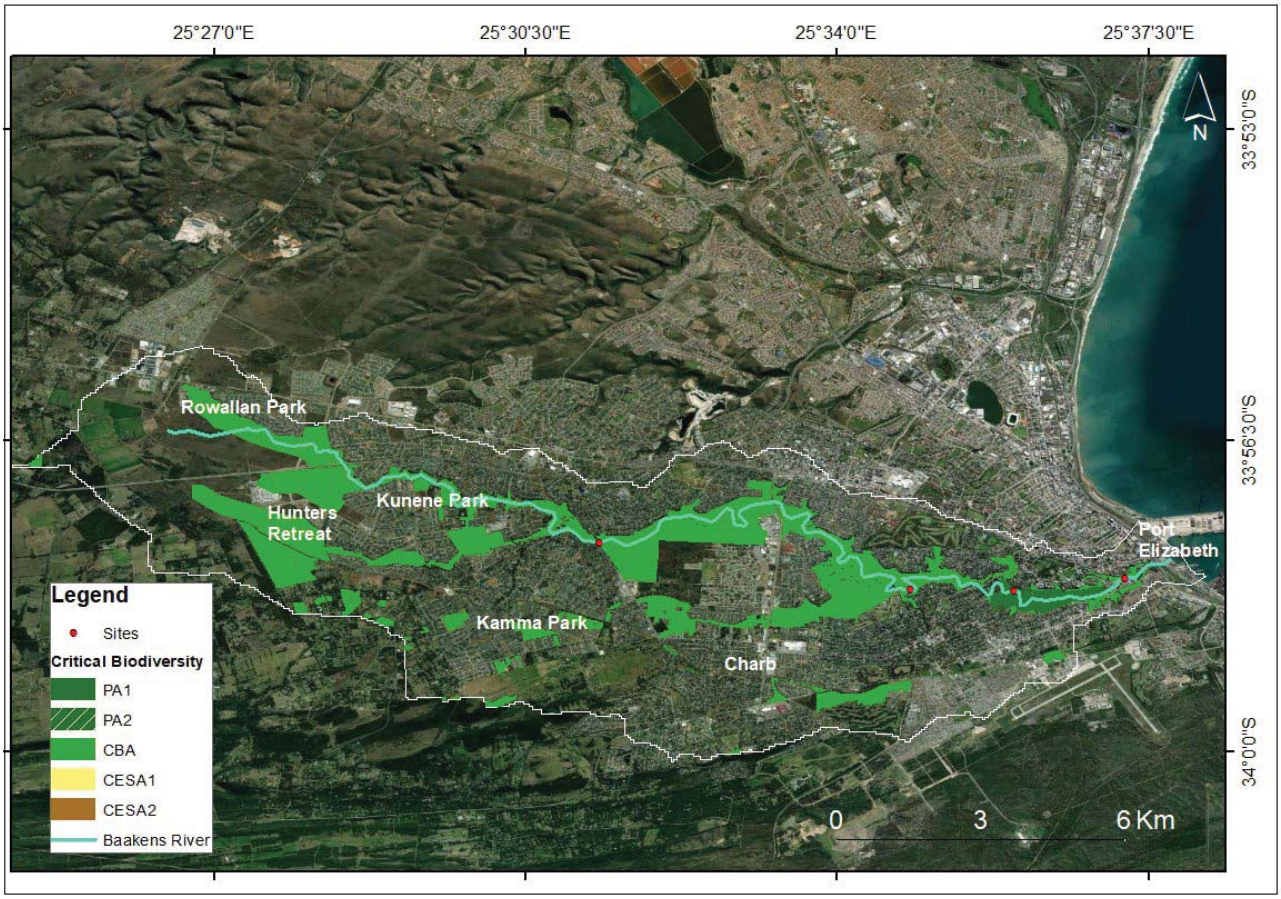

Figure 6.9 Critical Biodiversity Areas (CBA) and Protected Areas (PA1) of the Baakens River catchment (boundary shown in white)

According to the gazetted NMB Bioregional Plan (2014), the land management objective for CBA areas is *'to maintain or restore natural ecosystem structure and function'*. The Land Management Recommendations are '*to obtain formal conservation protection for highest priority sites, and to institute conservation management for all sites'*. These recommendations should be implemented in the (largely undeveloped) upper Baakens catchment at a minimum.

The National Environmental Management Protected Areas Act (NEMPA, Act 53 of 2003) Part 4, 28 (1) states that the Minister or MEC may by notice in the Gazette '*(a) declare any area specified in the notice as a protected environment'*. In Section (2) it states that *'A declaration under subsection (l)(a) may only be issued to regulate the area as a buffer zone for the protection of a special nature reserve, world heritage site or nature reserve; to enable owners of land to take collective action to conserve biodiversity on their land and to seek legal recognition therefor; to protect the area if the area is sensitive to development due to its (i) biological diversity; (ii) natural characteristics; (iii) scientific, cultural, historical, archeological or geological value; (iv) scenic and landscape value; or (v) provision* of *environmental goods and services; to protect a specific*

ecosystem outside of a special nature reserve, world heritage site or nature reserve; (or) to ensure that the use of natural resources in the area is sustainable (..). '

Many of these criteria apply, and could be used to justify the protection of this important upper catchment area, and the wetlands within it which serve such critical functions, particularly in managing the urban hydrology of the river. The area has CBA status and is home to the critically endangered honeybush (*Cyclopia pubescens*) fynbos plant, which is endemic (occurs globally only in this area) and dependent on healthy seep wetlands. It is also home to numerous other plant species of special concern (SSCs).

Responsible Parties: NMBM, DEDEA, Consultants.

NB. Stakeholder participation is essential for this exercise

6.4.7 Water quantity intervention: Clear and manage AIV in the lower catchment

This intervention measure applies to the lower catchment, from the Essexvale entrance of Settlers Park to the Baakens River mouth at the Port (Reaches 5 and 6). It also applies to Rehabilitation Scenario 3 (Chapter 7).

AIV in these reaches range from aquatic, leafy plants to shrubs and small trees, to tall trees. It comprises mainly *Myriophyllum aquaticum* (Parrot's Feather; an aquatic pant), *Cestrum laevigatum* (Inkberry; shrub or small tree), *Nasturtium officinale* (herbaceous marginal zone riparian plant), *Ricinus communis* (Casteroil Bush; shrub), *Sesbanea punicea* (Red Sesbanea; shrub), *Ipomoea cairica* (Morning glory Bush; shrub/creeper), *Eucalyptus camaldulensis* (River Red Gum; tall tree) and *Eucalyptus lehmannii* (Bluegum, tall tree).

AIV removal and maintenance should prioritise woody vegetation (trees and shrubs). The guidelines for removal and management are presented in Appendix 2. Where replanting is to take place (especially Reach 6), indigenous plant species already characteristic of the area should be used (Table 6.2).

6.4.8 Water quantity intervention: Restore floodplain function where possible

The improvement of floodplain function is critical in the management of urban floods. In order to restore the natural flood management (NFM) capability of the catchment, and to address this urgent urban issue, initial focus areas for floodplain rehabilitation should be the upper catchment in the area of Hunters Retreat, and in the lower catchment from the lower end of Settlers Valley to the coast. The former intervention has been discussed earlier in this section, and the latter is dealt with in Section 7.4.

Table 6.2 Proposed indigenous plant species to be used for planting into denuded / low density areas

Species	Common Name/s	Lifeform
Afrocarpus falcatus	Outeniqua yellowwood	Tree
*Cyperus dives**	Giant sedge	Sedge
*Cyperus textilis**	Tall star sedge	Sedge
Erythrina caffra	Coast coral tree	Tree
Ficus sur	Broomcluster Fig	Tree
Harpephyllum caffrum	Wild Plum	Tree
*Leersia hexandra**	Rice Grass	Grass
Nuxia floribunda		Shrub
Olea europaea subsp. africana	Wild Olive	Shrub / tree
*Phragmites australis**	Common reed	Reed
Pittosporum viridiflorum	Cheesewood	Tree
Sideroxylon inerme	White milkwood	Tree
Syzygium cordatum subsp. cordatum	Waterberry	Tree
*Zantedeschia aethiopica**	White Arum Lily	Bulbous

* These wetland / marginal zone species to be used along active banks and water's edge

6.4.9 Water quantity intervention: Initiate flow gauging in the river

Flow data are an important component of river management, particularly in an urban system with a history of damaging floods, like the Baakens. Although these data will not aid in predicting future flood intensity, they provide a baseline against which to compare future flow data.

Flow gauging in the Baakens River is recommended. The main justifications for this are:

- To establish a long-term data set essential to understanding the river regime and its change over time, particularly in the light of climate change threats;
- To establish habitat/depth relationships (ecohydraulic parameters) for the rehabilitation of the channel for movement of fish and invertebrates;
- To assign some level of probability to extreme events such as floods and low water levels to assist with planning and management.

Lallemant (2017) points out that the importance of these measurements is reinforced by the current challenges of global warming, the restoration or preservation of natural environments and their biodiversity, the social demand for knowledge, and the increased vulnerability of society.

In addition, a study of present day hydrology of Baakens should be commissioned. This information will provide to management and scientists important information on the range of flows encountered in the catchment under different conditions (e.g. drought, dry season, wet season, flood), a baseline against which to monitor the efficacy of actions such as rainwater tank installations, and a cue for management of the catchment during both baseflows and high flows.

Flow measurement requires a hydraulic control structure, the development of a rating curve (depth vs discharge) and installation of a depth meter. Alternatively, real time water-depth monitoring using installed water-level monitoring sensors is possible, and requires a rating relationship. Hydrometric sensors could be installed at one or two secure points in the catchment to procure such real-time data.

Responsible Party: NMB Metro possibly in partnership with Nelson Mandela University

7 REHABILITATION SCENARIO 3. IMPROVE CONNECTIVITY, CHANNEL FORM AND HABITAT

7.1 INTRODUCTION

This section of the report focusses on the lower river and estuary, i.e. the lower 1 km of channel, between Bridge Street and the Port. In this section particularly, there have been major interventions in the channel, beginning as early as the 1860s. These have resulted in the loss of the system's natural form, lateral connectivity (between the channel and the floodplain) and longitudinal connectivity (between ocean, estuary and river). and habitat

For the purposes of this study, this section of river was referred to as **Reach 6**. It is further divided into **Reach 6A**, which is a section of natural channel extending from the Brickmakerskloof Bridge for 175 m downstream**, Reach 6B** which is a gabion-clad channel from end 6A to the area of the lower Valley Road traffic circle (the river-estuary interface); and **Reach 6C**, the estuary, which is thought to have extended from more or less this area to the ocean (currently the Port).

Figure 7.1 Aerial view of the lower kilometre of the Baakens River showing Reaches 6A, B and C and our study Site 4 (Google Earth ©)

7.2 CONNECTIVITY AND CHANNEL FORM: PROBLEMS

7.2.1 Problem: Loss of natural channel form

This section of the Baakens more than any other has been subjected to major urban impacts including the development of the urban area on its banks and literally into its channel, at the cost of the riverine and estuarine integrity.

The canalisation associated with width-restriction, loss of depth, removal of instream habitat, and clearing of much of the floodplain vegetation in this section of the river, has had numerous consequences, including:

- loss of associated instream biodiversity.
- loss of riparian corridor and channel-floodplain connectivity on the right bank.
- reduction in ocean-estuarine and estuarine-riverine connectivity.
- loss of important habitat and cover for juvenile fish entering the estuary from the ocean.
- loss of the system's Natural Flood Management (NFM) capability in this section.

Channel in Reach 6A. (Brickmakerskloof and 175 m downstream): The upper section of this section of river is natural channel and habitat. Riparian vegetation is dense and impenetrable and comprises a combination of indigenous and alien species. It was not possible to access the channel.

Gabion lined canal in Reach 6B. (End R6A to the river below Fort Frederick – proposed Baakens Parkway section): In this section opposite the Valley Road complex, the river is entirely different. Here the floodplain has been totally cleared of vegetation, barring a few large trees. The channel has been cleared of habitat and is gabion-lined. Channel width is 3-5 m. The left bank marginal and riparian zones are intact and relatively healthy, however the right bank vegetation is limited to a narrow marginal zone which includes some dense reed stands. Beyond the channel-edge, the right bank has been cleared and grassed. In this section there has been bank-scour in places, and the gabions have been damaged, releasing rock into the channel (Figure 7.4).

Concrete canal in Reach 6C. (From end R6B to Port – Estuary): In its natural state, the Baakens estuary was a wide shallow system and a popular recreational site for the early Settlers of the early to mid-1800s. Working with historic maps drawn to scale (e.g. Figure 7.3 top), it is estimated that the estuarine width varied from 50 to 70 m at its widest, and possibly more depending on tide.

In its natural state, the lower end of the estuary appears to have been confined by two small rocky promontories close to the mouth (see Figure 7.3). The major hydraulic control at this lower point was reportedly a bedrock bar (McCleland 2017 citing Harradine 1996). A high tide would push in over this bar, and water would be trapped behind it, forming the extensive lagoon. During the outgoing tide water would flow over it. This bedrock bar apparently now forms the foundation of one or more of the freeway bridges (McCleland 2017). [1]

[1] This bedrock bar was not visible during our site investigations, however locating and surveying it would be an important element of the recommended ecohydraulic studies, in order to establish what a more natural depth for the lower estuary would be.

During 1864, the Municipality narrowed the channel of the Baakens River near the mouth, initially by discarding quarried rock into the estuary on the left (west) bank. Further dumping followed, with permission of the Council (McCleland 2017). Over time, the estuary was restricted to its present state: a concrete-lined canal, 2.6 m wide and 0.5 m high (Figure 7.5). The in-filled estuarine areas and the original Baakens floodplain were transformed into raised, hardened surfaces and developed as part of the city. Today, numerous buildings and factories are located on this 'reclaimed' land, much of which is within the most recently modelled 1:100 year flood line (SRK 2014).

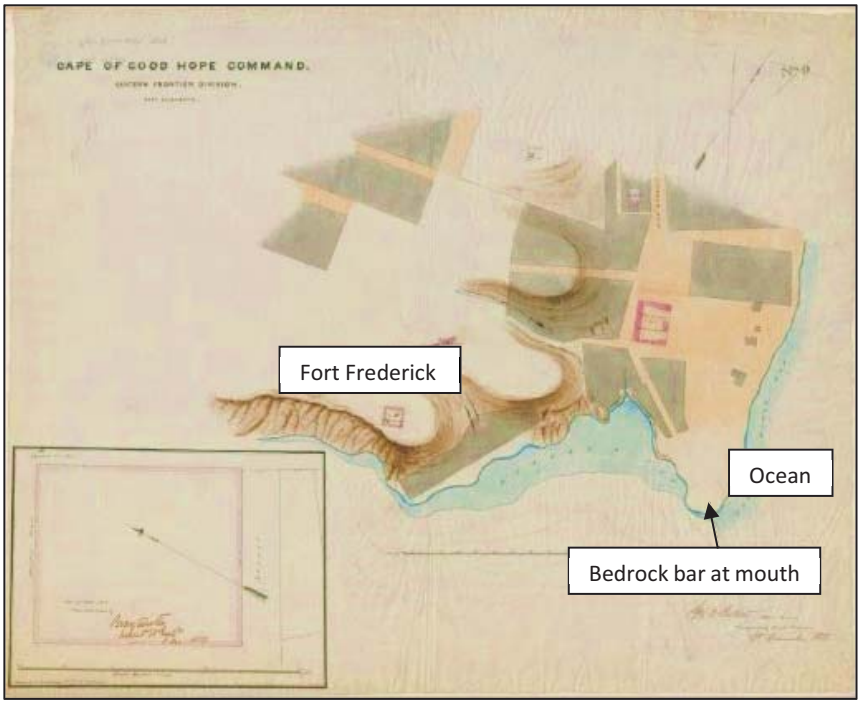

Figure 7.2 The 1867 Engineers map of the Baakens Estuary (from McCleland 2017)

Figure 7.3 An image of the lagoon from the 1860s (McCleland 2017, 2022).

Figure 7.4 Reach 6B – the gabion-lined channel opposite the Valley Road complex. Note the broken gabions and the reed-infestation.

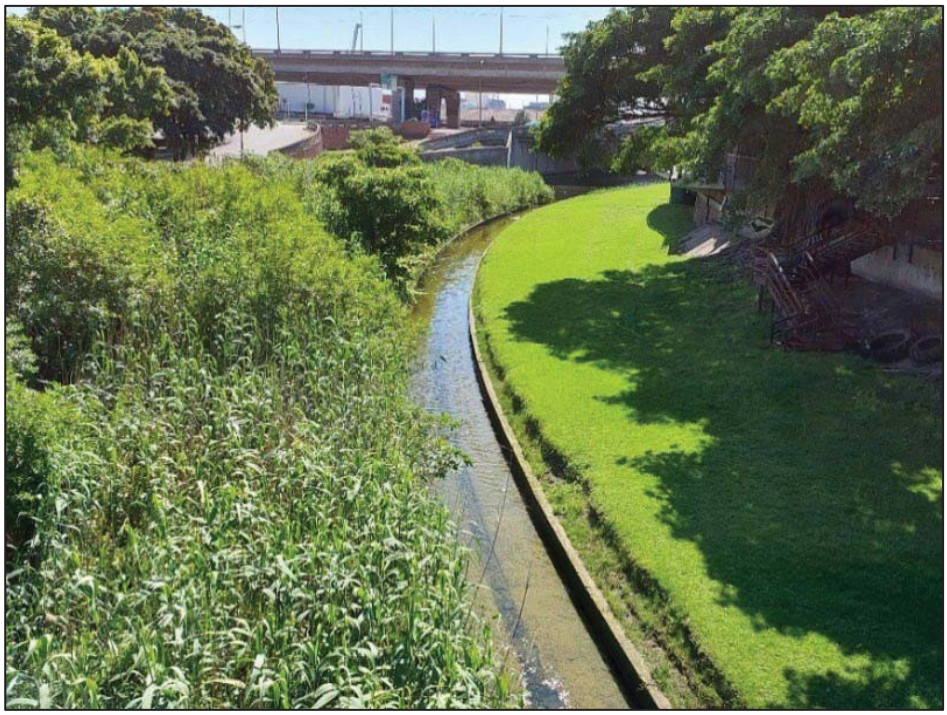

Figure 7.5 The Baakens estuary in Reach 6C its current canalised state, looking downstream towards the Port.

7.2.2 Problem: Loss of natural system connectivity

Upstream barriers to fish movement

The longitudinal connectivity of the system, i.e. that between ocean, estuary, freshwater and wetlands along the river's length, and the estuarine functionality, has been significantly reduced in this lower section. Many species of larval fish would, under natural conditions, move into the estuary and continue with their life-cycle in the protected estuarine environment. The concretized canal in its current state does not provide cover for these juveniles, as there is no instream habitat and no small inlets or refugia. Being highly visible, the fish larvae are easy prey for birds and amphibians.

Table 7.1 Catadromous fish species found in the Baakens River

FISH SPECIES		CONSERVATION STATUS AND DISCUSSION
SCIENTIFIC NAME	COMMON NAME	
CATADROMOUS FISH SPECIES:		
Myxus capensis	Freshwater mullet	*IUCN Status: Least Concern*. Spawns in inshore zones of the sea, with fry and juveniles (20 to 80 mm in length) penetrating far upstream (often > 50 km) in the absence of instream barriers. This species is considered locally threatened due to construction of instream barriers in coastal rivers. *Baakens River:* Presently found upstream to Holland Weir in Settlers Park (Bok, 1994; Muller *et al*. 2014.
Mugil cephalus	Flathead mullet	*IUCN Status: Least Concern*. Marine spawning, partially catadromous species penetrating upstream into freshwater, but more common in estuaries. *Baakens River:* Found seasonally to just upstream of Bridge Street (Bok 1994).
Monodactylus falciformis	Cape moony	*IUCN Status: Least Concern*. Marine spawning, partially catadromous species common in estuaries, penetrating upstream into freshwater, often in large numbers. Baakens River: Reported to penetrate to pool upstream of Holland Park Weir (Muller *et al*. 2014).
Anguilla mossambica	Longfin eel	*IUCN Status: Least Concern*. Marine spawning obligatory catadromous species able to negotiate (climb over) instream barriers and penetrates into the upper reaches of most coastal rivers. Baakens River: Should occur throughout system, able to crawl in splash zone over high instream barriers, only recorded up to Hawthorn Avenue, Sunridge Park.
Eleotris fusca	Dusky sleeper	*IUCN Status: Least Concern.* Marine / estuarine migrant usually found near freshwater-estuarine interface in coastal rivers, rare in this region. *Baakens River:* Found upstream to Bridge Street, low numbers only (Muller *et. al.* 2014).
Awaous aeneofuscus	Freshwater goby	*IUCN Status: Least Concern.* Estuarine migrant found in lower reaches of coastal rivers in low numbers, but rare in this region. *Baakens River*: Reported in the lower Baakens near the Tramways Building (Strydom 2014).
Stenogobius ?polyzona	Banded goby	*IUCN Status: Data Deficient.* Estuarine migrant found in lower reaches of coastal rivers, *Baakens River*: Were found below Bridgestreet Bridge. This a new distribution record and may be a new undescribed species (Strydom 2014).

Furthermore, numerous instream barriers to fish movement such as road causeways and weirs have been constructed in the Baakens River channel. These impede upstream fish migrations. Catadromous fish breed in the sea and migrate as larvae and juveniles upstream via estuaries into the freshwater reaches of coastal rivers as part of their natural life cycle. The catadromous fish found in the Baakens River are listed in Table 7.1. Many of these man-made instream structures are located upstream of Reach 6, but still within the lower reaches of the Baakens (Reach 5, Settlers Park and Reach 4, Dodds Farm). A number of the crossings in Settlers Park are shown in Figure 7.6.

In addition, instream barriers will impede the movement of indigenous primary freshwater fish species in the Baakens (i.e. species confined to freshwater reaches). These fish species require longitudinal connectivity in order to migrate up and downstream to optimum feeding and breeding habitats at various time of the year. Instream barriers could also prevent these fish from re-colonising river reaches where fish populations have been wiped out by, for example, a fish kill due to a sewage spillage, which – as discussed – is currently a common occurrence in the Baakens River. An annotated list of primary freshwater fish species found in the Baakens River is given in Table 7.2.

Table 7.2 Primary indigenous freshwater fish species found in the Baakens River

PRIMARY FRESHWATER INDIGENOUS FISH SPECIES		
Pseudobarbus afer	Eastern Cape redfin	*IUCN Status: Endangered.* This so-called "Mandela lineage" is confined to the Baakens, Swartkops and Sundays rivers; *Baakens River:* Previously found throughout the catchment, but population appears now to be confined to reach in Settlers Park (Strydom 2014).
Sandelia capensis	Cape kurper	*IUCN Status: Data Deficient*. Considered by local scientists as a species of special concern and warrants special protection. *Baakens River:* This species is found throughout the system.
Enteromius pallidus	Goldie barb	*IUCN Status: Least Concern*. Populations within the Eastern Cape (*E. pallidus South*) may be a distinct species and under threat. Baakens River: Present in nearly all reaches of the system.

7.3 CONNECTIVITY AND CHANNEL FORM: OBJECTIVES

To improve system lateral and longitudinal connectivity of the Baakens River through a process of naturalising the canalised river and estuary; installing fishways on constructed instream barriers; and reinstating instream, marginal and riparian habitat for a suite of biota. All these measures should be designed to fit in with the existing concept plans for the Baakens River Parkway.

Figure 7.6 Six of the stream crossings requiring fishways in Settlers Park

7.4 CONNECTIVITY AND CHANNEL FORM: INTERVENTIONS

The following rehabilitation interventions are recommended for the reinstatement of partial system lateral and longitudinal connectivity:

- Install fishways on all barriers to upstream migration by fish.
- Naturalise the lower river and estuarine channels and floodplain in Reaches 6B and 6C to return functionality and increase flood conveyance.
- Reintroduce instream, marginal and riparian vegetation habitat in Reaches 6B and 6C as appropriate.

7.4.1 Connectivity Intervention: Install fishways

By Anton Bok

It is recommended that fishways be installed on all man-made barriers to fish migration in the Baakens River, to facilitate fish and eel upstream migration, and to reconnect the estuary and lower part of the river with the upper sections.

The alternative intervention to address the ecological problem of loss of connectivity would be to remove these barriers altogether, which – despite being preferable – could result in ecological damage, as this is rarely done in South African river systems and the expertise required is rare.

7.4.1.1 Conceptual designs of fishways

Hydraulic conditions in fishway

The successful design of a fishway depends largely on providing the hydraulic conditions (such as depth and maximum flow velocities) which suit the species for which the fishway is intended. Fishways in the Baakens River will have to accommodate the jumping ability and swimming preferences of fish below 100 mm in length, as well as the climbing behaviour of eels. The latter species avoid deep, turbulent water and fast currents and use shallow water and the splash zone on the edge of the main flow to climb or crawl over barriers to migration.

Swimming speed is directly related to fish length and the burst speed (maximum speed maintained for less than 15 seconds) is normally about 15 times the body length. Mullet fry migrating up from the estuary could be as small as 20 to 30 mm in length. For catadromous fish migrating up the Baakens River from the estuary, this means that a maximum flow velocity in fishways of no more than 1 $m.s^{-1}$ is preferable. Although incapable of these speeds in open water, the very small fish tend to swim close to the bottom or sides where friction reduces current velocities.

Design Options

The construction of 'natural' fishways (also called by-pass channels) that resemble natural rapids or riffle sections of streams is considered a viable design for the Baakens River. These will enable fish to migrate over the various weirs and causeways blocking upstream fish migrations. If properly designed, with no bottlenecks due to unfavourable hydraulic conditions, these natural fishways can be very effective and relatively inexpensive to construct.

It is important to try to create relatively 'natural' conditions in terms of gradient, flow velocity, water depth, channel roughness and substrate in these informal fishways or bypass channels.

There are a number of fishway design features that need to be considered in relation to the target fish species and site characteristics:

- **River flow:** The fishways should be designed to operate effectively during medium to low-flow conditions which are usually of longer duration, rather than during short-term periods of high flows. A delay in migration during floods or high flows, which may last a few days or even weeks, will have minimum impact.
- **Location of fishway entrance (i.e. downstream end):** The fishway entrance should be located as near as possible to the furthest upstream point or line to which the migrating fish are able to penetrate at a barrier. As small fish migrating upstream avoid high velocity water in the centre of the channel, the fishway entrance should be near the river bank, near the base of the barrier.
- **The fishway exit (i.e. upstream end):** This should be located away from the spillway in an area of low-flow to ensure that tired fish exiting the fishway are not swept back downstream.
- **Predation:** The fish should be given some measure of protection during passage through the fishway, such as placement of rocks within the fishway channel.
- **Construction materials:** A variety of materials could theoretically be used in the construction of the fishway. However, a concrete channel embedded with natural river stones and rocks of various sizes (e.g. 50 to 300 mm diameter.) should be a suitable and inexpensive option, as well as aesthetically pleasing.
- **Slope:** The fishway channel should be set at a relatively gentle slope averaging at least 1:12 (preferably greater) in order to reduce current velocities and minimise turbulence.
- **Channel width:** The channel width and profile should be variable so as to create variable flow velocities down the fishway – similar to that found in a natural riffle or rapid in a stream. The result should be a series of small pools (deeper, low velocity areas) and alternating with short riffles (faster flowing, shallower areas) along the length of the fishway. The channel width and profile will depend on the anticipated water flows down the fishway, which are in turn related to stream flows (medium to low) in the Baakens River. A width of 0.5 to 1.0 m is suggested.
- **Water Depth**: The water depth should vary from about 20-40 cm in pools to about 8-20 cm in faster-flowing riffle areas. Although pool and riffle depths will vary with flow volumes, under 'normal' flow conditions a water depth in riffles between pools of about 10 cm and pool depths of over 25 cm should be maintained to allow unimpeded upstream migration of juvenile fish and also to afford some protection from predation by piscivorous birds.
- **Current velocities:** Current velocities will vary considerably depending on water depth and position in the fishway, but should allow weak swimming or small fish to negotiate the high velocity areas between pools. As juvenile fish have burst swimming speeds of less than about 1 $m.s^{-1}$ (burst speed = maximum speed maintained for less than 15 seconds), velocities within the fishway should allow for this.
- **Channel baffles and roughness:** Suitable hydraulic conditions to facilitate fish migration up the fishway (see above) could be created by alternated broadening and tapering sections along the channel, varying the slope, and creating deeper and shallower areas. This variation in channel width, slope and profile could be enhanced by the placement of cobbles and boulders of suitable sizes and shapes in the channel. In addition, the roughness of the channel (and hence reduction in current velocities) could be increased by having a rough (slurry) finish and embedding pebbles and cobbles in the bottom and sides. The larger (> 150 mm diameter) cobbles in particular will provide the upstream-migrating fish with some hydraulic cover.
- **Splash zones:** As mentioned above, eels prefer to negotiate barriers by climbing or crawling in the splash zones created on the edge on the flowing water. The sides of the fishway should thus be shaped to ensure these splash zones are formed. The need for suitable splash zones is particularly important in the high velocity riffle areas.

Figure 7.7 Rock-ramp bypass channel on a low weir in the Lenne River, Germany (from Bok *et al*. 2007).

Fishway recommendations for specific barriers

All the conceptual design principles discussed above should be applied when designing fishways at the various barriers to migration in the Baakens River. Financial constraints, as well as the structural integrity of the existing instream barrier in question, could dictate the detailed design of the fishway to be built at each barrier in Settlers Park and upstream. The most suitable design should be finalised only after biological, engineering and budget constraints have been fully explored for each barrier in question.

Note: In the event of a flood damaging or destroying any of the existing crossings in the future, it is recommended that these are not reinstated, but that all artificial spoil material is removed off-site and remedial measures applied to the bed and banks. Ideally there should be minimal man-made crossings along the length of the river, and these all require fishways.

Responsible Party: MBDA

Figure 7.8 A 2007 photograph of Holland Weir (Settlers Park), seen from the left bank

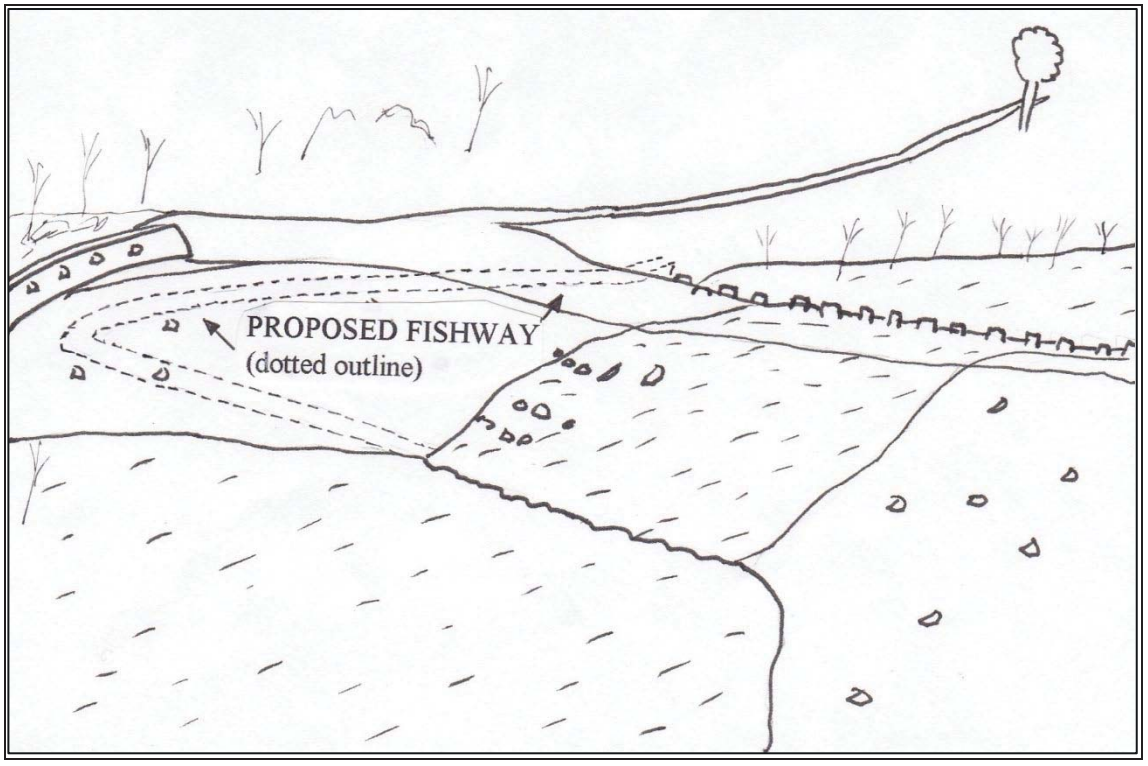

Figure 7.9 Sketch of proposed location of the bypass channel for Holland Weir, to enable fish passage (Bok, 2007)

7.4.2 Channel form intervention: Naturalise channel morphology and reinstate habitat in the lower river and estuary

7.4.2.1 Introduction

In addition to restoring system connectivity as already described, rehabilitation efforts in the lower reaches of the Baakens River should focus on the naturalisation of river channel morphology and, in the lower section of Reach 6, of estuarine form and function.

The process should aim to:

- Remove some of the hard elements (e.g. canal sides) and reinstate more natural channel morphology;
- Increase the hydraulic conveyance in the channel to lessen the current day 'bottleneck' effect on flood flows in this lower section. No interventions should compromise this outcome**.**
- Reintroduce appropriate habitat elements and use these to create more diverse instream and bank hydraulic conditions. (NB. key habitat elements, e.g. small boulders should be pinned into channel to prevent movement under high flow conditions)
- Focus on creating habitat, cover and rest area for juvenile indigenous fish;
- Improve marginal vegetation habitat on both banks. Use the indigenous plants that are already there wherever possible;
- Plant recommended riparian tree species on the cleared banks to reinstate floodplain functionality;
- Establish a nursery for river plants.

7.4.2.2 Case studies

Several organisations worldwide have been involved in this type of urban river restoration in recent decades, and several restoration designs have been shown to be effective. Some of these are directly relevant to the Baakens River, Reach 6.

Restoration efforts have addressed, inter alia, naturalising channel morphology, managing overland floodwaters, creating floodplain wetlands and detention features, providing or enhancing public (or private) access to riverscapes, and removing or bypassing barriers, to name but a few.

The River Restoration Centre (RRC), for example, is an independent and impartial not-for-profit National (UK) organization that provides expert advice for best practise river restoration, habitat enhancement and catchment management. Some of their river restoration techniques and structures that have demonstrated success are shown in the following sections as ideas for the various channel interventions in the lower reaches of the Baakens River (e.g. Figure 7.18). Further ideas are included as Appendix 3.

The principles on which channel naturalisation in the Baakens are based are as follows:

i. Channel naturalisation is only necessary in those sections where the natural channel has been interfered with (narrowed and either lined with gabions or replaced with a concrete canal as in Reaches 6B, 6C).
ii. As this is a highly urbanised catchment with a history of damaging floods, channel naturalisation must serve to re-establish lateral and longitudinal connectivity and improve conditions for biota, while also where possible increasing flood conveyance capacity, improving channel-bank connectivity, and generally reinstating some of the natural flood management (NFM) capacity of the lower river.
iii. Rehabilitation interventions must result in a net increase in the channel's flood conveyance capacity. For example, when habitat elements (e.g. boulders, rocks, marginal vegetation) are introduced into the channel, this will increase channel roughness and decrease flow velocity and thus flood conveyance. This effect must be compensated for by the increase in channel cross-sectional dimensions.
iv. Ecohydraulics and Sediment studies are necessary to advise on the appropriate channel dimensions, bank stabilisation method, optimal size of substrates (boulders, rock) to be used for bank stabilisation and instream habitat replacement, extent of habitat reinstatement, placement of substrates (habitat), best means of reconnecting channel to floodplain, etc. Final design should be done by Registered Civil Engineers in consultation with the Ecohydraulics and Sediment specialists.
v. Depth in the channel should be maintained at a minimum of 0.1 m to allow for fish movement in an upstream direction. For this reason it is advised that the low-flow channel is not widened at this stage.

7.4.2.3 Naturalise Reach 6A

(River alongside the new Bridgeway Complex on the right bank)

The channel in this section is relatively natural. The banks are steep and densely vegetated with a mix of indigenous and alien vegetation including dense stands of reeds (e.g. *Phragmites australis).* This section of the river is located in the upper section of the proposed Baakens Parkway (Section 2.3), and there are a number of restaurants alongside the river on the right bank. The aim here should be to create views of the river from the bank, to enhance the experience of patrons, and to provide space for new indigenous riparian plants to grow.

Interventions:

This will require removal of alien vegetation from both banks and thinning of indigenous vegetation, all under the supervision of a qualified Riparian Vegetation Specialist. The action of thinning this vegetation will also reduce flow resistance and create additional flood conveyance at this stormwater concentration point. It is also advised that upstream of the bridge, on both banks, alien vegetation is cleared and managed for at least a distance of 50-100 m upstream, and indigenous marginal/riparian vegetation is significantly thinned. This is both for security reasons and to clear the bridge opening for high flows and floods (Figure 7.10).

If it is necessary to increase overall flood conveyance capacity, and/or to stabilise the river bank in this section, it is advised that the bank be cut back to a series of wide terraces. As this area is part of the Baakens Parkway plan, the ideal materials to stabilise the terrace faces would be gabions. The horizontal surface of the terrace should be used both for planting of trees and riparian plants, and between these, to include meandering paths and seating areas.

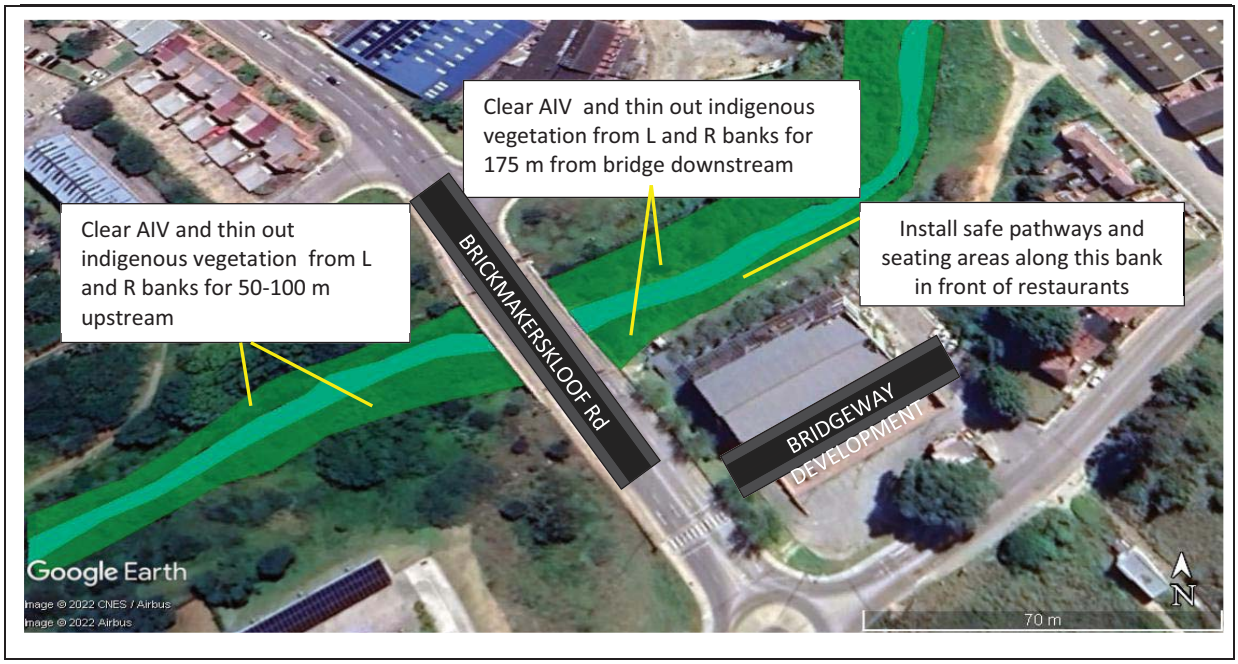

Figure 7.10 Google Earth © satellite image of Reach 6A, showing the recommended interventions

Figure 7.11 Left bank Reach 6A. View of the top of the bank in front of the Bridgeway complex of restaurants.

7.4.2.4 Naturalise Reach 6B

(Upper section of proposed Baakens Parkway)

Figure 7.12 Images of the river channel in Reach 6B. The channel is not visible from the banks (Top). The gabions lining the canal have disintegrated in areas and the banks have been scoured. Dense stands of reeds form a (broken) marginal zone and provide some instream habitat (Bottom L and R).

The following rehabilitation interventions are considered appropriate to this section, and are designed to align with the Baakens River Parkway Plan (Section 2.3):

Clear or thin out existing vegetation: Clear alien vegetation on both banks throughout Reach 6B. Thin out the lower-zone indigenous vegetation on the left and right banks of Reach 6B (Figure 7.12), leaving the vegetation with a bank-stabilising function intact. This exercise must be pre-planned and implemented under the direct guidance and supervision of a Riparian Vegetation Specialist. **Note:** The clearing of the left bank must be done manually and without the use of a TLB as this is intact valley vegetation and disturbance to it should be minimal.

Remove gabions on right bank: remove all vertical, bank-supporting gabions from the right bank channel edge. Many of these gabions are damaged. Retain rocks to supply materials for new gabions. Leave the channel base intact unless it is damaged, in which case it should be replaced with a new type of armouring (rip-rap or gabion baskets/sacks), to be advised by the Sediment Specialist.

Meander the right edge of the channel slightly to create a more natural-looking edge, without altering average width (as this will result in loss of baseflow depth),

Create embayments for fish where possible: These are short (1-2 m) 'inlet' areas on the right channel edge which will create a refuge or resting area for fish moving upstream against the flow. These should be planted with appropriate marginal species.

Create a terraced right bank (multi-stage channel): All along this section of the river (350 m), the right bank should be excavated and terraced to increase flow-conveyance, add biodiversity, and create a linkage both to the Parkway and to its users (e.g. Figure 7.13 and Figure 7.14). At this stage, there is not adequate information to recommend widening or deepening the active channel in this section, as was conceptualised in the GAPP Consortium (2014) and Buchanan (2013) plans. As rehabilitation works prove effective over time however, this may become possible.

Responsible Party: MBDA

Figure 7.13 Bank stabilisation using the gabion-terrace approach. A lower slope angle and greater terrace width is advised.

Figure 7.14 An example of cutting back and gabion-terracing the eroded right bank of the river, and armouring the bed with rock to create instream habitat. Constructed for flood management purposes at Silvermine Reserve (African Gabions Gallery)

Materials:

Although the use of gabions is not the preferred approach, as they are expensive and have a relatively short lifespan, the use of bioengineering (i.e. engineering with natural materials and minimal hard structures) is a relatively young a practice in South Africa and may not be the optimal solution in a section of river which already represents a flood hazard.

The gabion terraces should be designed in such a way that they can be planted into, increasing the overall longevity of the intervention, as tree and plant roots stabilize the river bank when the gabion disintegrates, and eventually give the banks a more natural look (see). The idea should be to allow the banks to re-wild (a more organic and less structured aesthetic) rather than to try and beautify and control growth here. The built elements of the Parkway on the floodplain should make use of gabions features and natural-wood walkways to tie-in to the design appearance of the Parkway and the landscaping ideas of the Bridgestreet Development

Functionality:

The interventions in this length of river should improve the ecological functionality of the river by adding:

- The equivalent of a **multi-stage channel** on the right bank of the river by using the terracing approach. This increases high flow and flood conveyance. The increase in channel cross section will determine the extent to which the conveyance capacity has been increased. Bank-terrace levels could be set at the same levels as estimated flows (e.g. 1:1, 1:2; 1:5 year high-flow levels).
- **A diverse marginal zone** leading to increased faunal biodiversity. The horizontal and vertical front surfaces of each terrace can be used as a planting support, and a healthy diverse marginal and riparian zone could be established, using only the indigenous plants recommended by a Riparian Specialist
- In-between these plantings, the gabion surfaces can serve as a base for constructed benches or pathways (see Figure 7.15). There is a good opportunity here to put people back in touch with

the river, purely by having access to a view of the channel, or by walking or sitting next to it, listening to the sound of the water, and having a view of the valley vegetation on the opposite bank (which is still intact and indigenous vegetation).

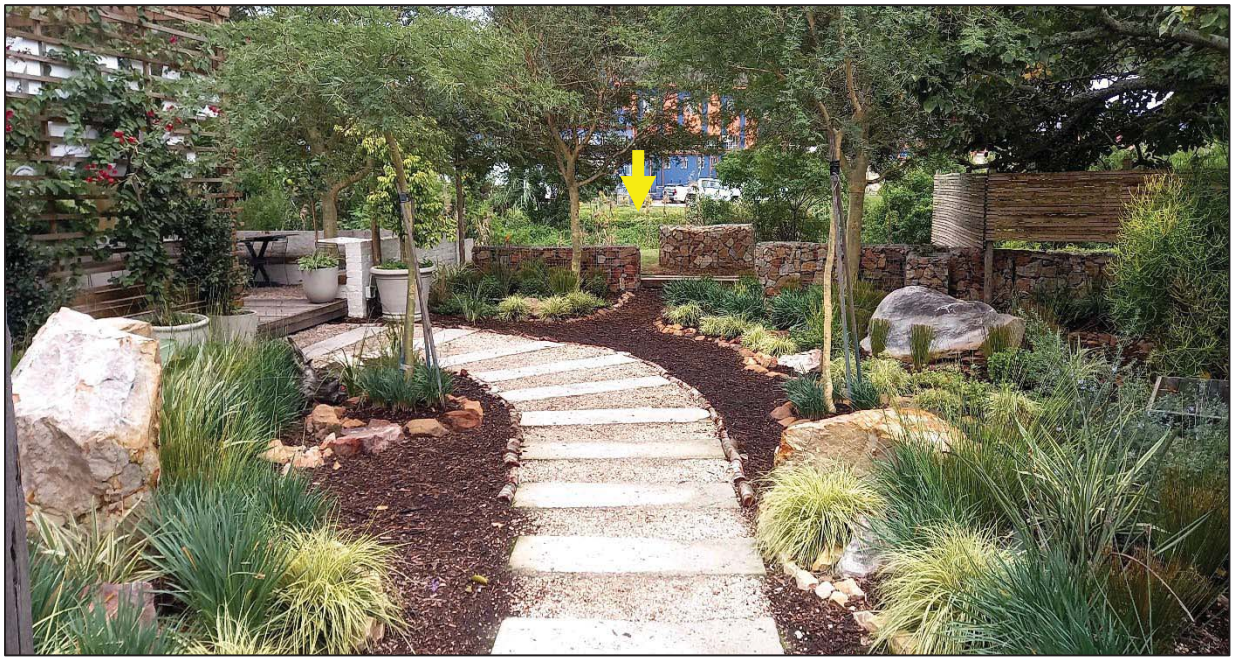

Figure 7.15 The landscape-design approach to the entrance to the Bridge Street Complex, which is a collection of restaurants including the Bridge St Brewery. This side of the complex faces the Baakens River (arrow).

		
A. Grassed terraces could provide seating areas	B. Indigenous plantings can be used on terraces into gabions	C. Seating or walking areas incorporated into gabions

Figure 7.16 Ideas for incorporating various parkway elements into the gabion terrace. Sources: A, B: https://www.containerwatergardens.net/12-gabion-ideas/ C: www.wiremeshgabions.com

7.4.2.5 Naturalise Reach 6C

(Estuarine interface and estuary, 440 m)

From an ecological perspective, this is a critical section of the Baakens system, representing in its natural state an extensive wetland ecosystem, the estuary, which also represents the connection between the ocean and the river and their biotas. The historic significance of this area of the catchment must also not be forgotten – the Baakens Fonteyn (fountain/freshwater spring near mouth) was probably one of the principal reasons for early settlement in this area (McCleland 2017).

Estuarine morphology, functionality, fauna and flora have been all but lost here, due to historic clearing of the banks and valley vegetation, roadbuilding, historic infilling of the lagoon in the 1860s, building on the reclaimed land, constraining the wide lagoon into a narrow concrete canal, and building a series of seven bridges over the mouth.

Unfortunately, it is not possible in the short term to restore this estuary, nor to reinstate its natural dynamic morphology and its functionality. The reasons for this include the fact that where the estuarine lagoon once spread out, now stand carparks, roads, buildings and factories. It is not envisioned that there would be sufficient reason or priority, under any political scenario, to demolish and remove any of these structures (or the many bridges) in order to rehabilitate the original estuary. In the absence of such a scenario, one must aim to do the best one can with what one has.

This lower 440 m section of the Baakens is also prone to severe flood damage, as it represents the final flow bottleneck in the system, particularly with all the modifications it has been subjected to.

Interventions:

These interventions are based on research and review of options, and discussions between Uys, MacKenzie and Bok (team members). Further inputs were made by Prof Nadine Strydom, Botany Department, Nelson Mandela University. Prof. Strydom is an Advisor to the project team. She has studied the fish of the Baakens River, and has authored reports and a paper in this regard (Strydom et al. 2013). As a specialist in larval fish biology and ecology, she is well placed to advise in this regard.

The most pragmatic interventions in this estuarine reach would focus on achieving a gradual return in estuarine functionality, through: a gradual undoing of some of the more extreme historic alterations (where safe and practical), creation of a multi-stage flow channel, increase of flood conveyance, maintenance of current baseflow depths, reintroduction of habitat and hydraulic diversity with a focus on providing cover and refugia for larval fish moving into the estuary (as a nursery area) or migrating up the system. All these objectives would be met to an acceptable degree by the actions recommended below, which are conceptual only (see Figure 7.17). Detailed hydraulic and sediment studies and engineering design would be required if these were to be implemented:

- **Clear AIV** in the 10-15 m strip on the left bank of the canal, up to the retaining wall (this to be done manually)
- **Manually thin out indigenous species** remaining on the left bank, leaving selected indigenous marginal or riparian species in situ to form part of the new bank.
- **Clear the debris** from the canal and from the mid-canal groove.
- **Remove the low vertical edge-walls of the concrete canal** along the entire length of the canal. While retaining this concrete base is not ideal, it is considered a pragmatic means of preventing scour.
- **Stabilise the edges of the cut canal base** with narrow gabion sacks (or another means). To avoid future undercutting of the concrete slab, these must be trenched in to an appropriate depth alongside the concrete canal base. Dimensions to be advised.
- **Maintain the current canal width** in order to maintain baseflow depth (> 0.1 m) for fish passage.

- **Maintain the current canal alignment** (initially at least, as meandering would reduce flow velocity during high flows)
- **Excavate and slope the left and right banks** in one of two ways:
  - Into a series of 3 broad terraces (dimensions to be advised) or
  - As a sloped embankment with a stable angle (the lower the slope angle the better, e.g. 1:3 to 1:5).
- **Stabilise the cut banks** There are many possible approaches, two provided here, and further options in the following paragraph (learning from others as recommended by Rutherfurd et al 2000):
  - Use boulders or rock slabs in a terrace formation to stabilise the banks, and plant into the toe of the bank. This will create habitat and cover for larval fish moving up the river (Figure 7.15)
  - Use gabion terracing as described for Reach 6B.
  - *Note: Using different stabilisation treatments on the left and right banks, and creating a non-symmetrical channel cross-section, is an option.*
- **Reintroduce habitat and hydraulic diversity** under advisement of the Sediment specialist. The principle form of habitat in this estuarine section should be marginal vegetation, to be planted at the toe (possibly into the gabion sacks) and on the lower slopes of the embankments. It may be a consideration to trial growing estuarine floodplain plants in this section if there is sufficient sediment trapping. In developing the Thesen Island marina, 25Ha of impacted saltmarsh was transplanted into the development to create an ecobelt, and to meet the condition 'No nett loss of salt marsh' (see Figure 7.19).

7.4.2.6 Learn and loan from case studies

Many urban rivers around the world have been exposed to similar alterations and impacts. Restoration is a well-developed practise in some other countries (e.g. UK, USA). There is merit in learning from and adapting ideas that have worked elsewhere on other similar projects.

One such instance is the River Restoration Group (UK) rehabilitation project on the River Marsden, Wiltshire, UK, completed in 1999 and reported in their substantial Manual of Restoration Techniques (1997 and 2020).

While the techniques for the River Marsden project used were developed to suit site-specific criteria, there are design elements that could be transferable to this lower section of the Baakens. Some of these are presented in Figure 7.13. The full rehabilitation report is included Appendix 3.

Responsible Party: MBDA

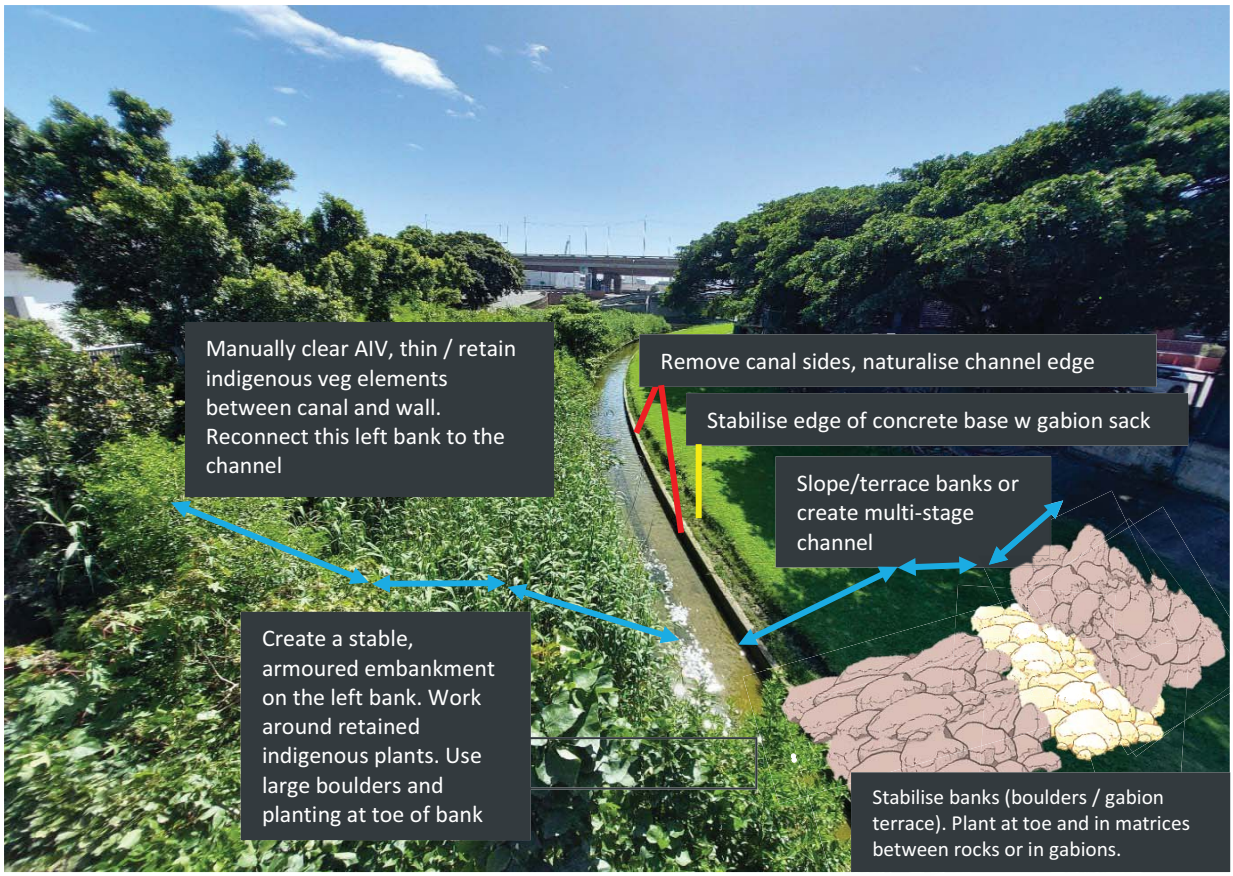

Figure 7.17 Conceptual ideas for renaturalisation of the estuary, Reach 6C

7.4.3 River naturalisation intervention: create flood channel (wetlands) on the floodplains

This intervention is included here as it ties in with the naturalisation of the river in this lower section.

Creating high flow or flood channels and floodplain wetland features to improve floodplain function, flood attenuation and biodiversity can be achieved in several locations in the lower reach of the Baakens River (Reaches 6B and 6C).

The technique involves creating flood channels that will be activated at high flows and floods, increasing flood conveyance capacity, and floodplain function. These channels are landscaped flow paths located on existing floodplain scrapes, scars or depressional wetland features. High flows will be guided along these channels, which will retain water and behave as wetland systems for variable lengths of time. This will require detailed hydraulic design. The intention would be to incorporate these features into the landscape planning of the floodplain, providing both ecological and educational value, and urban amenity. It is important that the systems when filled do not present a drowning hazard (i.e. must be shallow enough for a child to stand in). Large 'hopping blocks' of rock or concrete should be placed in the form of a pathway across these structures as safety features to be used by children accompanied by adults.

Responsible Party: MBDA with NMBM

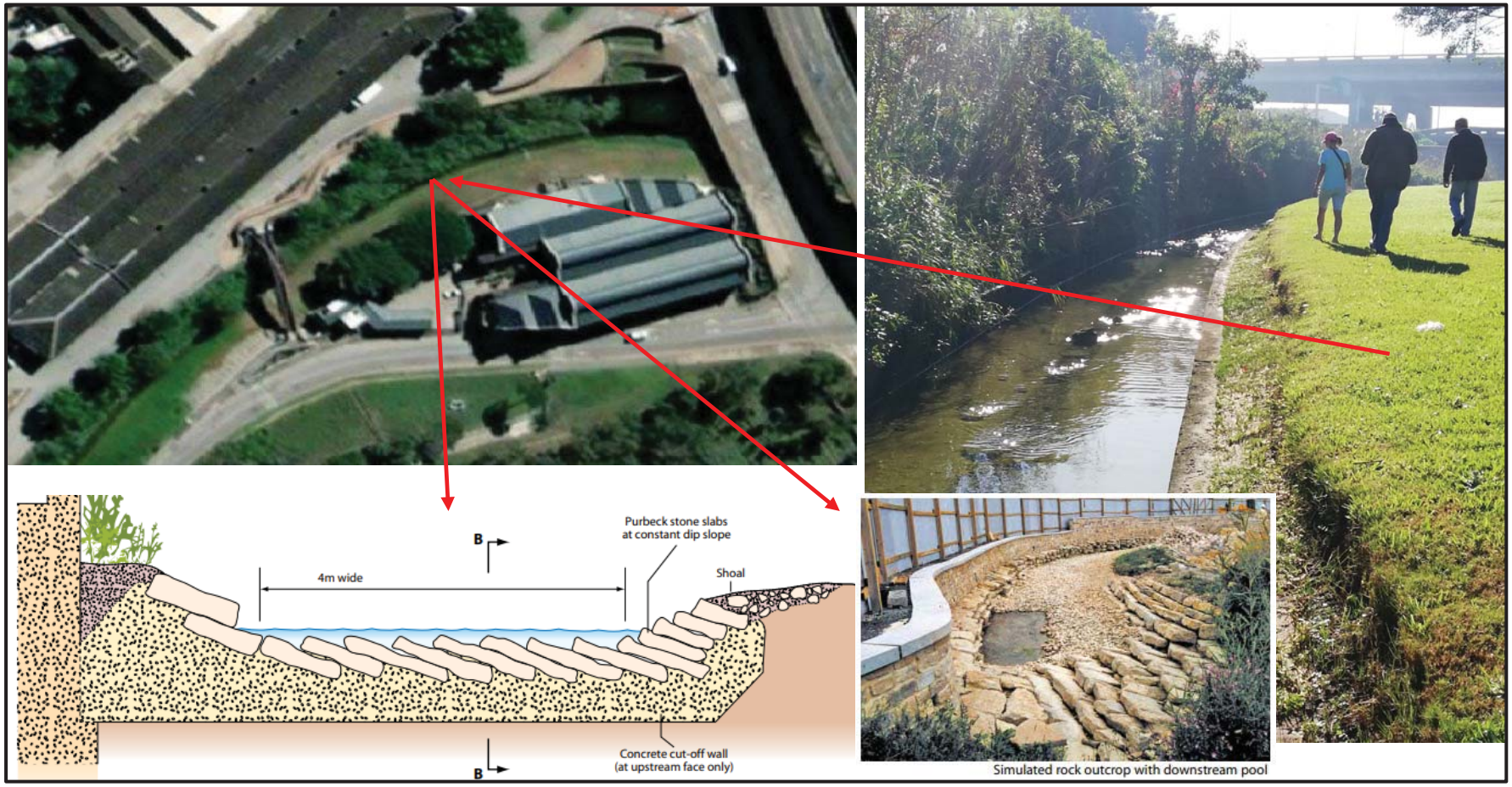

Figure 7.18 More detailed examples of in-channel structures that have successfully been used by the RRC at River Marsden in the UK to improve naturalised channel morphology and could assist in informing actions in Reach 6C (see Appendix 3).

Topsoiling the gabion/reno mattresses (Oct 2000)

Planting of saltmarsh sods (Feb.2002)

Planting with saltmarsh plugs

Salt marsh growth (2002)

Figure 7.19 The stages of planting saltmarsh plants in the development of the Thesen Island Marina. Salt marsh vegetation is a consideration for the lowest section of the Baakens Source: Maccaferri 2015

The flood channel approach would be useful in the following areas: lower Settlers Valley, the large floodplain area opposite the Valley Road complexes (the proposed MBDA Baakens Parkway area), and the large left bend in the river beneath Fort Frederick. The following options, as presented in Figure 7.20, should be considered:

1. Flood channel 1 – this option makes use of the former quarry area in Settlers Park which (according to the 2014 floodline study of SRK) will receive flood waters and activate wetland features excavated and planted in this area. This will provide additional flood attenuation and serve as a refuge for depleted amphibian species, and potentially fish species. (Note: the study team is aware of the option to develop this as an amphitheatre, but preference would be given to the amphitheatre included in the Mantis Green Lung Report of 2014, as described in Section 2.4.1.5.)

2. Flood channel 2 – this option should be installed in conjunction with AIV removal and is intended to serve as a small flood bench on the left bank, with some pooling in backwater areas. See the note on vegetation clearing.

3. Flood channel 3 – excavation in this area will serve to alleviate the flow-bottleneck effect at high flows, which will promote more efficient through-flow of floods.

4. Options for flood channels 4 to 6: these options are intended for flood attenuation and habitat creation (to improve biodiversity) but will have to be planned in conjunction with other waterfront designs to provide for safety for recreation and enjoyment of the area.

5. The options would be:
    a. Flood channel 4 only
    b. Flood channel 6 only
    c. Flood channels 4 and 6
    d. Food channel 4, 5 and 6 as one extended feature.

Excavation of these features should be guided by a wetland (and wetland plant) specialist.

Figure 7.20 High flow / flood channel installation options 1-6, with additional wetland habitat features.

8 STAKEHOLDER ENGAGEMENT

'Most stream rehabilitation projects are at least as much about people as they are about science and reconstruction'

Rutherfurd et al. 2000a

8.1 INTRODUCTION

The importance of stakeholder engagement in stream rehabilitation cannot be underestimated. It is not possible to achieve a vision without the input, support and opinions of others. Competing priorities (development vs. environment) are likely to become a source of contention during this process, so it is necessary to identify the various interests in the stream early on in the procedure. Rutherfurd et al. (2000) recommend that Step 2 of the rehabilitation process is the identification of the stakeholder community that has a common vision for the rehabilitation of the river, acknowledging that certain of the managing authorities (e.g. NMB Metro) are required to balance the needs of development and conservation in their work approach.

One of the mandated functions of the MBDA, in their catalytic programmes and special projects, is the 'identification and designation of stakeholders, and undertaking (of) work in partnership with the private sector, government agencies and civil society organisations' (MBDA 2018). The stakeholders identified for the implementation of projects include youth, organised business, Nelson Mandela Metro University, environmental lobby groups, NMB Tourism and its members, South End Museum and members, Wildlife and Environment Society of SA and its members, NMB Heritage Trust, sporting bodies, adventure groups, private sector owners, etc.

In the case of the Baakens River Precinct Development and the Baakens Parkway projects, there is active interest from several quarters in partnering with the rehabilitation and further protection of the river, and in reinstating the safety, natural and recreational value of open spaces. Some of these stakeholders have been engaged with during the course of this study.

8.2 PROPOSED STAKEHOLDER ENGAGEMENT FOR THE STUDY

The proposed stakeholder engagement for the duration of this project was as follows, as per the Method Statement presented at the outset:

Stakeholder Engagement

17. *This will involve meeting with key stakeholders and catchment community, including various groups set up on social media historically, to improve the catchment, to present and discuss project outcomes and rehabilitation options, actions and costings, and to engage with the Metro and community in discussion on which actions may be viable to initiate the shift of the selected sites/areas in the direction of ecological functionality, more natural conditions, and best recreational opportunities.*

As the project unfolded it became clear that single meeting with Stakeholders would not be an adequate interaction, and it was agreed that the Stakeholder Engagement should rather be a series of engagements throughout the Project. This has been a far more useful approach, however it is a very time consuming one, not ideally suited to the Scope of Work. It has been vital to the information-gathering and the setting of realistic scenarios for the rehabilitation of the Baakens River.

8.3 STAKEHOLDER ENGAGEMENTS TO DATE

The stakeholders identified during the course of the project (May 2022 to January 2023) are presented in the following Tables, together with the record of engagement.

INSTITUTION /ORGANISATION/ DEPT	INDIVIDUAL	DATES 2022	**NATURE OF ENGAGEMENT**
LOCAL GOVERNMENT & AGENCIES			
MANDELA BAY DEVELOPMENT AGENCY			
Development Projects: Planning	**Ms Singathwa Poswa**	May 2022 - March 2023	Preliminary meeting, site meeting, attendance at second Reference Group meeting, attendance at meeting between MBDA, NMBBC and this study Team, ongoing discussions and emails throughout project.
Development Projects: South End	**Ms Tamlynn David**	May 2022 - March 2023	Site meeting, Steering Committee Meeting Presentation, Attended meeting set up with NMBBC, Attended second Reference Group meeting; Ongoing assistance and engagement.
Development Projects: Urban Planner	**Ms Dorelle Sapere**	Various 2022	Emails and phone calls to establish contact. Unfortunately Ms Sapere has been on sick leave for some while.
NELSON MANDELA BAY METRO			
Mayoral Council - Infrastructure and Engineering Portfolio	**Councillor Andries vd Westhuizen**	Phone messages, Email	Request for information regarding the most up-to-date documentation on the Sanitation Plan and the current state of the sanitation in the catchment. Response to message, however no information received. The Councillor is extremely busy however.
Department of Infrastructure and Engineering (Water and Sanitation)	**Dr Barry Martin**	Various	Phone calls and emails to request a time to discuss the current issues as they pertain to the Baakens River. A request for information accompanied by a letter from the MBDA ACEO. No response received. Dr Martin is however engaged with water supply issues.

NELSON MANDELA BAY METRO			
Roads and Stormwater	**Mr Yusuf Gaffore**	9 and 30 Nov	Phone call and numerous emails, including one with a letter from MBDA ACEO, to request permission to obtain the annexures to the Floodline Report from SRK Engineers. No response received. Mr Gaffore is engaged with critical issues.
Directorate Public Health (Environmental Management, Parks: Senior conservation officer)	**Mr Luthando Crab**	25-Apr	Visit by MU to the St Georges NMB Metro Parks offices in attempt to get information on the state of Settlers and the Park Rangers. Referred to Mr Luthando Crab at the Metro offices. No response to the email requesting further information.
Engineering mentorship Programme within NMB Metro	**Mr David Raymer,** Uhambiso Consult. Working with National Business Initiative in the role of Mentor)	30-Nov to December	Discussions regarding broad water supply and sanitation. Mr Raymer also assisted with historic photographs of the river.
Engineering mentorship Programme within Metro	**Mr Donald Bagley -** part of TAMDEV, serving as a Technical mentor to mentees in regard to potable water infrastructure	05-Dec	Telephonic discussion regarding the Metro sanitation services. This is not Mr Bagley's mandate so he was not in a position to assist, however the conversation was instructive.
DE**PARTMENT OF WATER AND SANITATION (DWS)**			
Gqeberha DWS	**Mr Mzu Maneli**	Various, Nov22	Telephonic contact, email request, and return call to discuss the Baakens water quality data on the national DWS website, ongoing water quality monitoring in the Baakens, .and the notion of the interested stakeholders forming a Catchment Management Forum with DWS involvement. Very helpful discussion.
EDUCATIONAL INSTITUTIONS			
NELSON MANDELA UNIVERSITY			
Zoology Department	**Prof Nadine Strydom,** Larval fish specialist	23-May 2022	phone call to discuss the type of interventions envisaged on the Baakens Estuary.
		04-Nov 2022	Meeting in Gqeberha to discuss more detail on the proposed changes to the lower Baakens (estuary) and their likely efficacy.

Botany Department	**Mr Adrian Grobler** (plant specialist and Conservation Planner)	May 2022	Established contact via Facebook Messenger. Unable to meet to discuss project but showed great interest in the project and in the work being carried through.
PRIVATE ENTERPRISE			
ENGINEERING ADVICE AND SERVICES, P.E.			
Environmental Scientist	**Ms Lea Steyn**	May-22	Assistance with information on the Basic Assessment Report for the Baakens Precinct and other river related information
		Jun-22	Presented the Baakens Precinct Basic Assessment Report at the Reference Group meeting
HIVE ECOSYSTEMS			
Managing Director	**Mr Japie Buckle** (Formerly Working for Water, Working for Wetlands)	01-Nov	Meeting in Gqeberha. Discussion around the background to the 2014 Working for Water plans to clear the Baakens catchment of alien invasive vegetation (This was not implemented)..
NMB BUSINESS CHAMBER			
Projects Coordinator .	**Mr Renzo Driussi**	Numerous; May to December 2022	Regular and helpful communications with Mr Driussi, who has unfortunately now left NMBBC. Contact was initially made to request a copy of the Mantis Group 'Green Lung' Baakens River Rehabilitation report, commissioned by the Chamber, and referred to in Chapter 2. This led to discussions regarding a perceived need for the Chamber and the MBDA to be in active conversation in this regard. A meeting was set up for 20 October 2022 between NMBBC, MBDA and LWA. At the meeting Mr Gary Koekemoer, Chair of WESSA Algoa Bay Branch, presented the NMB BC Green and Blue Lung initiatives. Discussion ensued around these projects, climate change issues, and how to move forward collectively. A second meeting was set up for 29 November 2023 but was later postponed. No further date was set.

	Mr Renzo Driussi Cont.	02-Nov	Meeting in Gqeberha and site visit of lower river to discuss current state and recommended actions. Discussion of linkages and synergies between different Baakens River rehabilitation initiatives.
Chief Executive Officer	**Ms Denise van Huysteen**	20-Oct	Attendance at the meeting between MBDA, NMBBC and LWA.
Chief Operations Officer (now former)	**Mr Prince Maponsi**	23-Jun	Telephonic contact following email introductions over past month. Information regarding the Business Chamber's and Mantis EcoGoup involvement in Baakens River, and the Memorandum of Understanding between the Chamber and the Metro in this regard.
Chief Operations Officer	**Mr Ashwin Dyer**	20-Oct 2022	Chaired the meeting between MBDA, NMBBC and LWA in October 2022.
THE MANTIS GROUP			
Development Director	**Mr Bruce McNicol**	20-Oct 2022	Reciprocal emails regarding the Mantis Group Report.
URBAN DYNAMICS			
Urban Planner	**Mr Johan vd Westhuizen**	May-22	Emails and telephonic discussions. Assisted with discussion on the river, and project-related information.
ROSE BUCHANAN LANDSCAPE DESIGN			
Rose Buchanan Landscape Design	**Ms Rose Buchanan Landscape Design**	24 Nov 2022 and follow-up	Telephonic discussion and follow up email with RB from Rose Buchanan Landscape Design. RB did an MSc in 2013 on the rehabilitation of the river (Report Ch2). Lengthy discussion on her approach and what transpired with the report. MU requested further discussions and inputs, which were duly emailed to her within a day or two. Ms Buchanan is passionate about the rehabilitation and appropriate landscaping of the Baakens.

HIVE ECOSYSTEMS			
Formerly Working for Water, Working for Wetlands	**Mr Japie Buckle**	01-Nov	Meeting with MU in Gqeberha. Discussion re: the 2014 Working for Water plans to clear the Baakens catchment of alien invasive vegetation.
ORGANISATIONS AND COMMUNITY GROUPS			
Wildlife & Environment Society of SA, Algoa Bay Branch; Algoa Bay Ocean Stewards (ABOS), AIM Political Party; Civil Society Coalition (of which the Business Chamber is part); #theshitisreal campaign (social media)	**Mr Gary Koekemoer represents all of these organisations. He is Chair of WESSA, Algoa Bay Branch.**	Various Nov 22 – Project closure. New member of Project Reference Group.	GK is involved at several levels in the catchment and with the numerous organisations listed here. He is actively involved with groups that are working to improve issues of concern city wide, and assisting the Metro to identify and solve problems wherever possible. Interactions with GK include emails and discussions regarding, and information sharing via community social media group ABOS. These interactions are always fruitful and have been most valuable in assisting the team to understand the crucial issues of the Baakens.
Community Crime Awareness	**Ms Ellen Paasche initiated and runs this organisation**	16 May 2022, In regular contact to project closure. New member of Project Reference Group.	EP is a valley resident. She initiated the CCA group during Lockdown to address the crime and poaching of live animals in the valley. She also reports all water quality issues directly to the Metro. EP sends information on the river issues and the community action in this regard, This has broadened the team's understanding of the numerous issues faced by the Metro, the various communities of the catchment, and the river and its biota.
ACTIVE COMMUNITY MEMBERS			
Valley resident and MTB cyclist	**Ms Candy Boonzaaier**	16-May 2022	CB runs an MTB business and is active in the MTB community. She is very familiar with the valley, the trails and the various projects underway. She gave the team a guided walk through Dodd's Farm, discussing the river and issues en-route. This was invaluable assistance in setting the context for the field studies.

ACTIVE COMMUNITY MEMBERS			
Valley resident, MTB cyclist	**Mr Johan Gerryts**	16-May 2022	JG is former Chairperson of Fat Traxx MTB club. The club had a Memorandum of Understanding with NMB Metro to lay new trails through the valley, maintain them, and provide security cameras This initiative is still active (although the MOU may have expired), JG met with this project team on site, and we discussed many issues pertaining to the river and its environs. This provided great insights.
Valley resident, MTB cyclist, initiator of the Community Crime Awareness (CCA) group	**Ms Ellen Paasche**	16 May 2022, November 2022, and ongoing	EP is a valley resident. She initiated the CCA group during Covid-19 Lockdown to address the crime, and the poaching of live animals in the valley. She also reports all water quality issues directly to the Metro. EP is in touch regularly and sends information on the river and current issues by email.. This interaction has been very helpful and has assisted in broadening the Team's understanding of the river, the numerous impacts on it, and the power of the individual to effect change.
Resident, No 3 The Close, Lorraine (House at Site 1)	**Mr David Stutthard**	17-May 2022	Mr Stutthard spoke to the Team as we were sampling Site 1. He lives on the banks of the river and is directly involved with the water quality issues and the pump stations, through his own work.

AUTHORS/WRITERS			
Author of the four volume book series 'Port Elizabeth of Yore', author of the Blog 'The Casual Observer' (http://thecasualobserver.co.za)	**Mr Dean McCleland**	November 2022 and ongoing	Telephonic discussion about the Baakens River, about which DM has published several intensively researched articles on his website. MU had a number of questions for DM. This initiated ongoing discussions via email, and DM has been kind enough to write more about the Baakens (December 7 2022 Blog) subsequently. DM has kindly emailed a number of historic photographs to MU.
Writer for The Casual Observer	**Mr Blain McCleland**	November 2022	Email query and response regarding the Bridges of the Baakens (BM wrote an article about this).

The value of this approach is that it has provided a platform for communicating at a more meaningful level with the Development Agency, some of the relevant authorities, and with individuals and organisations who are deeply committed to the City and to the future of their natural environment, and the Baakens River system in particular. This would not have been possible with a once-off stakeholder meeting. A number of individuals have been helpful in assisting with ground-truthing the river, providing local context, assisting with historical background and present day information, and have been willing to discuss the practicalities of proposed rehabilitation interventions.

It is clear however that Stakeholder participation is a slow process that must continue throughout the rehabilitation planning and decision-making phases. It is not the same as consultation. The ability of a number of parties representing different interests to work together in a common direction definitely requires the building of relationships and trust, and this can only be achieved through regular interaction, and eventually the structuring of a clear plan and objectives, and assigning of roles.

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PERSONAL COMMUNICATIONS

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APPENDICES

APPENDIX 1: DEVELOPMENT GUIDELINES FOR CBA AREAS IN THE METRO (SRK 2010 P.60)

CRITICAL BIODIVERSITY AREAS (AQUATIC ECOSYSTEMS) *Critically Endangered and Critical Ecological Process sites – in terms of NMBM pattern & ecological process targets INCLUDES wetland types, river reaches, estuaries and catchments
Keep in a **NATURAL** or **NEAR NATURAL** state
Conservation Resource Use – HIGH resource PROTECTION **Adjacent Land-Use** – CONSERVATION or buffer to adjacent development
BIODIVERSITY OFFSETS
• No realistic biodiversity offsets.
ECOLOGICAL RESERVE
Water Quantity
• Maintain mean annual run-off as close to natural as possible; • Where abstraction is absolutely necessary, off channel dam construction ONLY with the highest Ecological Reserve possible; • Improve regulation of abstractions from these rivers & encourage efficient water use throughout the area (i.e. demand control, recycling, use of grey water, rainwater tanks); and • Where water abstraction is licensed, all effluent must be treated and returned to natural water courses in order to obtain maximum utilization of scarce water resources.
Environmental Flow Requirements
• Flow regimes as close to natural as possible Retaining natural flow regimes (both in terms of magnitude and variability); Management actions to maintain natural flow regime should include: - Abstraction should occur during high flow seasons, not during low flow seasons; - Water release from dams should take note of the ecological requirements of CBA rivers. This includes at least one annual flood release (at most appropriate time of year for each system), even if the dam is not full; and - Optimal use should be made of existing abstractions through demand-management measures. Water must be correctly priced to prevent abuse and wastage.
Water Quality
• Water quality as close to NATURAL as possible; • The Target Water Quality Range (TWQR) (range of concentrations or levels) should ensure that no measurable adverse effects are expected on the health of aquatic ecosystems, and should therefore ensure their protection; • All effluent is treated and returned to natural water resources in order to obtain maximum utilization of scarce water resources (as per DWA Policy); and • A precautionary approach is required to protect the health of aquatic ecosystems, which means that active measures are taken to avert or minimise potential risks of undesirable impacts on the environment.
Monitoring & Management
• A management plan should developed for each biodiversity feature or site, for example – red data species, specific river reach habitat and • NMBM to investigate establishment of aquatic reserves (e.g. Swartkops Estuary).
Buffer Recommendations (CBA Buffers are 'NO-GO' areas) *Where an aquatic CBA is situated within a Ecological Corridor CBA, the width of the CORRIDOR will apply in concert with the buffers recommended below. UNLESS other land-uses (e.g. Agriculture) exist already OR a conservation land-use is proposed, the buffers recommended below will apply & should be actively enforced.*
It is important to NOTE that the following buffer recommendations DO NOT REPLACE a SITE LEVEL investigation.

River Buffers

To protect river integrity the following general buffers will apply:

- Mountain streams and upper foothills of all 1:500,000 (major) **rivers** = 50 m (these rivers generally have more confined riparian zones than lower foothills and lowland rivers; and are generally less threatened by agricultural practices);
- Lower foothills and lowland rivers of all 1:500,000 **rivers** = 100 m (these rivers generally have less confined riparian zones than mountain streams and upper foothills; and are more threatened by agricultural practices. These larger buffers are particularly important to lower the amount of pesticides etc. reaching the river); and
- All remaining 1:50,000 **streams** = 32 m (these rivers are generally the smaller upland streams corresponding to mountain streams and upper foothills. They are generally smaller rivers than those designated in the 1:500,000 rivers layer, and are assigned the riparian buffer required under South African legislation).

Alternatively

- If the 1:100 year flood line (or if flooding has occurred > 1:100 year flood line) is greater than the buffers prescribed above, then these flood lines will apply (i.e. it is important to re-evaluate flood lines to cater for the impact of climate change and reduce flood damage on new developments); and
- Enforcing the above riparian buffer zones along aquatic CBAs is crucial. The buffers will apply to crops, since rivers and their associated biota are highly susceptible to crop pesticides. It also applies to excluding livestock, which cause considerable bank erosion, with subsequent degradation of water quality. The access areas for livestock should be demarcated and all alien invasive plants within this zone should also be eradicated.

Estuary Buffer

- It is recommended that no new development around an estuary be permitted below 500 m from the high water mark or the 1:100 year flood line, whichever is the greatest;
- Where known flooding has occurred (e.g. Swartkops River Estuary) the highest flood line will apply (i.e. re-evaluate flood lines to cater for the impact of climate change and reduce flood damage on new developments); and
- Estuarine salt marshes should be protected and no activities allowed there.

Wetland Buffers

- Wetlands classified as CBA and are largely intact (natural to near natural), namely rank 1 & 2 wetlands, require a minimum buffer of 75 - 200 m;
- Ensure that delineation of the wetland boundary is undertaken by a specialist ecologist according to 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAF, 2003);
- No roads should be permitted to traverse these wetlands & their buffers; and
- Where a road or other water channelling structure runs close to a wetland and its buffer, and channels water into it, such water should be dispersed via multiple entry points with energy-dispersing structures. These drains must be small, dispersed low-volume, low-velocity structures. They must also be set back from the wetland and its buffer zone and be designed to spill into undisturbed natural vegetation at ground level. These provisions also apply to all urban storm-water outlets that spill into a wetland or up-slope of a wetland.

The following buffers are recommended for rank 1 and 2 wetlands, which vary according to size and wetland integrity (rank):

Size of Wetland	Rank 1	Rank 2
>20 ha	200 m	150 m
5 – 20 ha	150 m	100 m
< 5 ha	100 m	75 m

General Recommendations regarding Buffers -

- Do not permit infilling, excavation, drainage, hardened surfaces (including buildings and asphalt), intensive agriculture or any new developments within a **river, wetland or estuary**, their buffers, the 1:100 year flood line or highest flood line of the delineated edge,

whichever is the greatest.

- The "buffers" may need to be wider than the above recommendations, for example due to the presence of an important amphibian species. This should be determined on a case-by-case basis by a specialist ecologist in consultation with the Department of Water Affairs (DWA), the NMBM and DEDEA to reflect site-specific factors. The approach for determining buffer width should consider the current condition of the aquatic ecosystem, as well as the functioning of the system in the broader landscape, plus an assessment of the impacts to the ecosystem of the existing and proposed adjacent land-use and climate change impacts i.e. increased flooding at higher levels than previously recorded.

REHABILITATION

- Areas that are degraded or disturbed should be rehabilitated, through programmes such as Working for Water, Working for Wetlands and a systematic alien vegetation eradication programme implemented to improve biodiversity and water supply, especially upstream areas of estuaries and wetlands;
- Prohibit the stocking of farm dams (even off-stream dams) with alien fish;
- Remove alien fish where possible to allow for natural recovery of indigenous fish in consultation with DWA, DEDEA, EC Parks & NMBM;
- Stock dams with indigenous fish in consultation with DWA, DEDEA, EC Parks & NMBM; and
- Rehabilitate riparian zones to act as a buffer between the river and surrounding agricultural areas in consultation with the Department of Agriculture, Forestry and Fisheries (DAFF), Department of Water Affairs (DWA), DEDEA & NMBM.

MANAGING CUMULATIVE IMPACTS THROUGH TRANSFORMATION THRESHOLDS WITHIN CBA CATCHMENTS

- Development in CBA catchment areas should be biodiversity-friendly land-uses that discourage the following activities in upstream catchment areas to prevent unacceptable transformation levels & impacts on inland wetlands, estuaries and lowland rivers:
  - Large-scale abstraction, river diversion, impoundments, urban development, extensive woody alien invasion, river diversion / water transfer, Waste Water Treatment Works (WWTW) discharges, poorly serviced informal settlements, cultivation, impacts to floodplain hydrology, changes in water table (resulting from catchment-scale water transfers), catchment hardening.
- Catchment Developments (e.g. forestry) remain subject to standard DWA requirements regarding limits to reduction in mean annual runoff.

OTHER GENERAL MANAGEMENT GUIDELINES

- Aquaculture projects associated with aquatic CBAs e.g. off-stream dams, should not be permitted;
- Hydrological connections between systems (surface or groundwater) should not be disrupted (includes the need to manage post-development high flow and low flow runoff volumes);
- Manage jetties and structures on rivers and estuaries;
- Manage bio-physical and recreational carrying capacity of rivers and estuaries;
- Manage estuary mouth dynamics as close to natural as possible;
- Most of the estuaries & downstream wetlands are highly threatened by loss of freshwater inflows from upstream and by development encroachment. Management of these issues is considered critical;
- An Environmental Management Plan to be compiled for adjacent land-uses and should address the following issues: buffers, water quality, water flow, abstraction thresholds, alien fauna control, storm water etc.; and
- The Fynbos Forum Ecosystem Guidelines for Environmental Assessment in the Western Cape (de Villiers *et al.*, 2005) includes a section on river, estuary and wetland ecosystems that complements these guidelines.

APPENDIX 2. Preparing an AIV clearing plan

Planning for clearing should include the (refer to Martens et al., 2012 for more detail):

1) Use a map showing the presence of Port Jackson in the area. The area should be broken into workable blocks or polygons. Any natural or other desirable vegetation should also be indicated to ensure protection / low disturbance. This will help with deciding what clearing methods to use and how to manage the work site. Calculate the number of person days need to employ method/s of choice.
2) Prioritisation and work scheduling.
3) Budgeting.
4) Selection of clearing methods.
    i. Consider the role of fire in alien clearing operations. Fire with the appropriate management is a cost effective clearing method and it can be used to get rid of brushwood and even stimulate the growth of seedlings to assist with simplifying follow-up operations. If fire is used as part of the clearing plan, timeous manual follow-up of seedling regrowth (hand pulling) is critical.
    ii. See suggested method for Port Jackson above
    iii. To aid maintenance of wetlands (see below) prioritise wetland areas, especially where Port Jackson densities are low and work outwards towards higher density areas, in this way securing better condition wetland (and terrestrial) areas which will promote overall ecological state/condition and assist with natural indigenous vegetation recolonisation/spread.

5) Planning for rehabilitation
    i. Establishing indigenous vegetation cover in cleared areas if they are denuded
    ii. Where the possibility of erosion exists rehabilitation should be carried out

6) Monitoring
    i. Data collected as part of the planning phase will establish a baseline before clearing commences. Progress should be measured against this baseline starting condition
    ii. Mapping and dating cleared blocks as they are completed is a useful tool in prioritizing follow-up work
    iii. Ensure that the cleared site is revisited on a regular basis, 6 monthly at a minimum, following the completion of the initial clear to monitor the regrowth. This will ensure a timely follow-up can be initiated to reduce costs.

GUIDELINES FOR CLEARING AND MANAGING AIV IN THE LOWER CATCHMENT

The following guidelines apply to for removal / management of AIV in the lower catchment (Reaches 5 and 6).

Seedlings

a. Hand pulling: Plants are pulled out by hand roots and all. This is the preferred method of control. Minimise soil disturbance to reduce seed germination.
b. Foliar application: If other desirable vegetation is present, use selective herbicides or mixes that minimises damage to desirable vegetation.

Saplings / Coppice regrowth

a. Hand pulling: Plants are pulled out by hand roots and all or severed below ground level. Minimise soil disturbance to reduce seed germination. Hand pulling should be the preferred method in sensitive environments (rivers, wetlands or in close proximity to indigenous plants).
c. Foliar application: If other desirable vegetation is present, use selective herbicides or mixes that minimises damage to desirable vegetation.
d. Cut stump treatment: Cut stumps, including all side stems and suckers, as low to the ground as practically possible. Apply herbicide to the cut area as recommended on the label.
e. Mature Trees
    a. Ring barking: Treating standing trees as this will remove the problem of having to dispose of felled trees and will result in less disturbance to the site. Remove bark from the bottom of the stem to a height of 0.75-1.0 m. De-bark using bush knives or hatchets prior to herbicide application.

Pointers for planning alien vegetation clearing are the same as those listed above for the clearing of AIV in the upper catchment, but the target species and therefore method of choice differ.

Where replanting is to take place (especially Reach 6), indigenous plant species already characteristic of the area should be used.

A NOTE ON VEGETATION CLEARING AND REPLANTING

When clearing vegetation for the purposes of landscaping, it is important to recognize that the topsoil contains vital propagules for the subsequent replanting exercise. This is particularly relevant to creeping, stoloniferous grasses, sedges and reeds, and bulbous plant species, and also includes the seed bank. As such, vegetation (and topsoil) should not be stripped by rather reworked into the new landscape features thereby improving the probability of success of regrowth. This can also be augmented by additional planting of desired species. The following lists species relevant to the Baakens River valley and estuary:

1) Creeping grasses
    - *Leersia hexandra* (marginal, wet bank, emergent, wetland)
    - *Hemarthria altiissima* (marginal, wet bank, emergent, wetland)
    - *Cynodon dactylon* (dry bank, flood bench)
    - *Imperata cylindrica* (dry bank, seepage)
2) Sedges
    - *Cyperus dives* (wet bank, emergent, wetland)

- *Cyperus textilis* (dry bank, flood bench)

3) Tufted Grasses

- *Pennisetum macrourum* (wet bank, emergent)
- *Spartina maritima* (emergent, estuarine)
- *Setaria megaphylla* (dry bank, shade)

4) Reeds

- *Phragmites australis* (wet bank, dry bank, wetland)

5) Shrubs

- *Nuxia floribunda* (dry bank, flood bench)
- *Diospyros dicrophylla* (dry bank)

6) Trees

- *Erythrina caffra* (dry bank)
- *Ficus sur* (dry bank)
- *Syzygium cordatum* (wet bank, flood bench)

7) Wetland Plants

- *Typha capensis* (emergent)
- *Persicaria senegalensis* (emergent)

APPENDIX 3. EXAMPLES OF RIVER RESTORATION TECHNIQUES THAT HAVE PROVEN SUCCESS AND MAY WORK FOR THE BAAKENS RIVER.

1) Modifying riverbed levels, water levels and flows: simulated bedrock outcrops, in-channel protection areas (embayment areas) and improved within-channel morphology and hydraulic variability. **This case study provides ideas for the rehabilitation of the estuarine section of the Baakens.**

https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/5.4_Marden.pdf

2) Modifying riverbed levels, water levels and flows: Gravel reworking to restore low flow channels and within channel variability

https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/5.8_Hawley_Manor.pdf

3) Modifying riverbed levels, water levels and flows: Replacing an armoured bed with boulder step pools. **This case study provides ideas for Reach 6B, opposite the Valley Road Centre, where the river is gabion-clad at present (gabion baskets damaged).**

https://www.therrc.co.uk/MOT/Final_Versions_%28Secure%29/5.9_Inchewan_Burn.pdf

4) Creating / providing public (or private) safe urban riverside access. People enjoy being next to rivers and seeing the water in a safe and clean environment.