- **Inherent risk**: A risk which it is impossible to manage or transfer away (riskythinking.com).
  The risk found in the environment and in human activities that is part of existence (ventureline.com).
- **Natural Catchment**: The area of land from which any rainfall will drain naturally into watercourses through surface flow.
- **Residual risk**: The risk remaining after safeguards (mitigation strategies) have been implemented (www.wiktionary.com).
- **Reticulation Catchment**: The area of land from which rainfall will drain with artificial assistance into a watercourse, including all manmade drainage channels, tributaries, floodplains, estuaries and areas of water storage.
- **Stormwater System**: Differs from the potable water system and includes stormwater reticulation, bulk pipes, canals, rivers and wetlands.

INTRODUCTION

The City of Cape Town (the City) has an extensive network of rivers and wetlands which fulfil diverse ecological, aesthetic, recreational and infrastructure network functions. They form an important part of the natural landscape, provide beauty and a sense of place and belonging to the people, encourage tourism, and provide recreational opportunities, health benefits, natural hazard regulation and other ecosystem services.

Yesterday

Over the past few decades, however, many of these watercourses have been adversely impacted by pollution. The State of the Environment Report shows that, in terms of the Department of Water Affairs (DWA) water quality guidelines for recreation and aquatic ecosystems, 69% of vleis, and 42% of rivers in Cape Town have poor to bad water quality (City of Cape Town, 2008). This poses a significant risk to human health and aquatic biodiversity.

Today

The impacts of poor water quality in the stormwater system[1] may be far reaching, as the forgoing of recreational opportunities, for instance, may result in socially less desirable behaviour, negatively affecting the wellbeing of society and placing strain on social services in the City. Also, poor quality water used for urban farming activities may severely compromise food production and a source of income for many. Ultimately poor water quality poses a significant threat to human health, aquatic biodiversity and the added value that good quality water brings to the economy.

Tomorrow

The challenge, therefore, is to protect the inland waters from the impact of pollution, and to improve inland water quality to an acceptable level. Current City resources to manage pollution in inland waters are inadequate.

The Catchment, Stormwater and River Management (CSRM) Branch of the Transport, Roads, Stormwater and Major Projects Directorate of the City decided to launch a project to determine the additional resources required to manage pollution in stormwater and river systems to improve inland water quality compliance to an "acceptable level".

FINDINGS AND DISCUSSION: Yesterday, Today

Acceptable Water Quality

Background

One of the main challenges on this project was to determine what is meant by "acceptable water quality", whether current means of assessing and reporting on water quality for inland water quality are adequate, and to determine practical and achievable objectives in terms of water quality, in both the short and long term. Water quality standards and criteria will ultimately drive the interventions necessary to bring water quality of rivers and wetlands to a desired level.

An inland surface water monitoring network currently consists of approximately 100 monitoring sites where samples are collected in each of the major catchment areas. (See Figure 1)

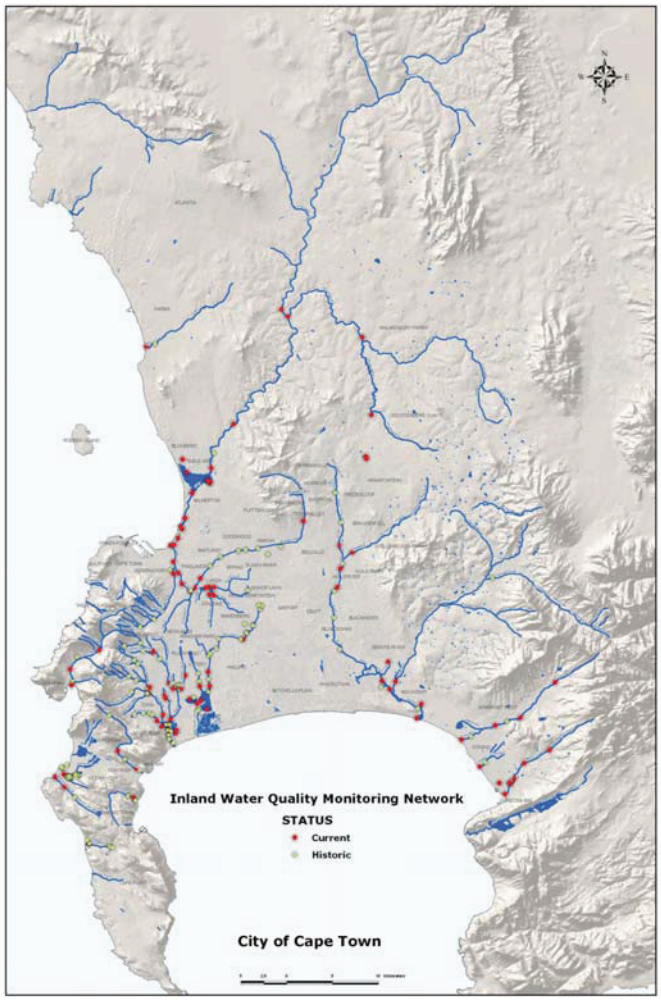

Figure 1: Inland Water Quality Monitoring Network

The number of inland water quality monitoring points was reduced in 2003, as resources were allocated to additional project-based monitoring and specialised pollution tracking, which was considered at the time to be more beneficial in terms of pollution management. Both rivers and wetlands are monitored and this occurs on a monthly basis, with both historical and current data being available. An extensive range of microbiological and chemical constituents is measured from these inland water samples.

Reporting on acceptable water quality

The City currently assesses and reports on these monthly water quality results from two perspectives: "ecosystem health", where median total phosphorus concentration is reported on, and "public health", where the percentage occurrence of the number of faecal coliforms being less than 1 000 counts per 100ml, are reported on. The relevant DWAF Water Quality Guideline series provides the basis for this evaluation (DWAF 1996a; DWAF, 1996b; DWAF, 1996c).

Under the auspices of a Water Quality Sub-Committee, it was noted that most of the results for various constituents fall within the DWA "unacceptable" category. Subdivisions of this category were therefore created as a management tool to help establish the responses and actions needed to prioritise rivers and wetlands and to help determine the sources of pollution.

The criteria agreed upon, as illustrated in the tables below, were then used to evaluate and to colour code the water quality data obtained from the City in order to provide a visual depiction of the water quality status of

[1] *It should be noted that for the purposes of this study, the stormwater system is distinguishable from the potable water system and includes stormwater reticulation, bulk pipes,canals, rivers and wetlands.*

the rivers and wetlands of Cape Town.

Table 1 Public Health Criteria: Categories

Unit	DWAF RECREATIONAL USE GUIDELINES (Vol 2)											
	Full contact						Intermediate contact					
	Target	Acceptable	Risk	Unacceptable			Target	Acceptable	Risk	Unacceptable		
Faecal Coliform count / 100 ml	0-130	131-400	401-2000	>2000			0-1000	1001-2000	2001-4000	>4000		
				Management 1	Management 2	Management 3				Management 1	Management 2	Management 3
				2001-10 000	10 001-100 000	>100 000				4001-10 000	10 001-100 000	>100 000
E.coli count / 100 ml	0-130	131-200	201-400	>400			No guideline	No guideline	No guideline	No guideline	No guideline	No guideline
				Management 1	Management 2	Management 3						
				401-2400	2401-20 000	>20 000						

Table 2 Ecosystem Health Criteria: Categories

Variable	Units	Natural	Good	Fair	Poor	Unacceptable	Comments
Temperature*#	°C	Depends on background (Upper boundary = 90th percentile; Lower boundary = 10th percentile); Good ±2°C; Fair ±4°C; Poor ± >4°C					Need to determine typical background water quality - not essential for prioritisation exercise
Total Suspended Solids #*	mg/l	Depends on background (Not more than 10% higher than background)					Need to determine typical background water quality - not essential for prioritisation exercise
Conductivity (EC)#*	mS/m	Depends on background (not more than 15% different from normal cycles)					Need to determine typical background water quality - not essential for prioritisation exercise
pH *	units	8-6.5	9-8 or 6.5-5.75	10-9 or 5.75--5	>10; <5		Need to determine typical background water quality - not essential for prioritisation exercise
Dissolved Oxygen*	mg/l	>8	8-6	6-4	4-2	<2	Also dependent on background DO levels to some extent. No unacceptable range given but if one selects equal bands then 2mg/l is the next logical band and is applicable to assessing the actual data
Soluble Reactive Phorphorus*	mg/l	<0.005	0.005 - 0.025	0.025 - 0.125	0.125-0.250	>0.250	Ranges as recommended in the latest water quality benchmarks for the Ecological Reserve (DWAF, 2005)
Total Inorganic Nitrogen*	mg/l	<0.25	0.25-1	1-4	4-10	>10	
Ammonia (NH3-N)*	mg/l	<0.015	0.015-0.058	0.058-0.1	0.1-0.2	>0.2	No unacceptable range given but if one selects equal bands then 0.2mg/l is the next logical band and is applicable to assessing the actual data
Blue Green Algae Toxins (Microcystin)@	µg/l	<10		10-50	>50		Ranges as recommended in the World Health Organisation (WHO) guidelines
Algae (Chl-a)*	µg/l	<10	10-20	20-30	30-40	>40	No unacceptable range given but if one selects equal bands then 40µg/l is the next logical band and is applicable to assessing the actual data

South African Water Quality Guidelines (DWAF, 1996)
* Ecological Reserve water quality benchmarks (Jooste and Rossouw, 2002)
@ Recreational Guideline World Health Organisation (2003)

All the public health and ecosystem health water quality data for all of the monitoring points for a 10 year period were colour coded according to the categories discussed above.

Catchment Analysis and Sources of Pollution

An analysis of each of the catchments, rivers (including canals) or river reaches, as the case may be, depending on the water quality information from the monitoring points, was undertaken to obtain an understanding of the situation in each of these discrete units. It is important to understand that the catchments invariably span several administrative areas within the City, indicating, from a catchment management perspective, a fragmented operational approach.

Considerable assistance was provided by the various members of the Project Steering Committee, the Water Quality Sub-Committee, workshops and site visits, as well as previous reports made available by the City. The major sources of pollution with respect to water quality in river systems and stormwater which stand out from the many, many types of point or diffuse sources of pollution are the following:

- Greywater and sewage from informal settlements
- Wastewater treatment works
- Blockages and overflows of sewers (whether due to extraneous waste disposed into sewers, illegal rainwater disposal or previous bad practice in construction)
- Solid waste in water courses and such open areas
- Sewage pumpstations
- General urban runoff
- Agriculture
- Industry and construction
- Golf courses
- Canalisation of rivers[2].

Key General Water Quality Issues

Some of the key general issues affecting water quality in the river and stormwater systems in the Cape Town municipal area include:

Approach and Policy

There are many instances where reactive measures as opposed to proactive measures are used to address water pollution in the City. While these may be necessary in the short term; they are often temporary in nature, do not necessarily solve the underlying causes, and are more costly in the long term. Reactive work utilises resources that could have been used more productively, had more proactive measures been employed from the outset; which therefore prevents a sustainable improvement in water quality.

Institutional Issues

- **Roles and responsibilities:**
  - There is a shortcoming in terms of the integration and optimisation of the roles, responsibilities and budgets of the various departments within the City, and this is to the detriment of stormwater quality in Cape Town.
  - There is also currently a strong emphasis on the service delivery function of the City (which often includes many reactive measures such as the fixing of potholes and the unblocking of sewers), at times to the neglect of the authority function (policy-making, planning, by-laws and enforcement) that the City also needs to fulfil.
- **Interpretation and reporting of water quality data and incidents:**
  - Currently water quality is reported on to some audiences using rolling geometric means and percentage compliance; which hides the "peaks" in pollution levels that are of greatest concern.
  - The use of E. coli and Phosphorus as the indicators of human health and ecosystem health may, particularly for the more sensitive or problematic water bodies, not always provide sufficient information on water quality. A project to create a Water Quality Index and reporting tools for inland and coastal waters has commenced. It will develop public information materials; and water quality data and related information will be posted on the City's corporate website on a regular basis (Haskins, pers. comm., 2010).
  - Due to a lack of awareness and/or empowerment by the general public, there is likely to be an underreporting of pollution incidents within the City. So too, there may not be a well-known and/or adequately accessible complaints line. Also, many incidents that are reported may not be further investigated and recorded due to a lack of resources, thus feeding into an attitude of despair.
- **Sampling and monitoring:**
  - Water samples are currently not taken at certain historical water quality monitoring points and other points in the water systems which could offer significant insight into pollution sources.
  - For the more sensitive or problematic watercourses there is a gap in information where additional indicator organisms to those currently monitored would shed further light on unexplained or improbable E. coli values which occur from time to time.
- **Human resources:**
  - Water Pollution Control Inspectors of the Water & Sanitation (W&S) Department currently conduct limited programmed inspections of mainly industries (City of Cape Town, 2009). They do not conduct regular inspections of other business or residential property, but respond to complaints received from owners or tenants in these sectors. Statistics of the main transgressions are published in a quarterly report.

[2] This is an indirect pollution source as pollution is not attenuated in canals as well as it is in natural rivers, therefore resulting in higher pollution levels. Furthermore, canals are not as aesthetically pleasing as natural river systems, and may therefore induce less considerate behaviour towards their preservation.

– There is further a lack of staff, funding and consolidation of the inspectorate, resulting in certain shortcomings with respect to water quality management in the City.

• **Agriculture:**
– Of the agricultural activities that occur in many of the catchments in the City, animal husbandry is potentially an intense point source of bacteriological or faecal pollution and nutrients, while runoff from crop agriculture is also a source of nutrients, particularly where fertilisers, pesticides and manure are used and effluent from WWTW is used for irrigation or the sewage sludge used for compost.
– The City has inadequate resources to ensure compliance with the stormwater management by-law for the prevention of polluted or enriched irrigation water or enriched stormwater from farmlands from entering the main stormwater system.

• **Optimisation of resources/partnerships:**
– Limited resources have led to inadequate service provision for stormwater pollution management. Partnerships with other City departments, neighbouring municipalities and other external public and private organisations have not been established adequately to consolidate resources and to optimise pollution management.

Planning Issues

• **Service delivery: informal settlements and backyarders:**
– Cape Town has approximately 3,3 million people, with an estimated population growth rate of 1.65 %, which places further strain on a service delivery backlog in the City (Lewis, 2010). Lack of basic services due to current budget limitations particularly in housing, solid waste, and water and sanitation, directly and indirectly affect water quality in the rivers and wetlands of the Cape Town municipal area.
– A further problem in Cape Town is "backyard dwellers" whereby backyards in formal areas are occupied by informal dwellers, thereby putting strain on the service capacity in the area and increasing greywater and night soil issues, which lead to poor water quality in the stormwater and river water.

• **Strategic interventions:**
– There is a need for more strategic interventions (standards, by-laws and records) as proactive measures for the prevention of stormwater ingress, in particular.

• **Land use:**
– A legacy of land use, urban design and landscaping in the City with little regard for rivers, wetlands and other watercourses has a great impact on the water quality of inland water systems. Canalisation for instance, as is evident in many of the rivers in the Cape Town municipal area today, has caused tremendous ecological damage and reduces the ability of a river to attenuate pollutants.
– Incremental hardening/coverage of catchments through urban development is a major issue facing urban stormwater management, as rainwater is no longer infiltrated throughout the catchment but instead remains as runoff; increasing the risks of flooding and a deterioration of water quality. The Policy for the Management of Urban Stormwater Impacts was specifically developed to address these challenges.

Technical Issues

• **Infrastructure:**
– Leaking, inappropriate, and/or ageing municipal infrastructure, particularly sewage pumpstations, sewers and wastewater treatment works (WWTW), have an impact on water quality, as an overflow of sewage will contaminate the stormwater system.
– Failure in design, such as inadequate consideration of the number of users of certain infrastructure, may result in its premature breakdown and malfunction, which will then place the water quality of the receiving aquatic ecosystem at risk. The adequate management and operation of infrastructure is a further consideration in terms of water quality, as lack of knowledge and understanding of the context of the operations for which one is responsible, and appreciation of the impact of malfunctioning sewage pumpstations, for instance, will have a dire impact on the rivers.

• **Sewage pumpstations:**
– Spillage at sewage pumpstations can negatively impact water quality. Historical records show that the failure rate of sewage pumpstations in the City is such that approximately 20% of the pumpstations will experience a spillage on average once per year.

• **Sewer blockages:**
– According to a media release by the City on 23 March 2010 (City of Cape Town, 2010), the City has to attend to approximately 90 000 sewer blockages per year, which costs approximately R60 million. The majority of blockages are found to be due to foreign objects becoming lodged in the sewer, which inevitably cause a back-up in the sewage system and lead to an overflow at a low point, which may cause a serious pollution problem in the rivers and streams in the area.

• **Sewage disposal technologies**
– Sewage technologies such as conservancy tanks, septic tanks and soakaways are utilised in certain parts of Cape Town, such as in the upper reaches of the Sir Lowry's Pass River, Schusters River and Disa River. Poorly managed or dysfunctional systems or instances where the wastewater is removed and disposed of inappropriately, impact negatively on the stormwater system.

• **Cross-connections:**
– Past practices of cross-connections between sewer systems and stormwater systems are a further contributing factor to poor water quality. These cross-connections, many of which have been closed off, were intended to provide "overflow" routes for sewers, when blockages or "flooding" caused backing up or surcharging of sewers. These overflow routes all lead to nearby stormwater pipes or systems, thus keeping the overflow out of sight (and out of mind!).

• **Wastewater treatment works (WWTW):**
– Treated sewage effluent is one of the most common types of pollution found in urban rivers (Luger and Brown, undated). While the City of Cape Town did exceptionally well during the 2011 Green Drop Assessment Cycle, there are still WWTW that require significant improvement to achieve certification (DWA, 2011). While a broad range of criteria is assessed, a failure to achieve Green Drop Status implies that inadequately treated sewage is being discharged into stormwater and river systems, with dire consequences for ecosystem and public health
– There is currently a disparity beween WWTW effluent discharge standards or limits set by DWA versus the Water Quality Guidelines stipulated for recreation and acquatic ecosystems. Compliance in wastewater reports may therefore still result in a significant impact in terms of public and ecosystem health on the receiving water body.

• **Stormwater ingress and infiltration:**
– Excessive ingress and infiltration of stormwater into sewers, causing sewers to surcharge, have detrimental effects on stormwater and river quality. They can reduce the original design capacity of a sewer collection system and negatively affect the operation of WWTW (Stephenson and Barta, 2005) and result in sewer reticulation overflows (Thompson, pers. comm., 2010). Excessive increases in flows reduce the effectiveness of the biological treatment process, leading to partially treated wastewater leaving the WWTW and entering the receiving water bodies (Stephenson and Barta, 2005).

• **Solid waste:**
– Outside of the normal cleaning cycle conducted by SWM, a number of challenges still exist as solid waste is a large and ever-increasing challenge in Cape Town and is a particularly visual and extensive pollutant in the rivers, particularly within the higher density areas.
– Despite many awareness programmes and extensive area cleaning

[3] A by-law whereby a plumber's certificate is required before the transfer of a property can take place, has recently been introduced as a consequence of this project.

services, illegal dumping and discharge of solid waste into the stormwater and river systems still occurs widely (City of Cape Town, 2009b). Solid waste has both an aesthetic and polluting impact on rivers and wetlands and is a contributing factor to blockages of the stormwater and sewer system. Such blockages can result in stormwater stagnating on the street and negatively impacting on road surfaces, as well as on human health

- **Greywater:**
  - In some areas of Cape Town greywater (often containing constituents such as faecal coliforms, organic matter and chemical pollutants) is often disposed of onto roads or in the stormwater system due to a lack of alternative disposal options, or the inconvenience and inadequacy of the existing disposal facilities. This can negatively impact stormwater quality as well as the road surface.
- **Backyard garages:**
  - There are instances of illegal disposal of substances such as oil into the stormwater system. Water Pollution Control Officers and Law Enforcement Officers address complaints received from members of the public, but many incidents go unreported.

Communication

Many of the current challenges to the City are further compounded by a lack of education and awareness on the importance of good "environmental" stormwater quality and the means to attain and preserve good water quality.

- **Signage:**
  - Although there is a signage policy governing Cape Town as a whole, it is not implemented throughout. There is a shortcoming in terms of the compliance of City signage, visibility, branding and size, as well as maintenance and replacement.

Risk Assessment

A risk assessment was performed on the catchments of each of the rivers and wetlands. The risk assessment identified eleven risk events and associated consequences that could lead to deterioration in water quality.

Each catchment was then evaluated for the probability of the risk of the event occurring and the impact that such a risk event would have on the public health and ecosystem health of that catchment and the river downstream of that event. A vulnerability score was then calculated for each risk associated with that catchment.

The twelve most vulnerable rivers (or river reaches) and vleis were found to be:

- Lower Hout Bay River
- the middle reaches of the Bokramspruit
- Kuils River
- Soet River
- Vygekraal River
- the lower reaches of the Diep River (West Coast)
- Milnerton Lagoon
- the stormwater outfall at Theo Marais Park
- the stormwater channel from Bayside Mall
- Big and Little Lotus Canals
- Zeekoevlei
- Rondevlei.

This vulnerability score was then used to inform the prioritisation of the catchments described below.

Prioritisation of Catchments, Rivers and Wetlands

A prioritisation of catchments was undertaken as part of this project to assist the City management with the allocation of resources, bringing a sense of proportion. The outcomes provide guidance on a starting point for the allocation of limited resources. Ad hoc and emergency events that affect water quality will, however, still need to be attended to as the need arises.

A multi-criteria model using several inputs to determine those rivers, wetlands and catchments which should receive priority attention for the proposed interventions was developed. The criteria and their weightings (Table 3) were workshopped and agreed upon by the Project Steering Committee and the Water Quality Sub-Committee. Each catchment was then scored for each criterion, using a five-point scale. The scale and the outcomes of the prioritisation exercise were also workshopped and agreed upon with the Project Steering Committee and the Water Quality Sub-Committee.

Table 3 Prioritisation criteria and weighting

Criteria	Weighting
Public Health	32 %
Ecosystem Health	32%
Water Usage	8%
Downstream Impact/Algae	8%
Risk	8%
Pollution Load	12%

The outcomes of the prioritisation exercise provided results as shown in the table below:

Table 4 Catchment prioritisation results

Catchment	Score	Priority
Diep River (West Coast)/ Mosselbank	40	High
Salt River	40	
Zeekoe	39	
Eerste/Kuils	38	
Noordhoek	36	
Sir Lowry's Pass	34	Medium to high
Sout River	33	
Hout Bay	32	
Sand River	30	Low to Medium
South Peninsula	28	
Lourens	24	Low
Silvermine	20	

It should be noted that certain catchments, e.g. Mitchell's Plain, Khayelitsha and Atlantis could not be prioritised due to a lack of water quality data. Although these catchments do not have natural surface water drainage systems (e.g. rivers), they do have man-made drainage systems (e.g. open canals and stormwater ponds) in some of these systems.

With regard to vleis and wetlands, the outcome of the prioritisation is given in the following table.

Table 5 Prioritisation results for wetlands and vleis

Catchment	Vlei/Wetland	Score	Priority
Zeekoe	Zeekoevlei	49	High
Diep	Milnerton lagoon	47	
Diep	Rietvlei	40	Medium to High
Zeekoe	Rondevlei	40	
Noordhoek	Wildevoëlvlei	36	
Diep	Zoarvlei	34	Low to Medium
Sand River	Die Oog	31	
Sand River	Little Princessvlei	30	
Sand River	Langevlei	29	
Zeekoe	Princessvlei	26	Low
Sand River	Zandvlei	25	
Sand River	Westlake Wetland	24	
South Peninsula	Glencairnvlei	19	

Table 6 Prioritisation results for rivers and canals

Catchment	River	Score	Priority
Diep River (West Coast)/ Mosselbank	Diep (West Coast)	43	High
Salt River	Black	43	
Salt River	Jakkalsvlei	43	
Salt River	Vygekraal	43	
Eerste/Kuils	Kuils	43	
Salt River	Blomvlei	42	
Zeekoe	Big Lotus	42	
Diep River (West Coast)/ Mosselbank	Stormwater Channel from Bayside Mall	42	
Salt River	Salt River	42	
Sir Lowry's Pass	Soet	40	
Diep River (West Coast)/ Mosselbank	Stormwater outfall Theo Marais Park	40	
Zeekoe	Southfield Canal	39	
Sand River	Sand River Canal	38	
Diep River (West Coast)/ Mosselbank	Mosselbank	38	
Salt River	Langa Canal	37	Medium to High
Salt River	Elsieskraal	37	
Eerste/Kuils	Eerste	37	
Zeekoe	Little Lotus	36	
Eerste/Kuils	Kleinvlei Canal	36	
Sand River	Diep	34	
Diep River (West Coast)/ Mosselbank	Duikersvlei Stream	34	
Eerste/Kuils	Bottelary	34	
Sout River	Sout River	33	
Salt River	Liesbeek	33	
Sir Lowry's Pass	Sir Lowry's Pass	32	
Hout Bay	Hout Bay River (including Disa River)	32	
South Peninsula	Bokramspruit	32	
South Peninsula	Elses	32	
Eerste/Kuils	Moddergatspruit	29	Low to Medium
Sand River	Prinskasteel Keysers	29	
Sand River	Westlake River	28	
South Peninsula	Schusters	26	
Lourens	Lourens	24	Low
Silvermine	Silvermine	20	

CONCLUSIONS AND RECOMMENDATIONS Tomorrow

Required Resources

Drawing on the legacy of the past to engineer into the future and reduce the burden of pollution in the inland water systems of the Cape Town municipal area, the recommended resources required by the City are proactive, and sustainable measures as far as possible. The dictum "prevention is better than cure" is used as a guiding principle to avoid costly, inefficient, after-the-event reactive measures. The recommendations can be grouped as follows:

- General Recommendations: Approach, Institutional, Technical, Planning and Policy Issues (Top and High priority items only listed)
- General Recommendations: Budget implications
- Additional Recommendations per Catchment: Budget implications.

The budget implications show that R675,30 million in capital or once-off expenditure and R277,15 million in operational expenditure is required as additional resources to manage pollution in stormwater and river systems.

YESTERDAY TODAY TOMORROW

The additional funding alone, however, will not solve the current poor water quality in most stormwater systems. It is imperative that the so-called "soft issues" listed in the General Recommendations: Policy, Approach and Institutional issues receive attention. Merely "throwing money at the problem" will lead to sub-optimal outcomes, and ones which are unlikely to be sustainable.

General Recommendations: Approach, Institutional, Technical, Planning and Policy Issues (Top and High Priority items only)

Description	Benefit	Comment
Allocate more budget to & prioritise proactive measures	More efficient allocation of resources for sustainable water quality improvement. Reduces risk in longer term	Adopt as a policy
Adopt "prevention is better than cure" as guiding principle	Reduction in costly, after-the event solutions ensuring sustainable water quality improvement	Adopt as a policy
Establish inter-departmental Water Quality forum at senior level	Consolidation of efforts, roles & responsibilities and improved knowledge sharing	Reassign staff priorities
Establish consolidated pollution task team	Optimisation of resources to address pollution & avoidance of unintended consequences	Reassign staff priorities
Catchment management plans to outline all resource allocations, implementation plans & timeframes	Improved capacity to achieve water quality objectives	Adopt as a policy
Develop KPIs that will lead to improvement in water quality in rivers & stormwater systems. Review existing KPIs with regard to definition, interpretation of data & reporting	Incentive for senior management to eradicate water pollution. Improved adequacy of KPIs to measure performance of the City	Current KPIs inadequate to effect improvement
Review & update reporting of WQ data. Include peaks & exceptions in reporting, not just "averaged" results	Correct impression of state of rivers/wetlands for appropriate management response	
State specifically for top management attention that all results are likely to under-report actual situation	Improved understanding of water quality for improved management responses	
Institute external environmental compliance audits of infrastructure with pollution potential	Independent assessment of performance and compliance, risk reduction	
Establish Inspectorate Forum	Integrated human resources for all water quality related issues	Reassign staff priorities
Use proactive asset management approach, including audits & inspections for timeous replacement & upgrading of infrastructure	Greater budget, effort and energy efficiency	Adopt as policy
Prioritise installation of telemetry systems for all sewage pumpstations, ensuring they will also assist with reduction of ingress & infiltration	Ensuring that breakdowns can be attended to promptly & to assist with the elimination of stormwater ingress & sewer spillages	Already in budget of M: Retic
Engage with DWA & DEA on limiting phosphates in washing powders & detergents	Preventative, means of limiting phosphates reaching WWTW	City to agitate for new legislation
Incorporate in revision of By-laws an inspection to ensure that property at time of transfer does not contain illegal installations, esp. discharge of stormwater into sewers	Proactive measure to eliminate stormwater ingress into sewer	Needs to be accepted by Council
Ensure that prioritisation of catchments & rivers feeds into Master Plan for upgrading of informal settlements	Integrated development approach in consideration of water quality	
Integrated urban design & implementation approach		
- On site controls: Revise IZS to include all hardened surface as coverage	Improved on-site stormwater management for greater infiltration	Change IZS & reinforce as policy
- Off site controls: High coverage only to be permitted where proper neighbourhood scale stormwater management system is possible	Improved regional stormwater management to close ecological cycles closer to source	Change IZS & reinforce as policy (already in stormwater policy & SDF, but also needs to be included in IZS as per this report)
Establish policy for provision of services to backyarders in order of importance: - Solid waste - Grey/washwater - Sanitation - Water (last)	Improved health, improved housing and a healthy environment	Both opex and capex budgets can only be determined once a policy decision has been made