

TESTING AND DEVELOPMENT OF CATCHMENT SUSTAINABILITY INDICATORS

Report to the
Water Research Commission

by

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WRC Report No. KV 156/04
ISBN No. 1-77005-232-1

December 2004

Obtainable from:

**Water Research Commission
Private Bag x03
GEZINA 0031
Pretoria**

The publication of this report emanates from a project entitled: *Testing and Development of Catchment Sustainability Indicators* (WRC Consultancy Project No. K8/526)

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ACKNOWLEDGEMENTS

The authors would like to thank the following persons for their help in providing opinions and information for this project.

Adams, Nigel	DWAF, Pretoria
Badenhorst, Gerhard	DWAF Regional Office, Midmar
Bertram, Ernst	DWAF, Pretoria
Botes, Vic	Mhlathuze Water, Richards Bay
Botha, Hanno	DWAF, Pretoria
Braune Eberhard	DWAF, Pretoria
Cyrus, Digby	University of Zululand
Dickens, Chris	Umgeni Water
Dixon Paver, Hugh	DWAF Regional Office, Durban
Erasmus, Marica	Institute for Water Quality Studies, Pretoria
Geringer, Johan	DWAF, Pretoria
Gill, Tracey	South African Weather Bureau
Gravelet Blondin, Lin	DWAF Regional Office, Durban
Hector, Desiree	DWAF, Pretoria
Kasu, Rezaa	Working for Water, Cape Town
Kelbe, Bruce	University of Zululand
Kuhn, Kobus	DWAF, Pretoria
Marais, Deon	DEAT, Pretoria
Mitchell, Steve	Water Research Commission, Pretoria
Perkins, James	DWAF Regional Office, Durban
Pretorius, Rudi	Department of Environmental Affairs and Tourism
Rakgotho, Thabisile	DWAF Regional Office, Durban
Reddy, Jay	DWAF Regional Office, Durban
Roux, Dirk	CSIR, Pretoria
Rowlston, Bill	DWAF, Pretoria
Serfontein, Nico	Mhlathuze Water, Richards Bay
Seetal, Ash	DWAF, Pretoria
Sibanyoni, Francinah	DWAF, Pretoria
Smith, Mandi	DWAF, Pretoria
Strydom, Con	DWAF, Pretoria
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Vorster, Piet	DWAF Regional Office, Durban
Weston, Barbara	DWAF, Pretoria
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EXECUTIVE SUMMARY

One of the keys to successful integrated water resource management is the availability of good quality information. This is recognised in the National Water Act (No. 36 of 1998), which states that “the Minister is required to establish a national monitoring and information system for water resources as soon as possible”. The monitoring and information system should provide for the collection of appropriate data to assess the quantity, quality, use and rehabilitation of water resources at catchment and national levels, as well as compliance with resource quality objectives, health of aquatic ecosystems and atmospheric conditions that may impact on water resources.

One method of fulfilling some of these requirements is through the development and use of suitable indicators that provide a means of communicating information about progress towards a goal (such as sustainable resource management) in a significant and simplified manner.

This current research project therefore represents a test situation for a set of 40 indicators of catchment sustainability that were previously generated through consultation with water resource managers. The project objectives involved:

- Testing of the set on a selected catchment (the Mhlathuze) with the focus on data availability as well as the applicability of each indicator in terms of what it is meant to represent;
- Proposing alternative indicators where necessary and finalising an indicator set for use by water management authorities (particularly CMAs) in South Africa;
- Assessing the situation for a specific catchment, which in the case of this project was the Mhlathuze catchment on the north coast of KwaZulu-Natal (selected in collaboration with the Department of Water Affairs and Forestry).

On the basis of a simple numerical rating system, the study has shown that out of the 40 indicators within the set: two received a maximum rating of 20 in terms of the availability and quality of the data required to calculate them; sixteen received a rating of between 10 and 20; eight received a rating of between 4 and 10; and fourteen were given a zero-rating. The implications of the zero-rating mean that the current information management system for the pilot catchment is either not collecting, or not processing the relevant information to calculate the indicators. The implications of the other ratings, particularly those with values greater than 10, mean that the indicator can be currently estimated and reported on. In the case of the Mhlathuze only nine of the indicators were able to be estimated.

The study has allowed opportunity to further refine the set of generic indicators proposed by Walmsley (2003). Of the 40 indicators evaluated, several can be rejected as not being a priority for decision-making. The ones that are recommended as being good generic indicators are (see **Annexure 3** for detailed descriptions):

- SE1 Population Density
- SE2 Urbanisation
- SE6 Percentage of Households without access to water
- SE7 Percentage of Households without access to sanitation
- SE8 Percentage area under different economic land uses
- WB3. Demand as a proportion of total available
- WB4. Proportion of groundwater utilised
- WB5. Water requirements per sector as a percentage of total available
- WP3. Liquid waste discharged from point sources
- WP7. Conductivity at the lowest point in the geographical catchment
- WP8. P and N concentrations at the lowest point in the geographical catchment
- WP11. Turbidity at the lowest point in the geographical catchment
- WP12. Proportion of boreholes contaminated
- RC1. Percentage of catchment area covered by natural vegetation and by alien vegetation

- RC2. South African Scoring System (SASS) scores at selected site
- RC3. Fish Assemblage Integrity Index
- RC4. Index of Habitat Integrity in selected reaches
- RC5. Riparian Vegetation Index in selected reaches
- MN1. Index of level of CMA establishment in the catchment
- MN2. State of satisfaction
- MN3 Volume of water allocated as a proportion of total water available
- MN4. Water use efficiency for different sectors
- MN5. Percentage unaccounted for water in the catchment
- MN6. Ratio of sub-catchments for which the Ecological Reserve has been set
- MN7. Ratio of sub-catchments for which reliable hydrological data are available
- MN8. Ratio of sub-catchments for which reliable water quality data are available

The general assessment for the Mhlathuze catchment is somewhat disappointing in terms of the high expectations for a catchment that, at the outset of the project, was termed relatively “data rich”. The situation does however reflect that there is a large reality gap between what water resource managers feel should be monitored and what is actually measured and reported on. It also indicates that water resource management decisions are being made without a sound knowledge of broader catchment characteristics necessary to implement integrated water resource management.

The situation can be explained on the basis of several paradigms that hinder information management and reporting within the South African water sector. This project thus provides opportunity to raise these, as they will need to be addressed during the formation of Catchment Management Agencies and, most certainly will be key issues for the generation of successful individual catchment management strategies and information systems. Some of the key issues are:

- Apart from standard hydrological recording and water quality sampling, monitoring and assessment of catchments is largely done on a once off project basis and there does not appear to be routine long-term monitoring and reporting based on agreed formats and protocols. There is no agreed set of indicators for monitoring and assessing catchment characteristics in accordance with the intended policy to promote integrated water resource management.
- The information management system for catchments is fragmented with no central body or person responsible for handling information on individual specific catchments. At the present stage, the roles and responsibilities of central, regional and local agencies in information management and reporting are not well-defined. This carries implications such as higher risks associated with poorly informed decision making, as well as low cost-effectiveness of current monitoring and reporting approaches.
- The main approach to monitoring and assessing catchments is through modelling approaches that focus on the prediction of future water supply and demand. Historical empirical values are largely ignored in the reporting process and, when used, serve primarily to verify modelling approaches. It is for this reason that a zero-rating was given to most of the water balance indicators in the evaluated set.
- The envisaged long-term timetable for the establishment of Catchment Management Agencies (CMA) does not promote local ownership and responsibility for the initiation and development of the necessary monitoring programmes. A general impression gained during this study is that the development of indicators and local information management systems (monitoring and reporting) awaits the establishment of CMAs.
- There is a need to develop a better culture of information sharing within the water sector, particularly through formal and regular public reporting on the status of catchments. Integrated

water resource management will require information inputs from all stakeholders in the water sector and not solely from government.

- There has been a protracted process in both the formulation of a national classification system, and the official setting of the Reserve for catchments, which has had a restricting impact on the development of necessary monitoring and information management systems.
- The human resources allocated to catchment assessment appear to be predominantly external to the lead water resource management institutions. Most of the data collection and reporting on catchments is outsourced, meaning that most of the skills in the collection, ownership and interpretation of data are external to the main water resource management agencies.
- Finally, there is the assumption that all catchments behave similarly. The Mhlathuze is certainly not a simple catchment system as it has characteristics that do not necessarily make it easy to measure and monitor many of the indicators. The main features that detract are the topography and distinct separate hydrological systems (separate river channels, wetlands, coastal lakes and groundwater) and the proximity to the ocean.

This study has illustrated the complexity of the process of developing and using indicators. It has also identified and highlighted some difficulties that need to be overcome in the development of indicators and the establishment of appropriate information management systems for catchment management. Hopefully this report will be of use to parties that are involved in development and implementation of monitoring and reporting systems that meet the needs of water resource decision makers in South Africa.

1. INTRODUCTION

The ability of nations and societies to develop and prosper is linked directly to their ability to develop, utilise and protect their water resources. At the 1991 Dublin Conference on water resources (convened in preparation for the 1992 United Nations Rio de Janeiro Earth Summit - UNCED), it was concluded that, *“since water sustains all life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems”* (Dublin Statement 1992). Since then, it has been recognised that the sustainable use and holistic management of freshwater resources is the key to achieving the overall goal of sustainable development (e.g. Department of Environmental Affairs and Tourism 1998; Ministerial Declaration of the Hague on Water Security in the 21st Century 2000; UNESCO 2003).

An internationally accepted approach to sustainable water resources management is that of integrated water resources management on a catchment basis (UNESCO 2003). This approach is also one that forms the basis of South African policy and legislation, as outlined in the National Water Act of 1998 (No. 36 of 1998). Integrated water resources management represents the most practical approach to managing the resources of a catchment by integrating all environmental, economic and social issues within a catchment into an overall management philosophy, process and plan (Gorgens et al 1998). It is aimed at deriving the optimal mix of sustainable benefits for future generations, whilst protecting the natural resources, particularly water, and minimising the possible adverse social, economic and environmental consequences (Gorgens et al. 1998).

One of the keys to successful integrated water resource management is the availability of good quality information. This is recognised in the National Water Act (No. 36 of 1998), which states that the Minister is required to establish a national monitoring and information system for water resources as soon as possible. The aims of the system are provided in Section 140 of the Act as:

- a. *To store and provide data and information for the protection, sustainable use and management of water resources;*
- b. *To provide information for the development and implementation of the national water resource strategy;*
- c. *To provide information to water management institutions, water users and the public -*
 - i. *For research and development;*
 - ii. *For planning and environment impact assessments;*
 - iii. *For public safety and disaster management; and*
 - iv. *On the status of water resources.*

The monitoring and information system should provide for the collection of appropriate data to assess the quantity, quality, use and rehabilitation of water resources at catchment and national levels, as well as compliance with resource quality objectives, health of aquatic ecosystems and atmospheric conditions that may impact on water resources.

One method of fulfilling some of these requirements is through the development and use of suitable indicators that provide a means of communicating information about progress towards a goal (such as sustainable resource management) in a significant and simplified manner. There is currently a major international initiative aimed at developing indicators for measuring sustainable development within the

context of integrated water resource management via the World Water Forums and the World Water Assessment Programme (UNESCO 2003; www.unesco.org).

In 2002, as part of a research project at the University of the Free State, a set of 40 catchment sustainability indicators were developed for potential use in South Africa (Walmsley 2003). These indicators were developed through a participative process involving water management agencies, notably the Department of Water Affairs and Forestry (head and regional offices), local authorities, provincial authorities and water providers (Walmsley 2003). The indicators within the set may represent what may be described as “*preferred generic indicators*”, as their selection has been based on priority issues of sustainability for catchment management in South Africa (Walmsley 2003).

The process of developing indicators is a complex one involving a series of steps during which stakeholders progress from an initial conceptual stage that defines key issues to be monitored, followed by the generation of preferred indicators, and then to actual testing of individual indicators in terms of actual site relevance and the practicality of monitoring and reporting (OECD 1993; Hammond et al. 1995; UNESCO 2003). It was, therefore, recognised that the set of indicators generated by Walmsley (2003) requires further processing in terms of testing for practical usage in an actual catchment situation.

This current research project therefore represents a test situation for the set of indicators that was developed by Walmsley (2003) with the aims of:

- Testing of the set on a selected catchment with the focus on data availability as well as the applicability of each indicator in terms of what it is meant to represent;
- Proposing alternative indicators where necessary and finalising an indicator set for use by water management authorities (particularly CMAs) in South Africa;
- Assessing the situation for a specific catchment, which in the case of this project was the Mhlathuze catchment on the north coast of KwaZulu-Natal (selected in collaboration with the Department of Water Affairs and Forestry).

It is envisaged that the results will have practical application for the future development of catchment information systems in the emerging water management institutions that will be responsible for the local implementation of the integrated water resource management concepts, as advocated in the South African Water Act of 1998.

2. OVERVIEW OF INDICATORS

2.1 Introduction

An indicator is a measured parameter that provides information about an issue with a significance that extends beyond the parameter itself (OECD 1993), e.g. *E. Coli* counts in a water body provide an indicator of the level of faecal organic contamination as well as risk to the health of persons drinking such water. Agenda 21 (Chapter 40 – see DEAT 1998) states that “*indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to the self-regulating sustainability of integrated environmental and development systems*”. This has led to the acceptance of sustainability indicators as basic tools for facilitating public choices and supporting policy implementation (Hammond et al. 1995). They can be used to provide information on relevant issues; identify development-potential problems and perspectives; analyse and interpret potential conflicts and synergies, and assist in assessing policy implementation and impacts. In essence, they allow for the better organisation, synthesis and use of information.

There is a vast amount of published literature on the topic of indicators. It is not the intention of this section to provide an exhaustive review of indicators, but rather to emphasise key concepts associated with the topic. Some key references include: OECD 1993; Hammond, et al. 1995; Walmsley and Pretorius 1996; Department of Environmental Affairs and Tourism 2002; UNESCO 2003).

2.2 Objectives of Indicators

The main goal of indicators is to measure, monitor and report on progress towards sustainability so as to provide input into decision-making and policy. Indicators have numerous uses and potential for improving environmental management. Some of these include (Hammond et al. 1995; Walmsley & Pretorius 1996; Walmsley 2003):

- *Monitoring and assessing conditions and trends on a national, regional and global scale* - This provides baseline information for situation analyses, as well as forming the foundation for long-term monitoring.
- *Comparing situations* - This is particularly relevant in South Africa for strategic comparative analyses between water management areas, as well as between catchments in water management areas.
- *Assessing the effectiveness of policy* - South Africa is currently implementing new legislation. A set of indicators will be valuable in assessing the success of the legislation. In particular, performance indicators, which ascertain whether the legislation is being correctly implemented, can be compared to sustainability of catchment systems. If the performance indicators show that the policy is correctly implemented, and yet the sustainability indicators show a deterioration of the water resource, the policy and legislation will have to be re-evaluated.
- *Marking progress against a stated benchmark* - Indicators are ideal to evaluate a system against known benchmarks or targets. This is especially relevant in South African catchments where resource quality objectives will be established for all catchments as part of the Reserve-determination procedure.
- *Monitoring changes in public attitude and behaviour* - Because of South Africa's past, the Government is particularly aware of including the citizens of the country in decision-making, and all the current policy and legislation have been subjected to stringent public participation processes. Particularly in water management, the role of the public is becoming more prominent and water users will have more influence in catchment management once catchment management agencies have been established. It is, thus, important to understand public attitudes.

- *Ensuring understanding, participation and transparency in information transfer between interested and affected parties* – This links to the previous point: stakeholders involved in catchment management and the public need to be made aware of the issues in any given catchment or water management area. The social aspect of sustainability is becoming more prominent (World Summit on Sustainable Development 2002), and policies that require stakeholder and public understanding (e.g. water conservation and demand management) will surely fail without the public being continually informed.
- *Forecasting and projecting trends* – Once trends have been established, future scenarios can be extrapolated and planned for. This is particularly valuable where there is a good understanding of catchment processes.
- *Providing early warning information* – Indicators are excellent at providing an early warning, both in terms of trend analysis and in the meeting of targets. Trend analysis can provide a future warning system, whilst the meeting of targets can provide a “red-flagging” system for immediate concerns.

2.3 Criteria for Selection of Indicators

The OECD (1993) has provided a comprehensive guide to the selection and evaluation of indicators. These are based on considerations within three categories, notably:

1. With respect to *policy relevance and utility for users*, an indicator should:
 - Provide a representative picture of environmental conditions, pressure on the environment or society's response;
 - Be simple, easy to interpret and be able to show trends over time;
 - Be responsive to changes in the environment and related human activities;
 - Provide a basis for comparisons;
 - Be either national in scope or applicable to issues of national significance (e.g. catchment management), and
 - Have a target or threshold against which to compare it so that users are able to assess the significance of the values associated with it.
2. With respect to *analytical soundness* an indicator should:
 - Be theoretically well-founded in technical and scientific terms;
 - Be based on international standards and consensus about its validity, and
 - Lend itself to being linked to economic models, forecasting and information systems.
3. With respect to *measurability of the data* required to support the indicators should be:
 - Readily available or made available at a reasonable cost;
 - Adequately documented and of known quality, and
 - Updated at regular intervals in accordance with reliable procedures.

The International Institute for Sustainable Development has developed a set of ten principles (the Bellagio Principles) for the measurement of sustainable development, which take into account many of the selection criteria (<http://www.iisd.org/measure/principles/1.htm>). These principles are valuable in the identification and determination of sustainability indicators and are useful to ensure that the vision of sustainability is maintained throughout the process of developing indicators.

Table 1: Bellagio Principles that should be adhered to during the indicator development process
(<http://www.iisd.org/measure/principles/1.htm>).

PRINCIPLE	
1. Guiding vision and goals	1. Be guided by a clear vision of sustainable development and goals that define that vision
2. Holistic perspective	2. Include review of the whole system as well as its parts 3. Consider the well-being of social, ecological, and economic sub-systems, their state as well as the direction and rate of change of the state, of their component parts, and the interaction between parts 4. Consider both positive and negative consequences of human activity, in a way that reflects the costs and benefits for human and ecological systems, both in monetary and non-monetary terms
3. Essential elements	5. Consider equity and disparity within the current population and between present and future generations, dealing with such concerns as resource use, over-consumption and poverty, human rights, and access to services, as appropriate 6. Consider the ecological conditions on which life depends 7. Consider economic development and other, non-market activities that contribute to human/social well-being
4. Adequate scope	8. Adopt a time horizon long enough to capture both human and ecosystem time scales thus responding to needs of future generations as well as those current to short-term decision making 9. Define the space of study large enough to include not only local but also long distance impacts on people and ecosystems 10. Build on historic and current conditions to anticipate future conditions
5. Practical focus	11. An explicit set of categories or an organizing framework that links vision and goals to indicators and assessment criteria 12. A limited number of key issues for analysis 13. A limited number of indicators or indicator combinations to provide a clearer signal of progress 14. Standardising measurement wherever possible to permit comparison 15. Comparing indicator values to targets, reference values, ranges, thresholds, or direction of trends, as appropriate
6. Openness	16. Make the methods and data that are used accessible to all 17. Make explicit all judgements, assumptions, and uncertainties in data and interpretations
7. Effective communication	18. Be designed to address the needs of the audience and set of users 19. Draw from indicators and other tools that are stimulating and serve to engage decision-makers 20. Aim, from the outset, for simplicity in structure and use of clear and plain language
8. Broad participation	21. Obtain broad representation of key grass-roots, professional, technical and social groups, including youth, women, and indigenous people - to ensure recognition of diverse and changing values 22. Ensure the participation of decision-makers to secure a firm link to adopted policies and resulting action
9. Ongoing assessment	23. Develop a capacity for repeated measurement to determine trends 24. Be iterative, adaptive, and responsive to change and uncertainty because systems are complex and change frequently 25. Adjust goals, frameworks, and indicators as new insights are gained 26. Promote development of collective learning and feedback to decision-making
10. Institutional capacity	27. Clearly assigning responsibility and providing ongoing support in decision-making 28. Providing institutional capacity for data collection, maintenance, and documentation 29. Supporting development of local assessment capacity

These criteria and principles indicate that indicator development can be a complex and time-consuming process, primarily because it must involve interaction, input and agreement with water resource stakeholders.

2.4 Development of the Sustainability Indicators for Catchment Management in South Africa

The set of 40 indicators (see list in Annexure 3) was developed during 2001 and 2002 using approaches outlined by Walmsley (2003). The process of development was only able to adhere to nineteen of the Bellagio Principles (the other ten being assigned to future implementation of the indicators). In addition, only one principle, notably that of obtaining broad representation of key grassroots, professional, technical and social groups, could not strictly be adhered to during the development of the indicators.

Development of indicators can lead to an infinite list of indicators being generated. However, it is necessary to focus on those indicators that, as a set, are representative of the main sustainability issues within a catchment. This was achieved, firstly, through the identification of priority issues and, secondly, through limiting the indicators chosen to represent each issue (see Walmsley 2003). The process of developing the set of 40 indicators involved extensive interaction with members of the water resource management community throughout South Africa (Walmsley 2003). The outcome was a set of 40 indicators that, though possibly not comprehensive, provided, in the view of the water resource managers, a good indication of how to measure and monitor the level of sustainability in a catchment. An important feature was that the set represented the priority issues identified by managers for a generic hypothetical catchment.

For ease of interpretation by water resource managers, the indicators have been grouped according to traditional water management categories: socio-economic (eight indicators); water balance (five indicators); waste and pollution (twelve indicators); resource condition (six indicators), and management (nine indicators).

Depending on the requirements of water resource managers, the set has several uses, including amongst others:

- Providing a “red-flagging” system for catchment management agencies (CMAs) to identify potential or current problems in the catchment that could affect the sustainability of the whole;
- Providing the basis for a strategic assessment and reporting system for CMAs or for the Department, particularly with regard to the success or failure of current policy, and
- Providing a basis for national and international reporting on the State-of-the-Environment (including water resources), which was considered to be a key success factor by the World Summit 2002.

The set should however not be viewed as an institutional performance assessment system, but rather as a basis on which such performance systems can be developed.

3. METHODOLOGY

3.1 General Approach

The project was conducted using the following general approach:

1. The testing and evaluation focused on the descriptions for the 40 indicators that were defined in the set developed by Walmsley (2003). The indicators represent generic catchment indicators previously generated through interaction and agreement with water resource managers.
2. The testing and evaluation was done with emphasis on the availability and quality of data. However, some comment on relevance has also been included.
3. The project was essentially a desk study and did not involve any fieldwork. It required contacting and communicating with parties involved in relevant data collection and information processing.
4. It was assumed that parties would be cooperative in the sharing of information on the data and how they are collected.
5. It was assumed that enquiries for information would not lead to major investigations by the parties into the collection or processing of data during this study. It was however accepted that such enquiries might stimulate action from parties to further investigate the status of the situation on many of the indicators or their component variables.
6. The likelihood of the project encountering lack of data, non provision of data, non response to enquiries, indicators being redundant, or not applicable did not constitute failure, as the objective of the project was to test the current system of information management, test the availability of data, seek out potentially successful indicators, as well as eliminate those that are considered impractical.
7. The project would not generate a list of new proposed indicators, as this would require additional consultation and evaluation, beyond the scope of this project.

3.2 Interaction with Department of Water Affairs and Forestry and Other Parties

It was envisaged that this project would be of interest to the Department of Water Affairs and Forestry (DWAF), which has the national mandate to develop appropriate information systems for catchment and integrated water resource management. The project initiation therefore focused on interacting with relevant personnel within DWAF who could assist with the project or would be interested in the findings.

3.2.1 Capacity Building and Liaison

During the development of the indicator set in 2002, it became evident that there was a low general awareness within DWAF on the concept of indicators and their possible applications. Although the initial development of the indicator set assisted in initiating awareness, it was felt that this project could provide a useful means by which capacity could be further developed. Actions to promote capacity building and awareness were therefore included in the project work programme. These included:

- **Meetings with DWAF personnel involved with information and its management.** These included meetings with personnel from the following DWAF directorates and offices (see Annexure 1):
 - Abstraction and Infrastructure (Environment and Recreation)
 - Catchment Management;
 - Resource Allocation;
 - Resource Directed Measures;
 - Policy and Strategy Co-ordination;
 - The DWAF regional office in KwaZulu-Natal; and
 - Water Services.
- **Meetings and contact with other institutions** - during the project's inception phase, it was established that information and data on many of the indicators were available within a variety of

agencies and institutions (e.g. Mhlathuze Water Board, Richards Bay Municipality, University of Zululand, and other government departments). Contact and discussion with personnel from these organisations was therefore included in the work schedule (see **Annexure 1**).

- **The convening of an interactive workshop with DWAF personnel** – A workshop was convened on 18th June 2003 to introduce personnel from key directorates in DWAF to this indicator initiative, and to discuss departmental actions with regard to indicators. It was extremely successful in that it allowed for the exchange of information on a variety of separate parallel initiatives within DWAF aimed at developing and using indicators. It was quite clear that the project had high priority to DWAF and all participants agreed that the objectives were of relevance to their own initiatives (see **Annexure 2**). All attendees agreed to cooperate with the project in terms of providing information and feedback, if and when requested.
- **Establishment of an ongoing communication with DWAF** – it was agreed at the workshop that there would be ongoing communication on the progress and results of the project with the Sub-directorate: Environment and Recreation (Deputy Director: Barbara Weston).

3.2.2 Selection of a Pilot Catchment

Initial discussions with DWAF personnel centred round the selection of a pilot catchment, and after consultation with the DWAF Directorates of Catchment Management, Resource Directed Measures, Abstraction and Infrastructure (Environment and Recreation) and Resource Allocation, the **Mhlathuze River** catchment in KwaZulu-Natal was chosen as the pilot catchment. Although it is not in a water management area within which a CMA will shortly be established, it was considered to have the following advantages as a pilot catchment:

- It is one of the priority catchments for the KwaZulu-Natal Regional Office (Ashwin Seetal, DWAF, *pers. comm.*) and significant DWAF resources have been invested in its management;
- A strategic environmental assessment (SEA) has recently been completed which provides a benchmark for the catchment assessment and, thus, for the overall effectiveness of the indicators (DWAF 2000);
- It has recently been subjected to a major water resource study to determine operating rules and future phasing for water resource management (DWAF 2001);
- It has a statutory water board, Mhlathuze Water, which is also, by law, in a position to co-ordinate resources, determine and manage the fluctuation of demand, provide water services and, more importantly, engage in water resources management for the catchment;
- It has an established catchment management forum and the active participation of communities in water resource management;
- It has been earmarked as a pilot catchment for establishing and implementing water allocation procedures (Ashwin Seetal, Harrison Pienaar, DWAF, *pers. comm.*), and
- Because of a strong institutional framework and its status as a priority catchment, it is considered to be relatively data-rich.

To assist with the study, relevant reports and literature on the Mhlathuze were obtained from DWAF and other parties. Of particular relevance are the following documents that represent major projects aimed at assessing the sustainability of the Mhlathuze catchment.

1. Department of Water Affairs and Forestry (2001). Usuthu to Mhlathuze Water Management Area: Water Resources Situation Assessment. Knight Piesold Consulting. Report No. P 06000/00/0101.
2. Department of Water Affairs and Forestry, South Africa and Mhlathuze Water (2001). Mhlathuze Operating Rules and Future Phasing. Series of Reports prepared by consultants BKS (Pty) Ltd and Knight Piesold, including:
 - Hydrology Module Report: PB W120-00 0199
 - Water Demand Module Report: PB W120-00 0299
 - Groundwater (Coastal Lakes) Hydrology: PB W120-00 0399

- Water Demand Management Module Report: PB W120-00 0499
 - System Analysis Module Report: PB W120-00 0599
 - Water Quality Module Report: PB W120-00 0699
 - Phasing Analysis Module Report: PB W120-00 0799
 - Operating Rules Module Report: PB W120-00 0899
 - Main Report: PB W120-00 0999
3. Steyl I, DB, Versfeld and PJ Nelson (2000). Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – KZN. Report Number: SEA-01/2000. Department of Water Affairs and Forestry.
 4. Department of Water Affairs and Forestry, South Africa and Mhlathuze Water (2000). Mhlathuze System Ecological Reserve (Quantity) Study. Report No. W120-00-1199.

These documents contain an enormous amount of information on the Mhlathuze catchment and have also proved useful in assessing the indicators within the proposed set because several of the indicators have been used in these more recent assessments.

3.3 Testing of indicators

3.3.1 Criteria and Method for Testing

The original 40 indicators within the set were chosen primarily because they were associated with priority issues within water management in South Africa. The emphasis in the initial selection was therefore that of relevance. It should however be emphasised that all of the indicators within the set are not totally new, having been used elsewhere in other monitoring investigations, but not necessarily within a catchment context.

In developing criteria for evaluating the set for the Mhlathuze catchment it was felt that the focus should be on aspects related more to data availability and quality, as well as whether the indicators are actually currently used in assessing sustainability. Selection criteria were discussed at the DWAF workshop on June 18th 2003 (see **Annexure 2**). These were refined (following consultation during the exercise of collecting data and establishing what data were available) to include the following:

1. **Availability** – the extent that data and information were available following contact and discussion with the parties/persons who were responsible for collection or storage.
2. **Cost** – the price for providing the information.
3. **Confidence** – the reliability of the data/information in terms of providing “true” values of the indicator or its parameters.
4. **Historical record** – the length of time that the data/information has been collected, particularly with regard to long-term datasets that allowed for assessment and testing of the concept of sustainability.
5. **Temporal alignment of parameters** - many indicators require monitoring of more than one parameter. It is essential that these parameters have been measured simultaneously with each other.
6. **Spatial quality** – because the indicators are intended to represent the situation over a catchment area, it is important that data represents an integrated spatial perspective of that catchment.
7. **Frequency of collection** – indicators need to be monitored on an ongoing basis so as to be able to provide decision-makers with a measure of change. The time period between measurements should enhance the quality of decisions based on any changes.

8. **Processing time/efficiency** – the relative time taken between the collection of field data and the availability of the information for further processing and decision-making.
9. **Relatability/overlap with other indicators** – assessment of the status of a catchment is based on the whole indicator set. There is thus a need that data/information for the indicator should relate to each other, particularly from a temporal perspective.
10. **Empirical status** – it was noted that for some indicators, available data was not 100% empirical, but based on estimates that made use of variables that had been modelled. This criterion was therefore included.

It was also felt that it might be useful to provide a rough assessment of the relative overall status of each indicator by developing and using a rapid numerical evaluation. This was done by assigning a numerical score for each criterion (0=zero or non-existent; 1= intermediate; 2 = good) and summing up the scores to give an overall score for each indicator (see Table 2).

Table 2: Rating sheet for the assessment of each indicator

Criterion	Rating Non-existent or zero = 0; Intermediate = 1; Good = 2
Availability	
Cost of data	
Confidence	
Historical record	
Temporal alignment of parameters	
Spatial quality	
Frequency of collection	
Processing time/efficiency	
Relatability/overlap with other indicators	
Empirical status	
Total Score	

The total score for each indicator provides a means by which their relative status can be compared. It is acknowledged that this approach is subjective, but it was felt to be useful as part of the preliminary screening of each of the indicators.

3.3.2 Enquiries, Collection and Processing of Indicator Information

For each indicator the following procedure was adopted:

- General consultations were held with DWAF personnel, as well as others, to establish opinion on the indicator and identify possible sources of information (institution and personnel);
- Contact was made with the institution and relevant person to enquire about the use of the indicator and whether information was available. Previously published documentation and websites were also consulted and data from these used.
- In some cases, data were obtained at a small cost (e.g. rainfall from the South African Weather Bureau). However, in most cases, where data was available, parties provided information at no cost to the project although it is acknowledged that there was an internal cost to that institution. Where information was not available, the project did not see its mandate as being one of spending project funds to commission the institution (or person) to collect or process such information.
- Where possible, the indicators were calculated using the formulae presented in the individual evaluation fact sheets (**Annexure 3**). Problems in the data processing and calculation of each indicator (e.g. time scale differences between data etc.) have also been included.

- Where possible the information was processed to provide a picture of the status of the Mhlathuze catchment with respect to each of the indicators. This is given in the individual indicator sheets that are contained in **Annexure 3**.

3.3.3 Catchment assessment

It was originally envisaged that this project could also provide an integrated assessment of the sustainability of the pilot catchment based on the information for the indicators in this evaluated set. This was not able to be undertaken because:

- There is insufficient information on the majority of the indicators and therefore the project has been unable to make use of the full indicator set. However, where possible each of the indicator evaluation sheets contains a statement on the status of the catchment based on the indicator.
- Detailed studies have already been published by DWAF and Mhlathuze Water (2001), and Steyl et al. (2000), which provide an assessment of the sustainability of the catchment (although using other indicators and approaches).

This aspect is therefore one that should form part of any future investigations and assessments of the catchment.

4. EVALUATION OF INDICATOR SET

Evaluation comments for each of the indicators are presented in the separate indicator sheets in Annexure 3. This section contains a summary of the overall numerical rating for each of the indicators and the conclusions and recommendations (relevant pages in the Annexure 3 are also given).

4.1 Socio-Economic Indicators

SE1 Population density (page 1: rating value = 12)

The indicator is regularly used for water resource management decisions and should form part of any core indicator set for catchment assessment. However, there is a need to improve the method of assessing the total catchment population and improving on the time taken for processing empirical measurements.

SE2 Urbanisation (page 4: rating value = 12)

This indicator is being regularly used for water resource management decisions and should form part of any core indicator set for catchment assessment. However, there is a need to improve the method of assessing the urban and rural components of the catchment population, as well as improving the time taken in the processing of empirical measurements

SE3 Gross Geographic Product per capita (page 7: rating value = 0)

This indicator is not currently being used for routine water resource management decisions, consequently it cannot be recommended as a core indicator for catchment water resource management. It would however be useful if the catchment's GGP could be estimated and monitored in order for a better understanding to be developed of how various categories of water users contribute to the economy.

If the intention of this indicator is to obtain an idea of the relative ability of people to pay for water and water services, then income per capita, income per household, or percentage of people below the international poverty line would be better indicators of this status.

SE4 Human Development Index (page 9: rating value = 0)

This indicator is not currently being used to make water resource management decisions as none of its components relate directly to water. It does however provide an assessment of the relative quality of life of people. It might therefore be useful as an indicator that reflects the longer-term impacts of government's water resource allocation strategies (e.g. free basic water, provision of water services and sanitation etc.). There is however a need to develop and use monitoring approaches by which the provision of these water related services can be linked to upliftment in the quality of life of persons for which such strategies are directed. If the indicator is to be considered as a core catchment indicator then it should be more focused on that section of the catchment's population persons who are most affected by poverty rather than as a blanket indicator for the whole population.

SE5 Water Equity Coefficient (page 12: rating value = 1)

This indicator is not currently being used to make routine water resource management decisions in the catchment. It does however provide a useful way for obtaining an assessment of how the domestic sector is using water and therefore of use for the setting of policy on tariffs and water restrictions, as well as assessing water leakage and payment for services. Where metered supply systems are in place (e.g. the Municipalities of Richards Bay and Empangeni), it might be possible to develop and use this indicator. If the indicator is to be used as part of a core catchment set then there is a need for all municipalities in the catchment to monitor it and report collectively, thus providing a catchment-wide perspective for comparative purposes.

SE6 Percentage of Households without access to water (page 14: rating value = 16)

This indicator is currently being regularly used to make important decisions on the development of water resources infrastructure and the allocation of water, particularly to rural areas in the catchment. An efficient information management system is in place to monitor and report on its status throughout the country. This

is consistent with the government's priority national policy of providing basic services to water needy persons throughout the country. In view of the importance to local, regional, national and international decision-making, this indicator should therefore be a priority core indicator within any indicator set for catchment management.

SE7 Percentage of Households without access to sanitation (page 17: rating value = 16)

This indicator is currently being regularly used to make important decisions on development of water resources infrastructure and the allocation of water, particularly to rural areas in the catchment. An efficient information management system is in place to monitor and report on its status throughout the country. This is consistent with the government's priority national policy of providing basic services to sanitation needy persons throughout the country. In view of the importance to local, regional, national and international decision-making, this indicator should therefore be a priority core indicator within any indicator set for catchment management.

SE8 Percentage area under different economic land uses (page 19: rating value = 10)

This indicator is currently not being monitored on a regular basis, although there have been studies which provide information for specific years on the status quo of land uses which impact on water use. The indicator, as it is now defined (covering all land uses), is possibly too general to be of much value, and might therefore be improved by focusing on land uses that have a more direct impact on water use (e.g. forestry, agriculture, alien vegetation). An indicator that monitors such land use should form part of a core indicator set for catchment assessment.

4.2 Water Balance Indicators

WB1. Mean volume of precipitation onto the catchment (page 22: rating value = 2)

It is highly unlikely that there are sufficient rainfall stations in any catchment for direct rainfall measurements to be used to give meaningful assessments of precipitation volume. This requires fairly sophisticated hydrological modelling for each catchment. This indicator is therefore not an easy one to measure and monitor. Consideration should be given to using precipitation as a proxy indicator, which, combined with experience on operational criteria, will provide an indication of what levels of rainfall are required for water resource sustainability within the catchment. In view of the fact that rainfall is the main source of water to the catchment it is essential that this indicator (precipitation) is included in the core set for any catchment.

WB2. Total water available per capita (page 25: rating value = 5)

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. Because of its relationship to individual water users and not to water sector users, it is probably of limited use in routine decision-making. It therefore cannot rank as a priority indicator for a core set of catchment indicators. However, it is of concern that the information management system for the Mhlathuze catchment is unable to readily provide the historical record for the hydrological components of the indicator as these are highly relevant for routine decision-making. This confirms the statement by DWAF and Mhlathuze Water (2001) that the hydrological monitoring and reporting system requires upgrading in order to improve the reliability and availability of information.

WB3. Demand as a proportion of total available (page 27: rating value = 7)

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. It is however, an extremely important indicator as it reflects the degree of water stress in the catchment based on sector water requirements and the available water to satisfy these requirements. It should therefore be included as a core indicator. However, as for other hydrological and water balance indicators within this tested set (see also indicators WB2, WB4, WB5, MN3, MN5, and MN7, it is of concern that the information management system for the Mhlathuze catchment is unable to readily provide the historical record for the hydrological components of the indicator. This confirms the statement by DWAF and Mhlathuze Water (2002) that the

hydrological monitoring and reporting system requires upgrading in order to improve the reliability and availability of information.

WB4. Proportion of groundwater utilised (page 29: rating value = 0)

In light of the perceived importance of groundwater to water resource management, particularly in the coastal zone of the catchment, it is important that there should be an indicator that monitors and assesses the contribution of groundwater to water usage and water balance. It appears as if the situation is not simply one of monitoring borehole abstractions, but the selection of a suitable indicator (s) for groundwater will require an improved quantitative assessment of the overall role of groundwater in the catchment.

WB5. Water requirements per sector as a percentage of total available (page 31: rating value = 10)

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. It is however, an extremely important indicator as, like indicators WB3 and MN3, it reflects the degree of water stress in the catchment based on sector water requirements and the available water to satisfy these requirements. It should therefore be included as a core indicator. However, there is a need to consolidate these indicators (WB3, WB5 and MN3), which are variants on the same theme. There is no doubt that there is a need to monitor the supply of water and to balance it with demand, as well as to assess the efficiency of the allocation process. It is felt that consolidation of the three indicators could consider the following:

1. An indicator that monitors actual supply in relation to the long-term available yield – thus showing how the catchment has deviated from the long-term. This is a water balance indicator.
2. An indicator that assesses sector usage in relation to the actual supply. This is a water balance indicator.
3. An indicator that assesses usage against the planned or agreed allocation, which is a management indicator.

In the case of the first two of the proposed indicators there is a need to improve the hydrological monitoring information management system for the Mhlathuze catchment, which is currently unable to readily provide the reliable values for the hydrological components of the indicators.

4.3 Waste and Pollution Indicators

WP1. Amount of solid waste generated per square kilometer (page 34: rating value = 1)

This indicator suffers from the inherent problem that the conventional method for estimating the amount of waste that is generated is to assess the waste that is received at official dumpsites. Thus estimates are dependent on the records that are kept of the amounts received at the authorised dumpsites. In the case of the Mhlathuze catchment it is evident that there is not a good record of these amounts. In addition there is a high proportion of rural area where there is no waste collection. In view of these critical deficiencies, as well as the fact that it is not possible to assess the actual impact of any of the dumpsites on water resources, it is felt that this indicator is not a critical one to be included in a set of core indicators for catchment assessment.

If the indicator is important for any specific catchment then it should be reformulated to measure the amount of waste that is “disposed of” rather than the amount generated.

WP2. Proportion of waste generated per sector (page 37: rating value = 10)

This indicator requires a record of all of the solid waste generated by all of the sectors, even though the waste might have no impact on water resources. There is no available database or record of the waste amounts generated by the Mhlathuze sectors. In addition, this indicator is not currently being monitored or used for water resource decision-making. Consequently, it is felt that this indicator is not a critical one to be included in a core set for catchment assessment.

If the indicator is important for any specific catchment then it should be reformulated to measure the amount of waste that is “disposed of” by the sectors rather than the amount generated.

WP3. Liquid waste discharged from point sources (page 39: rating value = 0)

Discharges of liquid waste into watercourses have become an important part of South African water resource management not only because of their pollution impacts, but also because of their contribution to hydrology. This indicator is therefore considered to be an important one that should form part of a core indicator set. It is of particular concern that details on return flow volumes (for which permits are issued and for which details on discharge volumes are specified) are not readily available.

WP4. Loading of P, N, POPs and TDS from agricultural runoff (page 41: rating value = 0)

Although it would be desirable to have a measure of the impact of agricultural pollutants, it was felt that it was highly unlikely that technical monitoring of non-point sources is sufficiently developed to be able to yield reliable figures for decision-making purposes. In addition, this indicator calls for too many water quality variables (particularly non-conservative chemicals) and also is expressed as a loading figure that might be insignificant if the catchment was a large one with high volumes of water. For this reason it is felt that this indicator is not one that can be considered to be of high priority for a general catchment indicator set.

WP5. Loading of P and N from dense settlements (page 43: rating value = 0)

Although it would be desirable to have a measure of the impact of pollutants from dense settlements, it was felt that it was highly unlikely that technical monitoring of non-point sources is sufficiently developed to be able to yield reliable figures for decision-making purposes. This indicator is expressed as a loading figure that might be insignificant if the catchment was a large one with high volumes of water, and high loadings from other sources. For this reason it is felt that this indicator is not one that can be considered to be of high priority for a general catchment indicator set.

WP6. Loading of TDS and SO₄ from mine drainage (page 45: rating value = 0)

This indicator is more specific for catchments which have a high level of mining activities that cause acid mine drainage (e.g. coal mining and gold mining). In such catchments it will be important to have an estimate of the loading due to acid mine drainage. The indicator is expressed as a loading figure that might be insignificant if the catchment is a large one with high volumes of water, and high loadings from other sources. Therefore, in order to assess the significance, water resource managers will also need to know the total loading of TDS and sulphate from other sources. For these reasons it is felt that this indicator is not one that can be considered to be of high priority for a countrywide general catchment indicator set. It should rather be one that is used in specific catchments where mining is suspected to have a significant impact.

WP7. Conductivity at the lowest point in the geographical catchment (page 47: rating value = 16)

This indicator is a useful one for keeping a check on the general dissolved mineral content of the water that flows out of a catchment, thus providing a useful early warning signal for deterioration in water quality. It therefore merits inclusion in any core set of catchment indicators. The indicator is being monitored and data is readily available.

WP8. P and N concentrations at the lowest point in the geographical catchment (page 49: rating value = 15)

This indicator is a useful one for keeping a check on the general nutrient content of the water that flows out of a catchment, thus providing a useful early warning signal for deterioration in water quality and for potential eutrophication problems. It therefore merits inclusion in any core set of catchment indicators. The indicator is being monitored (although not actually measuring total P & N) and data are readily available.

WP9. Faecal coliforms in the major water resource for domestic and recreational use (page 51: rating value = 0)

This indicator is a useful one for keeping a check on the general health condition of water in the main storage reservoir. It merits inclusion in any core set of catchment indicators only if the public have access to the particular water body and there is a need to have an indication of potential health risks. It is not a difficult indicator to measure and monitor.

WP10. Daphnia toxicity test at the lowest point in the geographical catchment (page 53: rating value = 0)

This indicator is a useful one for monitoring the general health condition of water with respect to toxicity to invertebrate organisms, especially if it is suspected that there are potentially toxic discharges occurring upstream. It is not a difficult or expensive test to carry out. However it is felt that it does not merit inclusion as a priority indicator. It is felt that it merits inclusion only if it is suspected that toxic discharges are impacting on the water resource.

WP11. Turbidity at the lowest point in the geographical catchment (page 55: rating value = 14)

This indicator is a useful one for assessing the relative amounts of suspended material in the water and giving an indication of potential erosion and (or) the impacts of turbid waste discharges. It is not a difficult or expensive test to carry out. It is felt that it merits inclusion in a long-term core indicator set.

WP12. Proportion of boreholes contaminated (page 57: rating value = 0)

Groundwater is a water resource that could have increasing importance in terms of augmenting the supply of surface water. It is therefore important that groundwater sources be monitored and assessed, particularly in terms of contamination that affects fitness for use. This indicator thus merits inclusion within the set of core indicators. There is a need to upgrade the monitoring system for groundwater in the Mhlathuze catchment.

4.4 Resource Condition Indicators

RC1. Percentage of catchment area covered by natural vegetation and by alien vegetation (page 59: rating value = 10)

Vegetation has a significant impact on a landscape as it provides cover that reduces erosion and also impacts on runoff. However, there is a need for this indicator to be simplified to deal separately with either the issue of land cover or the issue of alien vegetation. In the case of the Mhlathuze catchment, where alien vegetation could be significant it possibly merits the inclusion of two indicators; one which assesses the extent of aliens, and the other which deals with natural vegetation cover (as part of land use). Both indicators would merit inclusion within the set of core indicators. There is an urgent need to introduce vegetation monitoring in this catchment.

RC2. South African Scoring System (SASS) scores at selected site (page 61: rating value = 10)

SASS is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

RC3. Fish Assemblage Integrity Index (page 64: rating value = 10)

FA11 is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

RC4. Index of Habitat Integrity in selected reaches (page 66: rating value = 0)

IHI determinations are part of an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and IHI is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

RC5. Riparian Vegetation Index in selected reaches (page 68: rating value = 0)

The RVI is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of the change that has occurred in the riparian zone of rivers and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core catchment indicator set. There is however a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of change to the riparian zone.

RC6. Percentage wetland area (page 70: rating value = 9)

This indicator is an extremely difficult one to measure and monitor because of the large variety of water resource types that are classified as wetlands, and which make up total wetland area. It is therefore unlikely that a technically acceptable value could be made available to decision-makers. Consequently, it is felt that this indicator should be modified to make it easier. A suggested indicator could be “the amount of land per annum that has been converted from a wetland category into other land use types”. This means that rather than measuring total wetland area, resource managers would measure only that portion that has been converted from wetland.

4.5 Management Indicators

MN1. Index of level of CMA establishment in the catchment (page 72: rating value = 20)

This indicator is one of the few that has been given a high rating based on the criteria for evaluation. This is because the information that is required for its calculation is readily available from the DWAF website (www.dwaf.gov.za), and requires no technical or electronic storage, or personnel to process it.

In view of the importance of CMA development for the implementation of the National Water Act it is felt that this management indicator is a priority for all catchments.

MN2. State of satisfaction (page 75: rating value = 0)

This indicator is one that provides feedback from the public and stakeholders on how they experience the delivery of water services and their rating of how water resources are being managed. There is a need for such feedback to be monitored and reacted on. It is felt that an indicator on the level of stakeholder satisfaction should be included in a core catchment indicator set. This would require water service providers to develop and introduce a suitable monitoring system for the various sectors that are served.

MN3 Volume of water allocated as a proportion of total water available (page 78: rating value = 18)

This indicator is already being used and monitored in the catchment and obviously forms an important part of water resource decision-making. It therefore merits an automatic inclusion into a core indicator set. It is of concern however that this study was not able to obtain up to date values.

MN4. Water use efficiency for different sectors (page 81: rating value = 9)

This indicator has been used for analysing the efficiency of certain sectors in the catchment, albeit on a once off basis. As an indicator, it has merits if it is used with caution to compare the performance of the separate sectors over time rather than as an inter sector comparison. It therefore merits inclusion as a core indicator.

MN5. Percentage unaccounted for water in the catchment (page 84: rating value = 3)

This indicator has been used for analysing the efficiency of certain sectors in the catchment, albeit on a once off basis. As an indicator, it has merits if it is used with caution to compare the performance of the separate sectors over time rather than as an inter sector comparison. It therefore merits inclusion as a core indicator.

MN6. Ratio of sub-catchments for which the Ecological Reserve has been set (page 86: rating value = 20)

Setting of the Ecological Reserve is a key component of South African water policy for all of the Water Management Areas. This indicator therefore has a high relevance in terms of progress towards implementation of policy and regulations. It therefore merits inclusion as a core indicator.

MN7. Ratio of sub-catchments for which reliable hydrological data are available (page 18: rating value = 18)

The presence of active and reliable hydrological monitoring stations in any catchment is important as it provides historical information on the surface water and flow patterns in the catchment. It also allows for verification of modelling predictions upon which water allocations are made. The indicator is thus a priority one to be included in a core set of catchment indicators. There is a need for monitoring of this indicator to include a methodology for assessing reliability of these stations.

MN8. Ratio of sub-catchments for which reliable water quality data are available (page 91: rating value = 18)

The presence of active and reliable water quality monitoring stations in any catchment is important as it provides valuable historical information on the quality of the surface water and allows for the identification of possible sources of pollution. The indicator is thus a priority one to be included in a core set of catchment indicators. There is however a need for monitoring of this indicator to include a methodology for assessing the reliability of these stations in terms of delivering the most relevant and accurate assessment of water quality.

MN9. Number of official resource condition reports (page 94: rating value = 4)

This indicator is considered to be too vague in terms of what it is actually measuring. Official reports are products that emerge from an information system that caters for the information requirements of water resource decision-makers. As a management indicator it would be more useful to have an indicator that quantifies the combined status of the catchment's information system and includes:

- Water quality monitoring
- Hydrological monitoring
- Databases
- Regular reporting based on an agreed core indicator set.

Such an indicator would require development in collaboration with the stakeholders involved in the catchment's information management system.

5. DISCUSSION AND CONCLUSIONS

The indicators that have been tested in this research project represent a desired generic indicator set, which South African water resource practitioners feel should be monitored in all catchments throughout the country. The process of evaluating this set has made use of a pilot catchment (the Mhlathuze) to test whether relevant data is being collected, and is readily available so that these indicators can be reported on.

Supported by a simple numerical rating system, the findings show that out of the 40 indicators within the set: two received a maximum rating of 20 in terms of the availability and quality of the data required to estimate them; sixteen received a rating of between 10 and 20; eight received a rating of between 4 and 10; and fourteen were given a zero-rating. The implications of the zero-rating mean that the current information management system for the pilot catchment is either not collecting, or not processing the relevant information to calculate the indicators. The implications of the other ratings, particularly those with values greater than 10, mean that those indicators can be currently estimated, and reported on. In the case of the Mhlathuze, only nine of the indicators were able to be processed during this study.

The study has also allowed opportunity to evaluate each of the indicators and further refine the set of generic indicators proposed by Walmsley (2003). Of the 40 indicators evaluated, several can be rejected as not being priority ones for decision-making. The ones that are recommended as being good generic indicators are included in Table 3.

Table 3: Suggested priority indicators
SE1 Population Density
SE2 Urbanisation
SE6 Percentage of Households without access to water
SE7 Percentage of Households without access to sanitation
SE8 Percentage area under different economic land uses
WB3. Demand as a proportion of total available
WB4. Proportion of groundwater utilised
WB5. Water requirements per sector as a percentage of total available
WP3. Liquid waste discharged from point sources
WP7. Conductivity at the lowest point in the geographical catchment
WP8. P and N concentrations at the lowest point in the geographical catchment
WP11. Turbidity at the lowest point in the geographical catchment
WP12. Proportion of boreholes contaminated
RC1. Percentage of catchment area covered by natural vegetation and by alien vegetation
RC2. South African Scoring System (SASS) scores at selected site
RC3. Fish Assemblage Integrity Index
RC4. Index of Habitat Integrity in selected reaches
RC5. Riparian Vegetation Index in selected reaches
MN1. Index of level of CMA establishment in the catchment
MN2. State of satisfaction
MN3 Volume of water allocated as a proportion of total water available
MN4. Water use efficiency for different sectors
MN5. Percentage unaccounted for water in the catchment
MN6. Ratio of sub-catchments for which the Ecological Reserve has been set
MN7. Ratio of sub-catchments for which reliable hydrological data are available
MN8. Ratio of sub-catchments for which reliable water quality data are available

Several of these indicators are not being routinely monitored in the Mhlathuze catchment and in order to use this set there is a need to establish a formal and structured long-term monitoring programme. This general assessment is somewhat disappointing in terms of the high expectations for the test catchment in that, at the outset of the project, it was termed relatively “data rich”. The situation does however reflect that there is a

large reality gap between what water resource managers feel should be monitored and what is actually measured and reported on. It also indicates that catchment water resource management decisions are being made without a sound knowledge of broader catchment characteristics necessary to implement integrated water resource management.

The situation can be explained on the basis of several paradigms and barriers that prevail in the South African water sector, and which are limiting the development of an information system to support South Africa's intended approach to integrated water resource management for catchments. This project provides opportunity to raise these, as they will need to be addressed during the formation of Catchment Management Agencies and, most certainly will be key issues for the generation of successful individual catchment management strategies. Some of the key issues and their consequences (Figure 1) are:

- Monitoring and assessment of catchments is largely done on a once off project basis and there does not appear to be routine long-term monitoring and reporting based on agreed formats and protocols. There is no agreed set of indicators for monitoring and assessing catchment characteristics in accordance with the intended policy to promote integrated water resource management.
- The information management system for catchments is fragmented with no central body or person responsible for handling information on individual specific catchments. At the present stage, the roles and responsibilities of central, regional and local agencies in information management and reporting are not well defined.
- The main approach to monitoring and assessing catchments is through modelling approaches that focus on the prediction of future water supply and demand. Historical empirical values are largely ignored in the reporting process and, when used, serve primarily to verify modelling approaches. It is for this reason that a zero-rating was given to most of the water balance indicators in the evaluated set.
- The envisaged long-term timetable for the establishment of Catchment Management Agencies (CMA) does not promote local ownership and responsibility for the initiation and development of the necessary monitoring programmes. A general impression gained during this study is that the development of indicators and local information management systems (monitoring and reporting) awaits the establishment of CMA.
- There is a need to develop a culture of information sharing within the water sector, particularly through formal and regular public reporting on the status of catchments. Integrated water resource management will require information inputs from all stakeholders in the water sector and not solely from government.
- The protracted process of formulating a national classification system and setting of the Reserve for catchments has also had a restricting impact on the monitoring and information management systems that are in operation.
- The human resources allocated to catchment assessment appear to be mainly external to the main water resource management institutions. Most of the data collection and reporting on catchments is outsourced, meaning that a large proportion of the skills in the collection, ownership and interpretation of data are external to the main water resource management agencies.

Finally, there is the assumption that all catchments behave similarly. The Mhlathuze is certainly not a simple catchment system as it has characteristics that do not necessarily make it easy to measure and monitor many of the indicators. The main features that detract are the topography and distinct separate hydrological systems (separate river channels, wetlands, coastal lakes and groundwater) and the proximity to the ocean.

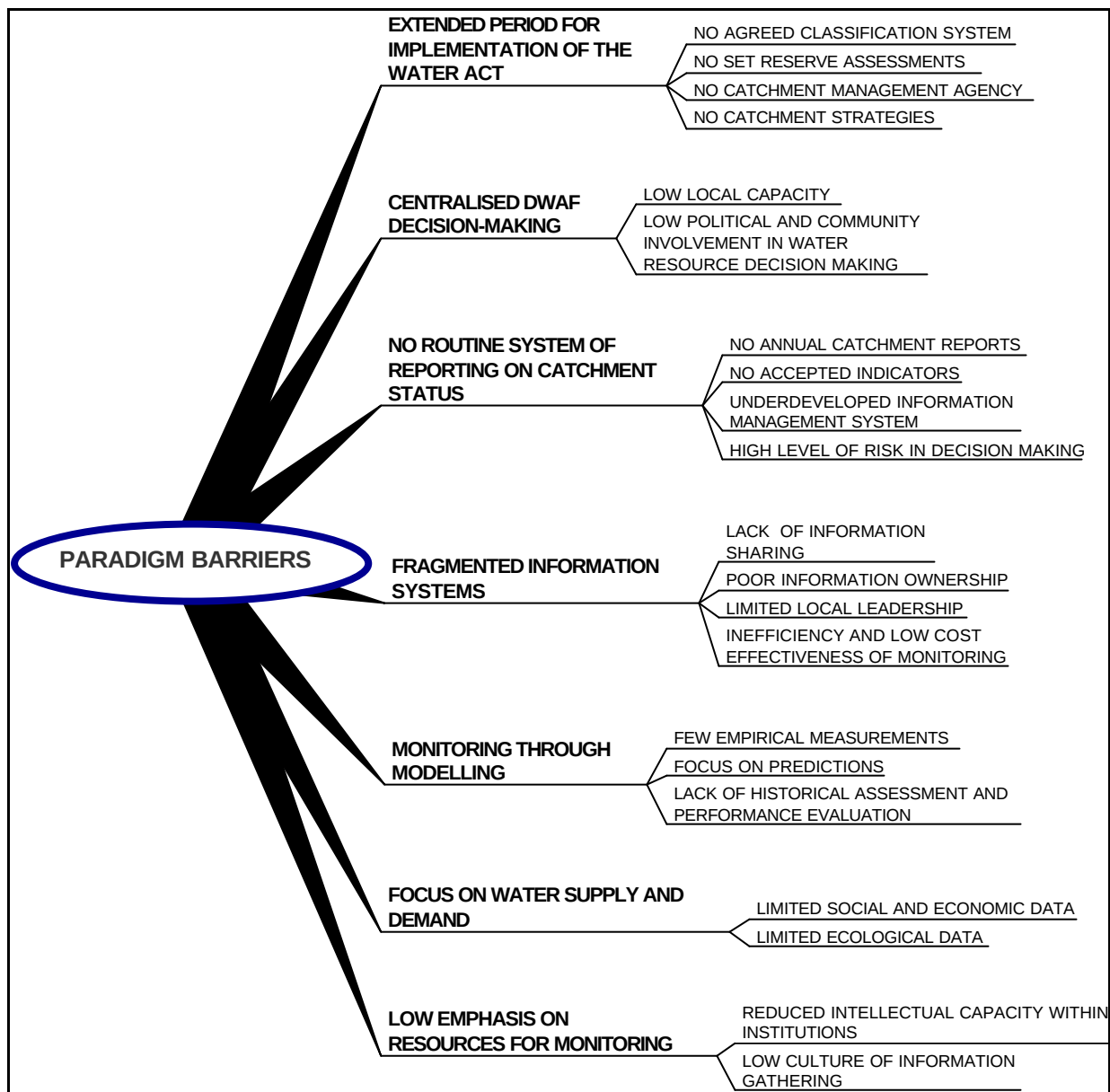


Figure 1: The main paradigm barriers (and some of their consequences) that are limiting the development of an information system to support South Africa's intended approach to integrated water resource management for catchments.

This study has illustrated the complexity in the process of developing and using indicators. It has also identified and highlighted some difficulties that need to be overcome in the establishment of appropriate information management systems for catchment management. Hopefully this report and its findings will be of use to the ongoing initiatives to establish a national information system, as mandated by the National Water Act, as well to all parties that wish to initiate and develop appropriate indicators for catchment monitoring and assessment.

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ANNEXURE 1

LIST OF PERSONS CONSULTED

A list of the persons who were consulted

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ANNEXURE 2

**PROCEEDINGS OF A WORKSHOP HELD ON 18TH JUNE 2003 AT THE DEPARTMENT OF
WATER AFFAIRS AND FORESTRY, PRETORIA**

1. WELCOME

Dr Dan Walmsley (Mzuri Consultants), as facilitator, welcomed everyone to the meeting. All workshop participants introduced themselves (see Appendix A for details).

2. INTRODUCTION AND AIM

Dr Walmsley explained that the indicator concept formed part of Agenda 21, which stated that “*indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to the self-regulating sustainability of integrated environmental and development systems*”. He outlined a concept diagram showing the life cycle of issues and how indicators can play a role in their management (Figure 1).

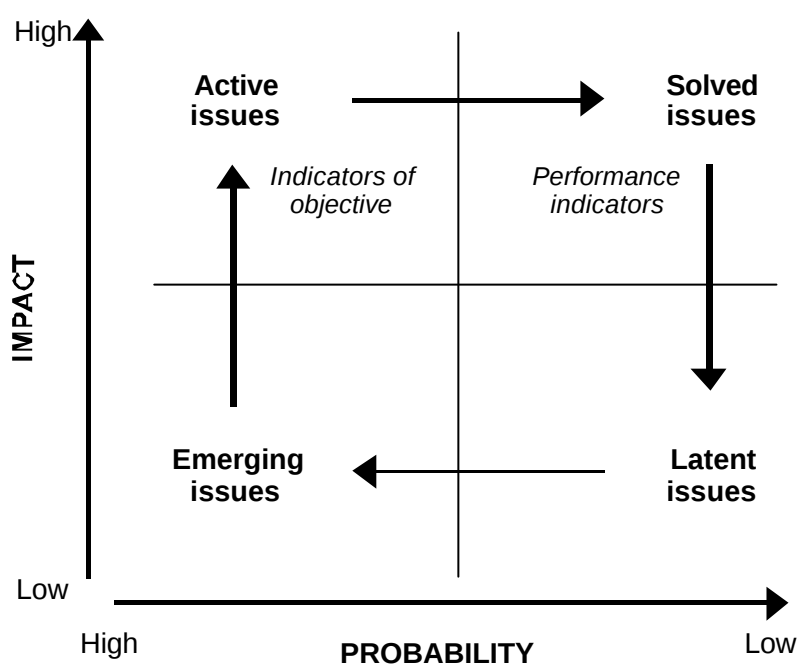


Figure 1: Issues-based indicator framework

Dr Walmsley explained that the aims of the workshop were to:

- Inform DWAF on national indicator initiatives;
- Provide information on the WRC Indicators Project;
- Discuss the relevance of the WRC Indicators Project to DWAF, and
- Develop an action plan for the development of indicators in DWAF.

3. NATIONAL INDICATORS INITIATIVES

Dr Pretorius outlined some of the initiatives that had been undertaken by the Department of Environmental Affairs and Tourism (DEAT) with regard to indicators over the last decade. A hardcopy of the presentation is provided in Appendix B.

The initiatives undertaken by DEAT included:

- The UN Commission for Sustainable Development indicator initiative;

- Environmental indicators for national state-of-the-environment reporting;
- Local level environmental sustainability indicators;
- Indicators to monitor the National Strategy for Sustainable Development;
- Indicator aggregation and indices;
- SADC state-of-the-environment reporting, and
- Household survey through Stats SA.

Important issues that have been highlighted by these initiatives include:

- Adequate reporting in absence of good environmental indicators is problematic;
- National indicators may mask local problems, thus it is necessary to have indicators at both levels;
- State-of-the-environment reporting and indicators can be a useful tool for local authorities to develop their integrated development plans.

4. DISCUSSION

On a question from Dr Fred van Zyl (DWAF), Dr Pretorius said that DEAT was aware of the limitations of the household survey with regard to their relevance at a local level. He added that indicators at local level would have to be specific for the different types of authority, that indicators for use by metropolitan councils would be different from those used by small town councils.

Mrs Barbara Weston (DWAF) pointed out that the important issue was liaison between organs of state. Dr Pretorius said that this was done mainly through the Committee for Environmental Co-ordination at a national level, and MINMEC at a provincial level.

5. WRC INDICATORS PROJECT

Dr Jay Walmsley provided background on the WRC indicators project, which provided focus for this workshop. A hardcopy of the presentation is provided in Appendix C.

Dr Walmsley said that the aim of the project was to develop a set of indicators that assists in the assessment of sustainability of South African catchment systems. The indicator set should be able to be used as:

- A “red-flagging” system for CMAs to identify potential or current problems;
- A basis for strategic assessment for CMAs/DWAF, particularly with regard to the success or failure of current policy;
- A basis for national and international reporting on the state-of-the-environment (water resources).

A draft set of indicators had been developed in the first phase of the project in 2001/02, through a participative process with water management authorities in the country. The set included 40 indicators, grouped into 5 categories - socio-economic (8 indicators), water balance (5 indicators), waste and pollution (12 indicators), resource condition (6 indicators) & management (9 indicators). See Appendix C for the list of indicators.

The project was currently in the test phase, which was being sponsored by the Water Research Commission as a short-term contract. This phase included testing the indicators on a pilot catchment, namely the Mhlathuze catchment. This would include data collection, calculation of the indicators, assessment of the indicators, development of proxy indicators, and a catchment assessment using the indicators.

Dr Walmsley stressed that, although the WRC project was short in duration, it required ongoing interaction with DWAF and could be used as a stepping-stone to encourage indicator development within the Department. It would also be a first step in developing an understanding of indicators in the Department.

6. DISCUSSION

Mr Linn Gravelet-Blondin (KZN Region) pointed out that, although the Mhlathuze catchment was appropriate for the study, due to the number of studies in the area, there should be a concerted effort to avoid stakeholder fatigue. This would require co-ordination with other projects working in the same catchment (e.g. compulsory licensing project). Dr Jay Walmsley assured him that due consideration would be taken of resource limitation and it was expected that most of the data would be accessible through head office.

Dr Cornelius Ruiters (DWAF) said that two other aspects needed to be taken into consideration. These were Section 14 of the National Water Act and the link with monitoring of indicators.

On a question from Mr Mbangi Nepfumbada (DWAF), Dr Jay Walmsley said that the essence of the WRC Project was the availability of data. The findings of the project would be documented in a data report. All indicators that were too complex or for which there were no data, would be substituted by proxies. The indicator set should be practical and implementable.

Mr Pieter Viljoen (DWAF) complimented Dr Pretorius on the national environmental indicator document that had been distributed. He emphasised that those indicators were only for the biophysical environment. He suggested that there was an imbalance in the catchment management indicator set between the biophysical indicators and the socio-economic indicators. Dr Jay Walmsley agreed, but added that the socio-economic indicators tended to be more aggregated and complex, thus expressing more information.

7. RELEVANCE OF WRC INDICATORS PROJECT TO DWAF

7.1 Environmental reporting in DWAF

Mrs Weston provided a short presentation on the role of indicators in environmental reporting in DWAF, especially with regard to the legislated requirement for DWAF to produce a consolidated environmental implementation and management plan (CEIMP; see Figure 2). NEMA and Agenda 21 required that the department develop a CEIMP, whilst the National Water Act and the Water Services Act both had policies and strategies attached to them that required reporting functions. None of these could occur without adequate information, which would, in turn, require a monitoring and information system. A monitoring system could include indicators to assist in monitoring progress.

Indicators that should be incorporated in the system included:

- Sustainable development indicators to determine whether there is a problem;
- Performance indicators, which should report on the tools for achieving objectives, and
- Compliance indicators to monitor compliance at all levels.

These will assist in determining whether an intervention is required. Mrs Weston suggested that the DWAF's KPAs be used as a basis for performance and compliance indicators.

Mrs Weston stressed that there was a gap in communication, both within the Department and with other departments, and that there needed some mechanism to co-ordinate action. There were currently over 70 reporting requirements for DWAF. These should be undertaken in a manner that not only ensured compliance, but that was also beneficial to DWAF. She added that there was a culture of policy development without implementation.

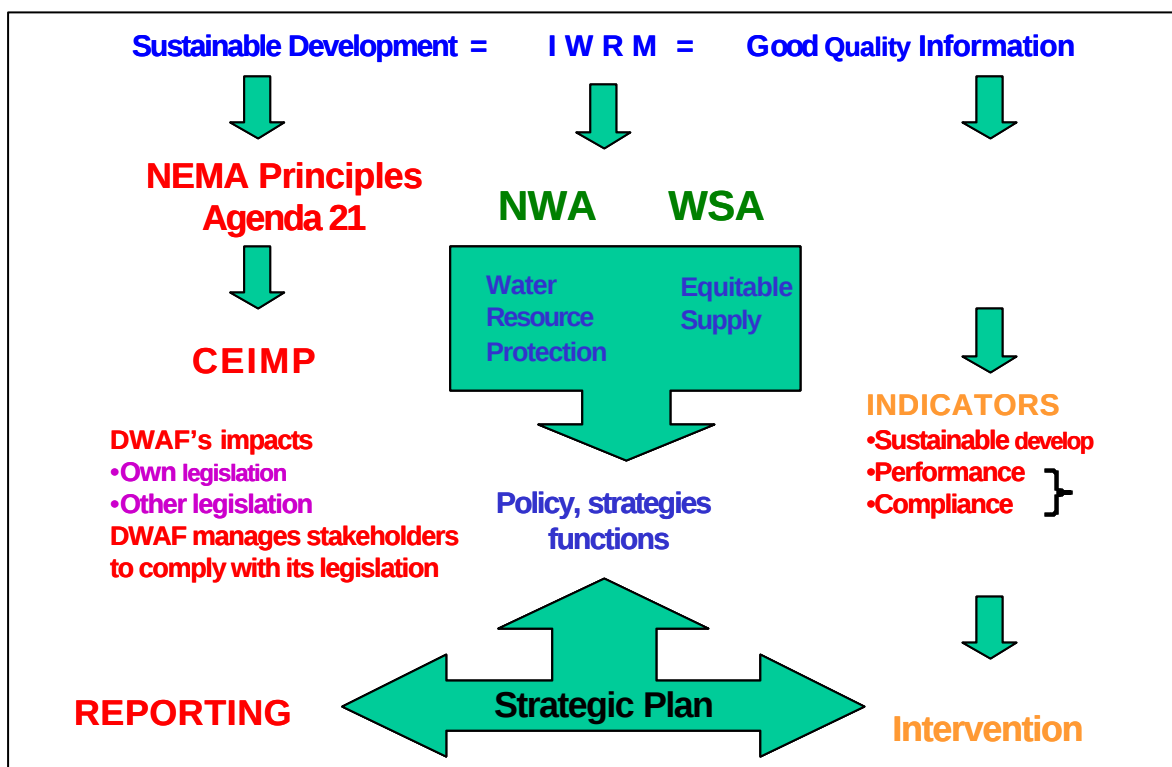


Figure 2: Role of indicators in environmental reporting.

7.2 National Water Reporting Framework

Dr Van Zyl provided a brief outline on the National Water Reporting Framework that was to be developed by DWAF on request of the Minister. It would form part of a global reporting initiative and was the first national pilot project for the World Water Assessment Programme.

Although the project would focus on some of the issues identified at the WSSD (e.g. how do you monitor “water and food” or “water and economic development”), DWAF’s formal reporting requirements would need to be taken into consideration. Additionally the National Water Reporting Framework would need to take into account the whole water sector and not just DWAF. It was envisaged that a dynamic reporting structure would be put in place that could allow ongoing reporting on a regular basis, probably electronically based. In essence the structure would become a business tool to assist with performance evaluation, compliance and achievement of strategic goals.

Dr Van Zyl said that Mr Bill Rowlston had developed a simple framework for assessing information, as follows:

- Available – useful;
- Available – not useful;
- Not available – required.

This would be used to assist in this project.

A task team had already been established as a first step in this project. It was envisaged that a first order reporting framework be developed by August. Information to populate this would be collected in time for presentation at the Africa Summit in December.

Mr Eberhard Braune (DWAF), as part of the project task team, added that the project would essentially have two parts:

- A concept of indicators within the framework of the national strategy, objectives and reporting requirements that came under the umbrella of national water resource sustainability;
- A business analysis that would lead to the supporting information management system and monitoring. This would provide a sustainable flow of information.

Mr Van Zyl said that the indicators would have to be outcome based.

7.3 Discussion

Mr Gravelet-Blondin said that he was unaware of the CEIMP initiative. This emphasised the basic communication problem that was being experienced in DWAF. He stressed the capacity problem in the regions, which made implementation of many initiatives problematic. This was iterated by Mr Bonani Madikizela (DWAF) who said that the Act had to be implemented from the bottom-up and the capacity was required on the ground. Currently there was extensive use of consultants, and DWAF needed to get its house in order. Information was provided through monitoring and assessment, for which capacity was required.

Dr Dan Walmsley outlined a model for capacity requirements that would need to be addressed with regard to indicators. Capacity consisted of three elements:

- Skills, created through training, education and experience;
- Motivation, created through the organisation, leadership, work environment, awareness, rewards and salary, and
- Opportunity, created through legislation, environmental management systems, facilities and equipment.

Mrs Eustathia Bofilatos (DWAF) said that indicators had been developed to determine the success of CMA establishment, but that these were on a different level to the catchment management indicators of the WRC project.

On a comment from Dr Van Zyl, Dr Dan Walmsley said that he had developed sustainability indicators for Eskom, which were linked to the executive bonus system. Mrs Weston agreed that indicator development in DWAF should be linked to the business system, like Eskom.

8. ACTION PLAN

8.1 What does DWAF need to do?

It was recognised in the workshop that there were many indicator initiatives currently being undertaken in DWAF, but that there was little co-ordination between them. It was agreed that the development of the National Water Sector Reporting System would be the vehicle by which these initiatives could be brought into a single functioning system.

Dr Van Zyl said that a *national* task team for the project would be established shortly. A situation assessment would need to be done with regard to information requirements and availability. It was possible that pilot studies would need to be used to start populating the established system. It was envisaged that several theme-based workshops would be required to ensure success.

Several actions, which would be required for the development of a reporting system to be to be successful, were identified by the workshop participants. These included:

- Develop a common objective and common understanding, especially from a CMA/WMA water resource management perspective;

- Design and institutionalise a system, which must include a framework and an adaptive management tool;
- Identify current initiatives and align them with the common objective;
- Identify new initiatives;
- Identify and get on board responsible contributors and stakeholders;
- Identify all KPAs, KPIs and themes that need to be included in the project and align them to the common objective;
- Ensure consultation within and outside DWAF, especially with the regional offices and external research organisations;
- Develop and maintain capacity (skills, motivation and opportunity);
- Align the framework and indicators to legislation, policy and strategy.

Several initiatives, which should be included in the project, were identified by the workshop participants. They included:

- Indicators for the annual report;
- CEIMP report indicators;
- CMA performance indicators (institutional oversight);
- environmental impact management system;
- Environmental management framework;
- Information programmes;
- Management system for environmental management;
- Non-consumptive use indicators;
- RDM indicators;
- Resource-directed water quality management indicators;
- Social development framework (Institutional Oversight);
- Socio-economic indicators (Institutional Oversight), and
- Water quality management performance management system.

8.2 Interaction with the WRC project

It was agreed that the results of the WRC project would be important input for some of the other initiatives in DWAF. Interaction with DWAF would take place at three levels:

1. Ongoing interaction with an individual “entry point” in DWAF. It was agreed that Mrs Weston would be the designated entry point.
2. Intermittent interaction with other indicator initiatives within DWAF (see 6.1 above), as well as other interested parties. All formal project reports will sent by e-mail to the following people:
 - Valerie du Plessis;
 - Eberhard Braune;
 - Precious Hlubi;
 - Eustathia Bofilatos;
 - Jean Msiza;
 - Gerry Munro;
 - Lorraine Fick;
 - Pieter Viljoen;
 - Harrison Pienaar;
 - Ash Seetal;
 - Fred Van Zyl;
 - Bill Rowlston;
 - Joe Hansman (KwaZulu-Natal);

- Mike Warren;
 - Michael Singh and
 - Johan Van Rooyen.
3. Interaction for data acquisition, with people throughout DWAF, including the regional office (James Perkins and Jay Reddy).

Additionally, a feedback seminar on the results of the WRC project would be held in November.

8.3 Criteria for indicator evaluation

Workshop participants were asked to comment on the criteria for indicator evaluation. The final indicator evaluation criteria were identified as:

- Data are available;
- Data are of known confidence;
- Data are available over historical time (i.e. not once off data collection);
- The indicator can be used for future planning;
- The indicator can be presented in a way that is unambiguous;
- The indicator provides timely information;
- The indicator is sensitive to change/trends in the system;
- Targets, goals and thresholds can be set for the indicator;
- The indicator must be easy to calculate, and
- The indicator should be linked to cause and effect.

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ANNEXURE 3

INDICATOR SET WITH EVALUATION COMMENTS

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1: POPULATION DENSITY		
Social	Population change	Driving force

- 1. Definition:** Total population size within the catchment divided by its surface area (persons km⁻²)
- 2. Purpose:** To measure the concentration of the human population with reference to space. Population density can be used as a partial indicator of human requirements and activities in an area.
- 3. Relevance to sustainable water resource management:** A high or growing population density can threaten the sustainability of water resources by exceeding the carrying capacity of the resource. This is particularly true in catchments where freshwater resources are limited (i.e. most South African catchments). At the same time, population density is considered to be a driving force of technological change in production. A high population density is the main defining feature of urban areas. A high concentration of population also means more local demand for sanitation, services, waste management and general amenities, all of which require water.

Empirical values of population estimates are needed in order to obtain values for the Basic Water component of the Reserve estimate.

- 4. Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Poverty/vulnerability;
 - Inequity;
 - Inequitable access to services;
 - Waste generation/waste management;
 - Domestic demand for water;
 - Water allocation/Reserve;
 - Runoff from dense settlements;
 - Microbiological contamination;
 - Demand management;
 - Social viability, and
 - Habitat condition.
- 5. Limitations and potential problems:** The significance of the indicator is limited in larger catchments where population distribution varies significantly. For instance, in downstream catchments there may be a low population density, with the main human impacts arising upstream.
- 6. Calculating the indicator:**

$$SE1 = P_T / A_T$$

Where: P_T = Total catchment population (number)
 A_T = Total surface area (km²).

7. Data Collection for the Mhlathuze Catchment

Data were provided on request by the DWAF Directorate of Water Services. The parameters for this indicator include:

1. Total surface area (A_T). This parameter has been estimated according to normal geographic GIS methods. The value is set at 4 209 km² and is a constant.

2. Total catchment population (P_T). The method used to estimate population is based on an enumerated areas approach in which functional urban areas have been identified within magisterial districts that coincide with the catchment boundary. DWAF reports that this method of estimating population shows fair agreement with census estimates (Mr K Kuhn, personal communication). An estimate of the Mhlathuze catchment population was made by DWAF during a baseline survey carried out in 1995. The 1995 survey also made use of several other sources of data. The 1995 population of the catchment was estimated at 375 539 persons, of which 93 525 were urban and 282 014 were rural. This yields a population density of 89 persons/km².

Population estimates for the catchment are made regularly (every 6 months) by DWAF using a modelling approach and a database that has been populated with survey data from a DWAF baseline survey done in 1995, and supported with national census statistics (1996). The data are readily available on request.

At the time of this study, the only empirical estimate made for the indicator has been that done during the DWAF 1995 baseline survey, supported by the 1996 Census data. The 2001 Census data have not yet been processed into the catchment database.

The main shortcomings of the available data and their use in providing “best estimate” values for populations are:

- The DWAF method of population estimate that uses a functional urban areas approach.
- The enumerated areas approach does not exactly cover the area within the catchment boundary.
- Monitoring for this catchment is largely based on a modelling approach that uses one empirical measurement of the population (the estimate made in the 1995 baseline survey) to project all other estimates. It is not clear how DWAF verifies these estimate

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Evaluation summary table for data on the indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	12

8. Trends

Based on the DWAF modelling approach to predicting population, the population change trend in the Mhlathuze catchment for the period 1995 to 2005 is shown in Figure 1 below which assumes a population growth rate of approximately 1.75%. To give a context to the values for the Mhlathuze it should be noted that the population density for South Africa in 2001 was 36.75 persons per square kilometer and the country’s average annual population growth rate was 1.32% (see Statistics South

Africa - www.statssa.gov.za). This also contrasts with more densely populated areas of South Africa e.g. the Pretoria Metropolitan Area which has a population density of 1,300 persons per square kilometer (more than ten times greater than that of the Mhlathuze catchment) and where the population has increased annually by 4 % between the 1996 and the 2001 Census (see www.environment.gov.za).

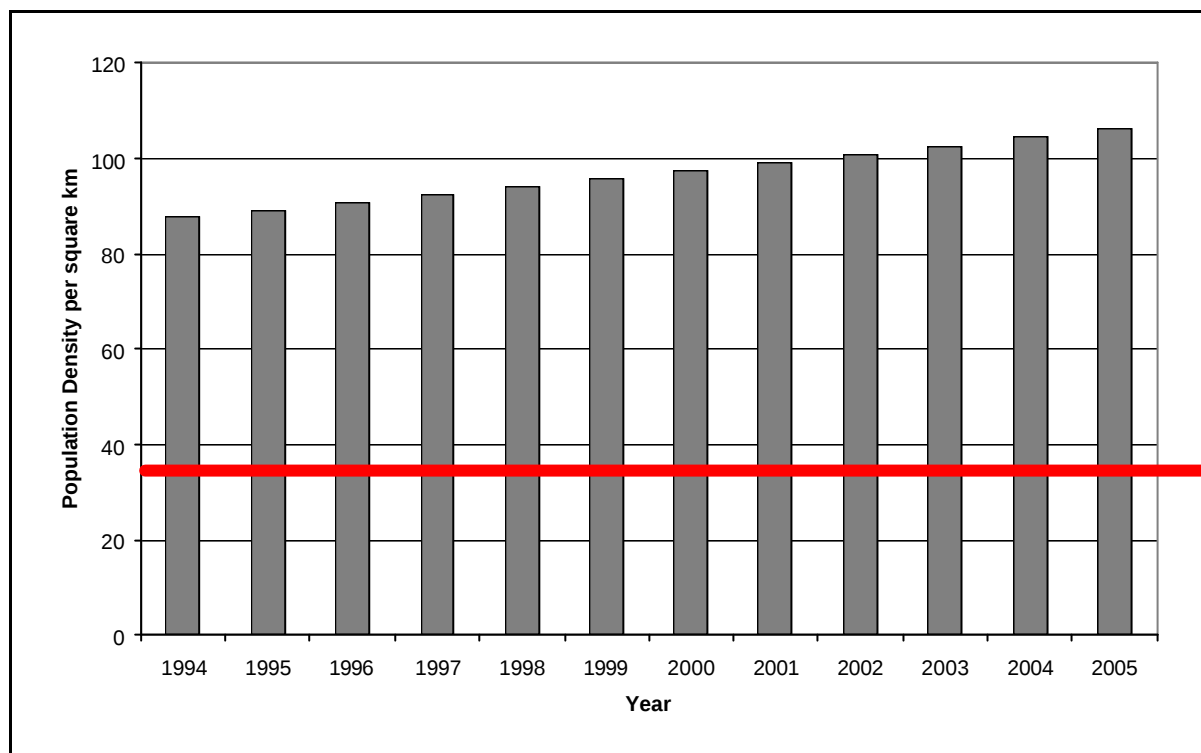


Figure 1: Population density change estimates for the Mhlathuze catchment, based on a 1995-baseline study, supported by 1996 Census. From 1996 onwards, figures are projections based on modelling. Horizontal line represents average density for South Africa (1999). Data provided by Directorate of Water Services, Department of Water Affairs and Forestry, Pretoria.

9. Conclusions and Recommendations

The indicator is regularly used for water resource management decisions and should form part of any core indicator set for catchment assessment. However, there is a need to improve the method of assessing the total catchment population and improving on the time taken for processing empirical measurements.

10. References

- Department of Water Affairs and Forestry 2003. Water Resources Situation Assessment. Directorate of Water Resources Planning. Report No: P 06000/00/0101.
- Steyl I, Versfeld D B and P J Nelson 2000. Strategic Environmental Assessment for Water Use: Mhlathuze Catchment. Department of Water Affairs and Forestry. Report No. SEA/ 01-2000.

SE2: EXTENT OF URBANISATION		
Social	Human settlement	Driving force

- 1. Definition:** The percentage of the catchment population living in semi-formal and formal urban areas as defined by the National Census (%).
- 2. Purpose:** To measure the number of people living in both formal and informal urban areas. It is useful as an indicator of urban development and, by default, gives an indication of percentage of people living in rural areas.
- 3. Relevance to sustainable water resource management:** The number of people in urban and rural environments has an impact on the infrastructure and water requirements, as well as waste management and pollution potential. In a highly urbanised environment, the infrastructure requirements will be high, especially with regard to sanitation, water supply and pollution management.

Reliable empirical values of the population living in urban and rural areas are essential in order for efficient and effective planning for the delivery of basic services based on the Millennium Development Goals, as well as in the assessment of the basic water component of the Reserve.

- 4. Linkages:** This indicator may be linked to the following issues:
 - a. Land-use change;
 - b. Demand management;
 - c. Waste generation/pollution management;
 - d. Inequity;
 - e. Inequitable access to services;
 - f. Poverty/vulnerability;
 - g. Domestic demand for water;
 - h. Runoff from dense settlements;
 - i. Microbiological contamination;
 - j. Social viability, and
 - k. Habitat condition.
- 5. Limitations and potential problems:** This indicator is dependent on Census information and urban classification. Census information is only available in 5-yearly cycles, whilst urban classification still requires clarification.

6. Calculating the indicator:

$$SE2 = P_U / P_T \times 100$$

Where: P_U = Semi-formal and formal urban population (number)

P_T = Total catchment population (number).

7. Data for the Mhlathuze Catchment

Data was readily obtained from the DWAF Directorate of Water Services. Information for this indicator included:

1. Total catchment population (P_T). The method used to estimate population is based on an enumerated areas approach in which functional urban areas have been identified within magisterial districts that coincide with the catchment boundary. DWAF reports that this method of estimating population shows fair agreement with census estimates. An estimate of the

Mhlathuze catchment population was made by DWAF during a baseline survey carried out in 1995. The 1995 survey also made use of several other sources of data. The 1995 population of the catchment was estimated at **375 539** persons.

2. Semi-formal and formal urban population number (P_U). Estimates of this parameter were also made during the 1995 survey. The value amounted to **93 525** persons living in formal urban areas.

Population estimates for the catchment are done regularly (every 6 months) by DWAF using a modelling approach and a database that has been populated with survey data (primarily from a DWAF baseline survey done in 1995) and supported with national census statistics. The only empirical estimate that can be made for the indicator is based on the population value for the 1995 baseline survey, which yields an **urbanisation value of 24.9 %**.

The main shortcomings to the available data and their use in providing “best estimate” values for this indicator are:

- The method of population estimate which uses a functional urban areas approach;
- Monitoring for this catchment is largely based on a modelling approach that uses one empirical measurement of the population (the estimate made in the 1995 baseline survey) to project all other estimates. It is not clear how DWAF verifies these estimates; and
- The enumerated areas approach does not exactly cover the area within the catchment boundary.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of obtaining data	2
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	12

8. Trends

Based on the DWAF modelling approach to assessing population, the urban population trend in the Mhlathuze catchment for the period 1995 to 2005 is shown in Figure 2 below. Because of the method of estimating populations there is a constant percentage of urbanisation (24.9%) in the catchment. The actual empirical value for urbanisation in the Mhlathuze catchment (between 1996 and 2001) can only be estimated when the data from the 2001 Census has been assessed. The average urban population density value for South Africa in 1996 was 46.3% (see www.enviro.gov/soer), thus the catchment has approximately half the extent of urbanisation as the rest of South Africa.

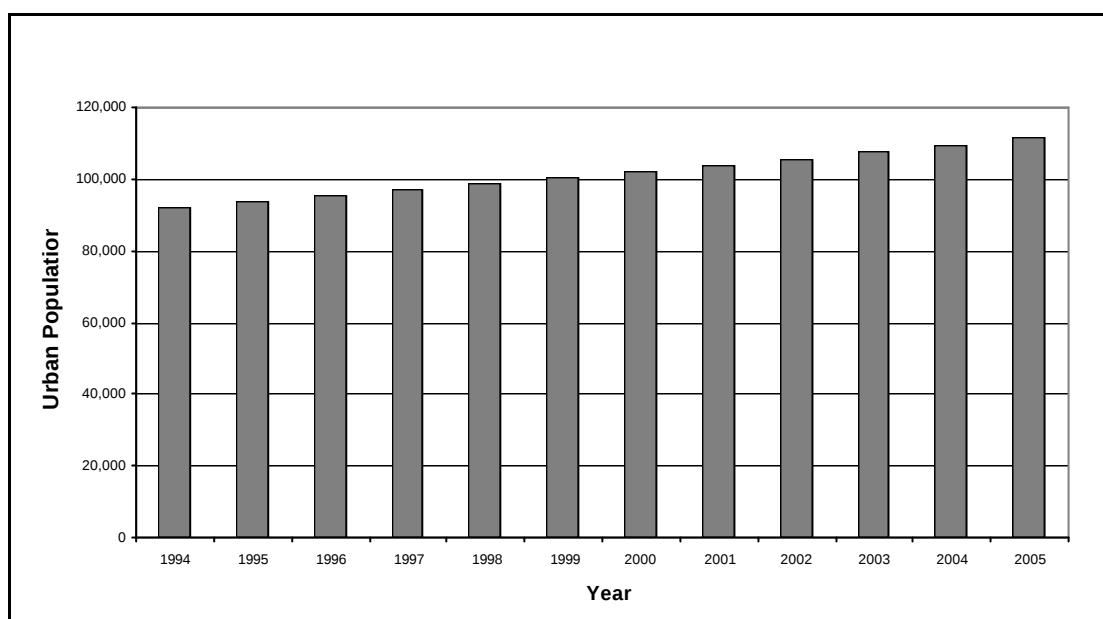


Figure 2: Urban population estimates for the Mhlathuze catchment, based on a 1995-baseline study, supported by 1996 Census data. From 1996 onwards, figures are projections based on modelling. Data provided by Kobus Kuhn, Directorate of Water Services, Department of Water Affairs and Forestry, Pretoria.

9. Conclusions and Recommendations

This indicator is being regularly used for water resource management decisions and should form part of any core indicator set for catchment assessment. However, there is a need to improve the method of assessing the urban and rural components of the catchment population, as well as improving the time taken in the processing of empirical measurements

10. References

Department of Water Affairs and Forestry 2003 Water Resources Situation Assessment. Directorate of Water Resources Planning. Report No: P 06000/00/0101.

SE 3: GROSS GEOGRAPHIC PRODUCT PER CAPITA		
Economic	Poverty/Vulnerability	Driving force

- Definition:** Gross geographic product (GGP) per capita for a catchment is obtained by dividing annual GGP at current market prices by the catchment population (Rands capita⁻¹ or US\$ capita⁻¹ for international comparisons).
- Purpose:** To measure the wealth of a catchment area. GGP per capita is a basic economic growth indicator and measures the level and extent of total economic output. It reflects changes in total production of goods and services.
- Relevance to sustainable water resource management:** Growth in the production of goods and services is a basic determinant of how the economy fares. It indicates the pace per capita of income growth and also the rate at which resources, including water, are used. It does not directly measure sustainable development, but is a very important measure for the economic and developmental aspects of sustainable development, including people's consumption patterns and the use of renewable resources, such as water.
- Linkages:** This indicator may be linked to the following issues:
 - Economic use value;
 - Water allocation;
 - Poverty/vulnerability;
 - Waste generation;
 - Inequity;
 - Sectoral demand for water, and
 - Demand management.
- Limitations and potential problems:** At present GGP at catchment level is not calculated as part of the standard South African statistics, although it has been done within DWAF for certain planning cases for select areas.
- Calculating the indicator:**

GGP is calculated using standard procedures. The current price estimates of GGP are adjusted to GGP at constant prices with the use of price deflators.

Population estimates enable the conversion of total GGP to per capita levels using the following equation:

$$SE3 = GGP / P_T$$

Where: GGP = Annual Gross Geographic Product for the catchment
 P_T = Total catchment population (number).

7. Data for the Mhlathuze Catchment

Enquiries with relevant parties and examination of economic reports have indicated that there is a limited amount of economic information (DWAF 2002) on the GGP of the catchment. Although there is information on the economic characteristics of the wider sub-region and also specific industries and sectors (see also Richards Bay Spatial Development Initiative carried out by Development Bank of Southern Africa in 1998) this is insufficient to provide any reliable estimate of annual GGP for the catchment. Estimation of annual GGP for the catchment would require much

more detailed analysis and co-operation of the business sectors involved in economic activities within the catchment (see Dallymore 2000). It is thus not possible to provide even a ballpark figure for the GGP per capita.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible from this study to provide any trend for the GGP per capita for the catchment.

9. Conclusions and Recommendations

This indicator is not currently being used for routine water resource management decisions, consequently it cannot be recommended as a core indicator for catchment water resource management. It would however be useful if the catchment's GGP could be estimated and monitored in order for a better understanding to be developed of how various categories of water users contribute to the economy.

If the intention of this indicator is to obtain an idea of the relative ability of people to pay for water and water services, then income per capita, income per household, or percentage of people below the international poverty line would be better indicators of this status.

10. References

Dallimore A. 2000. Water Use and Dependency in the Mhlathuze Catchment: A Macro Economic and Sectoral Analysis. DRA-Development Report, 2000/05. In: Appendix E: Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – KwaZulu-Natal. Department of Water Affairs and Forestry. Report Number: SEA-01/2000.

Department of Water Affairs and Forestry 2002. The Distribution of South Africa's Population, Economic and Water Usage into the Long-term Future. Department of Water Affairs CD.

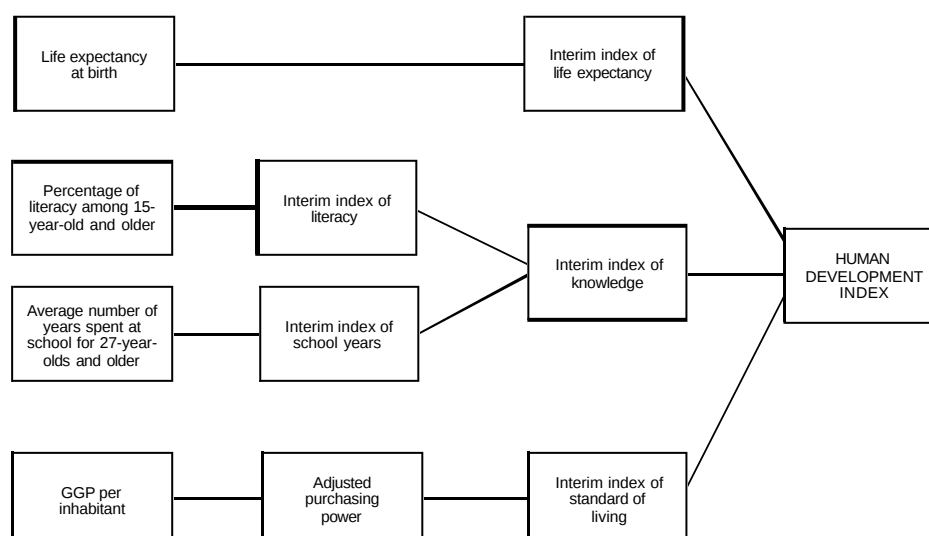
Development Bank of Southern Africa 1998. Richards Bay Spatial Development Initiative. Development Bank of Southern Africa, Johannesburg.

Steyl I, DB Versfeld and PJ Nelson. 2000. Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – KwaZulu-Natal. Department of Water Affairs and Forestry. Report Number: SEA-01/2000.

SE4: HUMAN DEVELOPMENT INDEX		
Social	Poverty/Vulnerability	Driving force

- Definition:** Composite, relative index that quantifies the extent of human development of a community (Index value between 0 and 1).
- Purpose:** To evaluate the level of human development based on measures of life expectancy, literacy and income. It is internationally accepted as an index of human vulnerability and standard of living.
- Relevance to sustainable water resource management:** This indicator is seen as a measure of people's ability to live a long and healthy life, to communicate, to participate in the life of the community and to have sufficient resources to obtain a decent living. If the level of human development is high in a catchment, the lower order needs are being met and high-order needs such as conservation can be dealt with. It also provides an indication of the potential of the population to rationally respond to resource management and sustainable development issues.
- Linkages:** This indicator may be linked to the following issues:
 - Poverty/vulnerability;
 - Population change;
 - Inequity;
 - Inequitable access to services, and
 - Social viability.
- Limitations and potential problems:** The greatest limitation to this index is that data are often limited and incomplete. It should also be taken into account that other indicators have been used in the index to represent similar aspects of development (e.g. GGP per capita, GGP per employed, services level).
- Calculating the indicator:**

The index is calculated as follows:



The initial data are transformed in one or two stages, according to their peculiarities, into interim indices that will be used to calculate the HDI. The following conventional minimum and maximum values for the different indices are used for the calculation of interim indices:

	Min	Max
Life expectancy at birth (a)	25	85
Literacy (%)	0	100
Number of school years	0	15
Purchasing power of GGP (USD)	200	40 000

The interim indices show the relative “distance” covered by a society, somewhere between the respective minimum and maximum figures. Accordingly, a 10-year education would be awarded a score of 0,667; and average life expectancy of 55 years would score 0,5. The interim index of knowledge is derived from a weighted average of literacy and years spent at school, where the weighting is 2 and 1 respectively.

The calculation of the interim index for standard of living assumes that the link between the growth of purchasing power and well-being is not proportional. Thus, the adjusted value of purchasing power is calculated before it is indexed. Income that exceeds the level of the world’s average income gradually decreases in the calculation of the adjusted value. If the GGP of the catchment per inhabitant does not exceed the world average (US \$5120), the adjusted purchasing power will be the actual one. The adjusted purchasing power, $W(y)$, will be:

$$\begin{aligned}
 W(y) &= y && \text{when } 0 < y \leq y^* \\
 W(y) &= y^* + 2(y - y^*) && \text{when } y^* < y \leq 2y^* \\
 W(y) &= y^* + 2(y - y^*) / 2 + 3(y - 2y^*) / 3 && \text{when } 2y^* < y \leq 3y^* \text{ etc.}
 \end{aligned}$$

Where: $W(y)$ = Adjusted purchasing power
 Y = GGP per capita (US\$)
 y^* = World average purchasing power.

Thus,

$$SE4 = (L + K + W(y)) / 3$$

Where: HDI = Human Development Index
 L = Life expectancy index
 K = Knowledge index

7. Data Collection for the Mhlathuze Catchment

There is inadequate data for the Mhlathuze catchment to estimate the components of the Human Development Index. No agency or institution is in a position to provide estimates of the HDI. In the Strategic Environmental Assessment carried out in 2000 (see Steyl et al. 2000; Dallimore 2000; van Jaarsveld 2000), most of the social characteristics of the Mhlathuze catchment are explained in a largely anecdotal fashion, with few empirical values for education, life expectancy or income. Some major points to emphasise are:

- The Mhlathuze catchment’s unemployment figure of 42.8% is higher than that of the average for KwaZulu Natal, which is 39.1%.
- The absolute majority of the population earns no income at all. Most of those that do earn an income earn between R2 401 and R6 000 per annum that translates into between R200 and R500 per month.

- An average of 26% of rural residents have no schooling, while only 9% of urban residents have no schooling. The age group with the highest percentage (9%) of uneducated rural people is between ages 30 and 59.

The Mhlathuze catchment would therefore be expected to have an extremely low HDI value. An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion		Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability		0
Cost of data		0
Confidence		0
Historical record		0
Temporal alignment of parameters		0
Spatial quality		0
Frequency of collection		0
Processing time/efficiency		0
Relatability/overlap with other indicators		0
Empirical status		0
	Total Score	0

8. Trends

Because of the absence of any data or HDI estimates, is not possible to provide any indication of trends.

9. Conclusions and Recommendations

This indicator is not currently being used to make water resource management decisions as none of its components relate directly to water. It does however provide an assessment of the relative quality of life of people. It might therefore be useful as an indicator that reflects the longer-term impacts of government's water resource allocation strategies (e.g. free basic water, provision of water services and sanitation etc.). There is however a need to develop and use monitoring approaches by which the provision of these water related services can be linked to upliftment in the quality of life of persons for which such strategies are directed. If the indicator is to be considered as a core catchment indicator then it should be more focused on that section of the catchment's population persons who are most affected by poverty rather than as a blanket indicator for the whole population.

10. References

Dallimore A 2000. Water Use and Dependency in the Mhlathuze Catchment: A Macro Economic and Sectoral Analysis. DRA-Development Report, 2000/05. In: "Appendix E: Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – Kwazulu-Natal. Department of Water Affairs and Forestry. Report Number: SEA-01/2000.

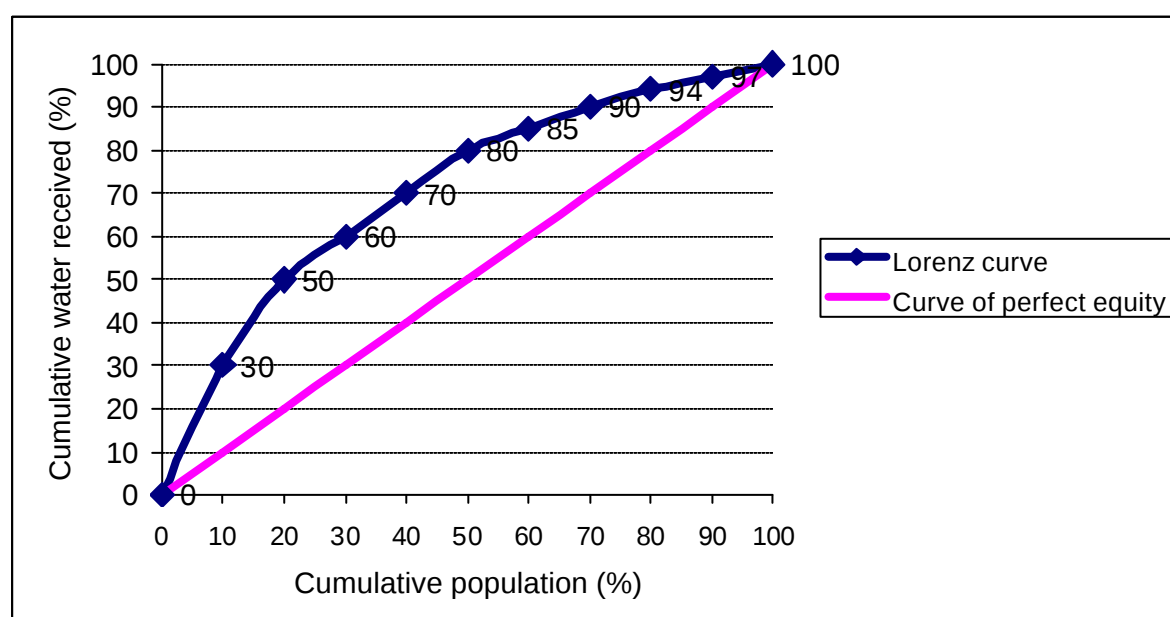
Steyl I, D B Versfeld and P J Nelson 2000. Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – Kwazulu-Natal. Department of Water Affairs and Forestry. Report Number:SEA-01/2000.

Van Jaarsveld R 2000. Social characteristics within the Mhlathuze catchment. In "Appendix D: Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – Kwazulu-Natal. Department of Water Affairs and Forestry. Report Number: SEA-01/2000.

SE5: WATER EQUITY COEFFICIENT		
Social	Inequity	Impact

- Definition:** Coefficient of equity of water allocation in the domestic sector based on the Lorenz curve of percentage water received against percentage of the population (Index value between 0 and 1)
- Purpose:** To evaluate the equitable sharing of resources by the domestic sector.
- Relevance to sustainable water resource management:** One of the cornerstones of the National Water Act (36 of 1998), along with sustainability, is equity. It is stated that water will be allocated in a manner that ensures equity and that past imbalances will be redressed. The domestic sector is particularly prone to imbalance, and is ideal for measuring inequity.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Poverty/vulnerability;
 - Population change
 - Social viability;
 - Availability of water;
 - Water allocation/Reserve, and
 - Inequitable access to resources.
- Limitations and potential problems:** This indicator will only be possible to monitor where water services have been implemented and where delivered volumes are measured. It is also only applicable to the domestic sector of water users.
- Calculation of the indicator:**

The cumulative proportion of domestic water received (y) is plotted against the cumulative percentage of the population (x) as shown in the hypothetical example below:



The Water Equity Coefficient is calculated from the above as follows:

$$SE5 = \frac{1}{2} \sum_{i=1}^k |x_i - y_i|$$

Where: x_i = relative frequency of x
 y_i = relative frequency of y
 k = number of classes.

7. Data Collection for the Mhlathuze Catchment

There is no agency or institution that is currently using this indicator in the Mhlathuze catchment for water resource management decisions. It was also not possible to obtain any reference to studies that have reported on this indicator for the catchment. This is not surprising in view of the rural nature of the Mhlathuze and the lack of metered water supply systems. Where water is metered and invoiced (e.g. in municipal areas) data are available to calculate this indicator, but this would then only be applicable to those areas and not for the catchment as a whole.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	1

8. Trends

It is not possible from this study to provide any trend on the water equity coefficient for the catchment.

9. Conclusions and Recommendations

This indicator is not currently being used to make routine water resource management decisions in the catchment. It does however provide a useful way for obtaining an assessment of how the domestic sector is using water and is therefore of use for the setting of policy on tariffs and water restrictions, as well as assessing water leakage and payment for services. Where metered supply systems are in place (e.g. the Municipalities of Richards Bay and Empangeni), it might be possible to develop and use this indicator. If the indicator is to be used as part of a core catchment set then there is a need for all municipalities in the catchment to monitoring it and report collectively, thus providing a catchment-wide perspective for comparative purposes.

10. References

Whitehead M. The Concepts and Principles of Equity and Health. WHO Regional Office for Europe (EURO). Copenhagen, Denmark. 1991

SE6: PERCENTAGE OF HOUSEHOLDS WITHOUT ACCESS TO WATER WITHIN 200m		
Social	Inequitable access	Impact/Pressure

- 1. Definition:** Proportion of households without access to water for domestic use within 200m (%).
- 2. Purpose:** To assess the infrastructure development in terms of water delivery for domestic purposes, as well as access to water resources, and availability of water for basic use.
- 3. Relevance to sustainable water resource management:** This indicator shows whether the local authorities and water providers are providing adequate water to the population of the catchment. It is assumed that those people that are not linked are required to collect their own water from other sources (rivers and reservoirs). If there are a high proportion of people not serviced, this has implications for the control of water consumption in the catchment. It also indicates how many people still require water in terms of government policy. In general, it deals with the lower end of the Lorenz curve discussed in SE5: Water Equity Coefficient. The indicator is also linked to the determination of the Reserve component for basic water which will ultimately form a priority allocation in all catchments.

South Africa has subscribed to the Millennium Development Goals, one of which is intended “to halve, by the year 2015, the proportion of the world’s people who are unable to reach, or to afford, safe drinking water”. The government’s current programme is to ensure that there are no water needy persons by March 2008 (van Zyl, personal communication). This indicator is therefore highly relevant to local, national and international political imperatives.

- 4. Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Poverty/Vulnerability;
 - Population change;
 - Availability of water;
 - Water allocation/Reserve;
 - Domestic demand for water
 - Inequity in terms of other services;
 - Social viability, and
 - Economic use value.
- 5. Limitations and potential problems:** This indicator is limited by the assumption that piped water within 200m is the minimum requirement for an adequate water supply. This has been obtained from the from the four RDP criteria: 1) at least 25ℓ per day; 2) a distance of less that 200m; 3) adequate quality and 4) a 98% assurance of supply.
- 6. Calculating the indicator:**

$$SE6 = P_{NW} / P_T \times 100$$

Where: P_{NW} = Households that do not receive piped water within 200m (number)
 P_T = Total catchment population (number).

7. Data Collection for the Mhlathuze Catchment

The DWAF Water Services database was contacted to obtain information on this indicator. Estimates for the water needy in the Mhlathuze catchment have been done by making use of the baseline population figures for the catchment in the years 1995/1996 and then subtracting the numbers of water units that have actually been delivered each year, thereafter (Kobus Kuhn,

personal communication). Population increases in the catchment have been taken into account using a modelling approach (see explanation under indicator SE1 on population growth rate).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of obtaining data	2
Confidence	1
Historical record	1
Temporal alignment of parameters	2
Spatial quality	1
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	1
Total Score	16

8. Trends

The trend in water needy persons is shown in Figure 1 below. This shows that in the four years after 1994, when the percentage of water needy was approximately 49% of the population, there was little change. However, a concerted delivery programme from 1998 onwards reduced this to a current 16% which is close to the national average of 14% (see red line on Figure 1). It is anticipated that there will be an almost zero percentage by the year 2008 as this is one of the targets that has been set by the South African Government (Mr F van Zyl, personal communication).

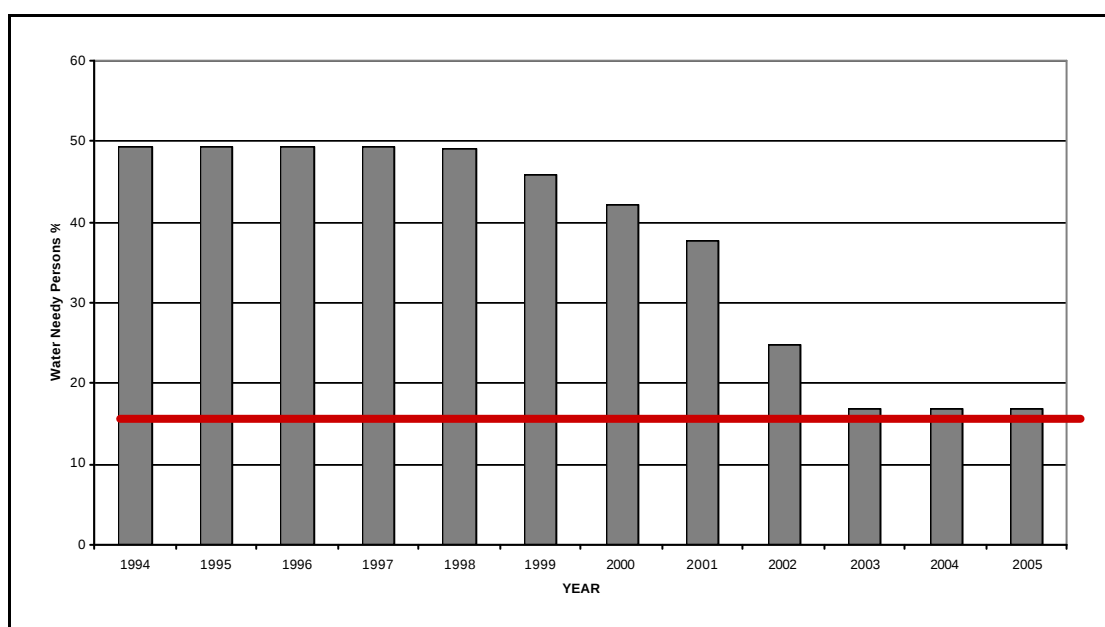


Figure 1: Water needy persons in the Mhlathuze catchment (data supplied by Directorate of Water Services, DWAF). Horizontal line represents the national average.

9. Conclusions and Recommendations

This indicator is currently being regularly used to make important decisions on the development of water resources infrastructure and the allocation of water, particularly to rural areas in the catchment. An efficient information management system is in place to monitor and report on its status throughout the country. This is consistent with the government's priority national policy of providing basic services to water needy persons throughout the country. In view of the importance to local, regional, national and international decision-making, this indicator should therefore be a priority core indicator within any indicator set for catchment management.

10. References

Department Of Water Affairs and Forestry (DWAF). 2002. Department of Water Affairs and Forestry Annual Report 2001-2002. DWAF Pretoria.

7: PERCENTAGE OF POPULATION WITHOUT ACCESS TO SANITATION		
Social	Inequitable access	Pressure/Impact

- Definition:** Proportion of population without access to any form of toilet facility (%).
- Purpose:** To assess the infrastructure development and need of the people in terms of sanitation. It is also an indicator of potential sewage pollution.
- Relevance to sustainable water resource management:** Toilet facilities may include fairly simple communal VIP toilets, septic tank systems or flush toilets. This indicator evaluates whether any of these are available and, as a result, shows whether there are adequate sanitation facilities in the catchment or not. It also assesses the potential for sewage pollution from runoff in areas where there are few toilet facilities provided. It is a key water resource pressure indicator.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlements;
 - Poverty/Vulnerability;
 - Waste generation and management;
 - Runoff from dense settlements;
 - Microbiological contamination, and
 - Social viability.
- Limitations and potential problems:** There are a few identifiable problems with this indicator, notably the fact that sanitation technology has different forms (e.g. VIP, pit latrine, septic tank, flush toilet etc) and also can be delivered in different ways (e.g. to community, to households or to individuals). Monitoring of all these qualifications could make this indicator difficult to implement. However, if the indicator deals with establishing the access to sanitation only by individuals, then this problem is reduced.
- Calculation of indicator:**

$$SE7 = P_{NT} / P_T \times 100$$

Where: P_{NT} = Population without any toilet facilities (number)
 P_T = Total catchment population (number).

7. Data Collection for the Mhlathuze Catchment

The estimates of the population without access to sanitation in the Mhlathuze catchment have been done by the Water Services Section (DWAF) making use of the baseline population figures for the catchment in the years 1995/1996 and then subtracting the numbers of sanitation units (VIP) that have actually been delivered each year, thereafter (Kobus Kuhn, personal communication). Population increases in the catchment have been taken into account using a modelling approach (see explanation under indicator SE1 on population growth rate).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of obtaining data	2
Confidence	1
Historical record	1
Temporal alignment of parameters	2
Spatial quality	1
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	1
Total Score	16

8. Trends

The trend indicates that from 1996 up until 2001 there was little change in the number of persons without access to sanitation, with the value remaining constant at above 70%. This was reduced slightly in 2002 to about 65%. The national average value for sanitation needy persons in 2003 is 37% (Kobus Kuhn, Personal communication).

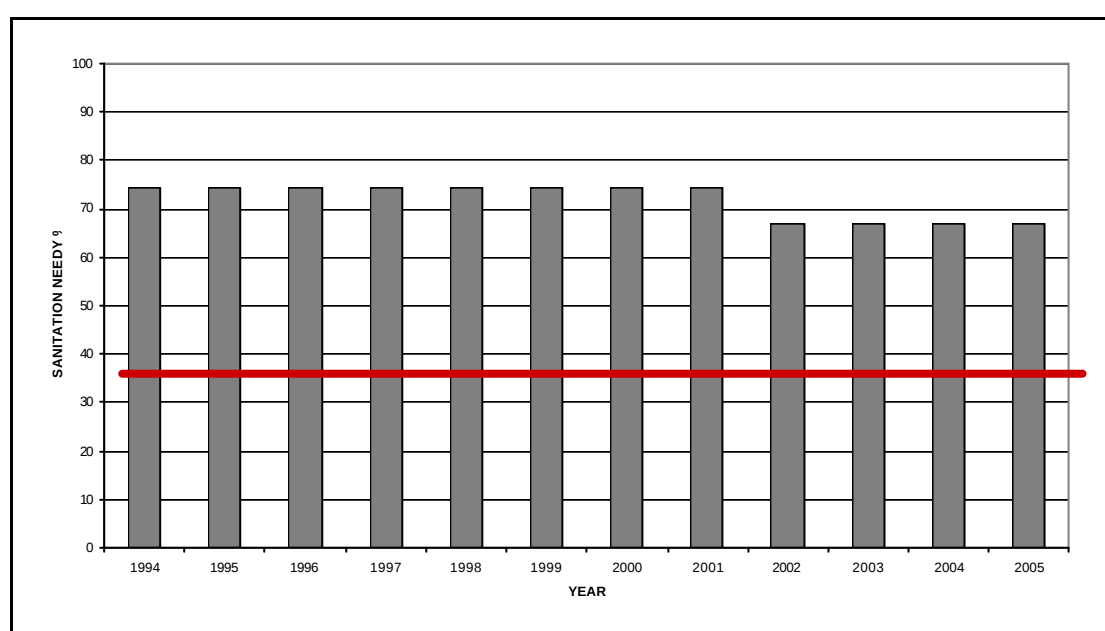


Figure 1: Percentage of sanitation needy persons in the Mhlathuze catchment (data supplied by Directorate of Water Services, DWAF). Horizontal line represents the national average.

9. Conclusions and Recommendations

This indicator is currently being regularly used to make important decisions on development of water resources infrastructure and the allocation of water, particularly to rural areas in the catchment. An efficient information management system is in place to monitor and report on its status throughout the country. This is consistent with the government's priority national policy of providing basic services to sanitation needy persons throughout the country. In view of the importance to local, regional, national and international decision-making, this indicator should therefore be a priority core indicator within any indicator set for catchment management.

10. References

Department Of Water Affairs and Forestry (DWAF). 2002b. The Development of a Sanitation Policy and Practice in South Africa. Preliminary Draft Paper. DWAF, Pretoria. 13 pp. <http://www.dwaf.co.za>.

8: PERCENTAGE AREA UNDER DIFFERENT ECONOMIC LAND USES		
Economic	Land use change	Driving force

- Definition:** Proportion of land in the catchment under different economic land uses (agriculture, mining, and industry).
- Purpose:** To provide an indication of the dominant economic land uses, specified as agriculture and forestry, mining and industry, in the catchment.
- Relevance to sustainable water resource management:** The land use in a catchment determines the character of the water resource. Certain land uses are beneficial to aquatic ecosystems and thus the water resource (e.g. conservation), others are detrimental (mainly economic land uses). The land use will determine the kind of problems apparent in a catchment (e.g. what type of pollution) and the management options available. The use of this indicator is also important to show changes over time.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Waste generation and management;
 - Population change;
 - Pollution (agricultural runoff; industrial point sources; mine drainage);
 - Water quality (all elements);
 - Sectoral demand for water;
 - Water allocation;
 - Altered ecosystem functioning;
 - Habitat condition, and
 - Economic use value.
- Limitations and potential problems:** Each catchment is unique and a certain land use should not presuppose a problem, but should act as a guide to the possibilities. The impact of specific land uses is also dependent on their actual siting and positioning relative to watercourses and water resource features (e.g. wetlands, reservoirs). There is also a problem on which categories of land use are officially accepted in South Africa as being relevant to water resource management (Deon Marais, personal communication).
- Calculation of indicator:**

Percentage cover for each land use can be calculated using the following equation:

$$SE8_{LU} = A_{LU} / A \times 100$$

Where: $SE8_{LU}$ = Percentage covered by land use
 A_{LU} = Area covered by land use (km²)
 A = Total surface area (km²).

7. Data Collection for the Mhlathuze Catchment

There does not appear to have been any systematic long-term monitoring of the land use patterns within the Mhlathuze catchment. There are figures for forestry and agriculture provided in the studies of Steyl *et al* (2000) and DWA and Mhlathuze Water (2002), but these report on the *status quo* when the studies were done and do not show any historical trend. Information for the land use status in 2002 was obtained from the Department of Environmental Affairs and Tourism who have made use of satellite imagery to provide the project with a “one off” estimate of certain land uses

(Deon Marais, personal communication - see Figure 1). It would be possible for land use estimates to be done routinely, but this would require an ongoing project carried out by an organisation with the capabilities of accessing and processing remote sensing data.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

There are several studies and reports that have provided estimates of land use in the Mhlathuze catchment (see DWAF & Mhlathuze Water 2000; DWAF 2000; Steyl et al 2000). However, it is not possible to provide any detailed analysis of trends in the temporal differences in land use. The estimates provided by DEAT (Figures 1 and 2) indicate that the main land uses are forestry and agriculture (subsistence and formal cultivated land). There is a large area of land (more than 50%) in the catchment that is categorised as “unspecified”, emphasising the rural character of the catchment and also the problem of categorising land use types.

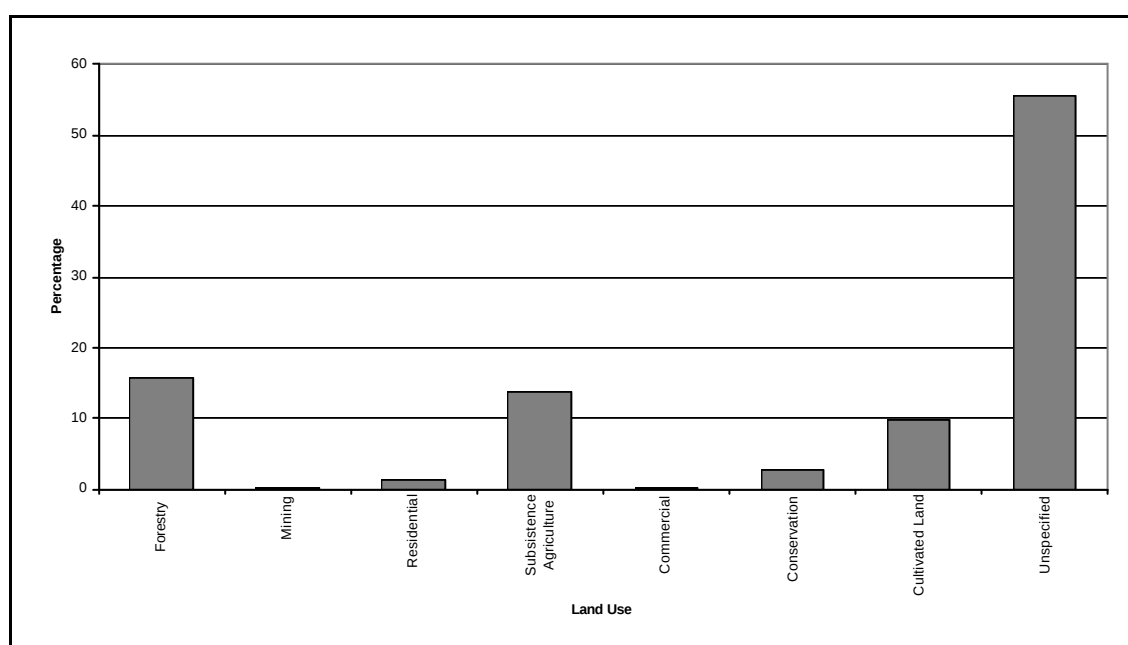


Figure 1: Percentage area of the Mhlathuze catchment under different land use types (information provided by DEAT and based on GIS data for January 1999).

9. Conclusions and Recommendations

This indicator is currently not being monitored on a regular basis, although there have been studies which provide information for specific years on the status quo of land uses which impact on water use. The indicator, as it is now defined (covering all land uses), is possibly too general to be of much value, and might therefore be improved by focusing on land uses that have a more direct impact on water use (e.g. forestry, agriculture, alien vegetation). An indicator that monitors such land use should form part of a core indicator set for catchment assessment.

10. References

Makhanya, E. 1993. The use of SPOT images for mapping rural settlements and land degradation in the less developed areas of South Africa. *ITC Journal* 3: 276-281.

WB1: MEAN VOLUME OF PRECIPITATION ONTO THE CATCHMENT		
Water balance	Climate variability/Catastrophic events	State

- Definition:** Annual precipitation converted to the volume of water falling on the catchment through precipitation ($\text{m}^3 \text{a}^{-1}$).
- Purpose:** To determine the amount of water falling on the catchment, and over time, whether there is short-term variability in the climate; the extent and intensity of dry and wet periods, and the long-term change in climate.
- Relevance to sustainable water resource management:** South Africa is a country that has a high variability in climate (and thus rainfall), not only spatially (dry in the West and wet in the East), but also temporally. The country experiences extremes in both floods and droughts. This is exacerbated by the global problem of climate change. With the long-term change in the climate, it is believed that catastrophic events such as floods and droughts are becoming more common, and therefore of greater concern to water resource managers. Floods and droughts both have severe social and economic implications for the country.
- Linkages:** This indicator may be linked to the following issues:
 - Poverty/vulnerability;
 - Availability of water;
 - Water quality, particularly sediment yield;
 - Altered ecosystem functioning;
 - Biodiversity change, and
 - Habitat condition.
- Limitations and potential problems:** Precipitation is only one aspect of the climate and there are other aspects (e.g. temperature, humidity, evaporation etc.). Precipitation is, however, the main climatic factor that influences the water resource characteristics within a catchment. Assessing the precipitation onto a catchment requires that there should be a suitable network of rainfall stations as a single meteorological station may not provide the full picture for the catchment.
- Calculation of the indicator:**

$$\text{WB1} = \sum_{i=1}^k \text{PE}$$

Where: PE = Amount of rainfall for each precipitation event ($\text{m}^3 \text{a}^{-1}$)
 k = Total number of precipitation events per annum.

7. Data for the Mhlathuze Catchment

There are only five long-term rainfall collection stations within the Mhlathuze catchment (South African Weather Bureau, 2003), and these are inadequate to provide any meaningful integrated measure of the volume of water falling onto the catchment. Rainfall data was obtained for three of the stations and these can, at best, provide an indication of the long-term rainfall variability for points in the catchment.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	0
Confidence	0
Historical record	1
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	2

8. Trends

The trends of precipitation for stations at Melmoth, Richards Bay and Empangeni are given in Figure 1. This shows that rainfall in the area varies both temporally and spatially. Since 1971 annual rainfall has varied between 517mm and 2190mm at the Richards Bay rainfall station, and the coastal area (Richards Bay/Empangeni) receives much more rainfall than the inland area (Melmoth).

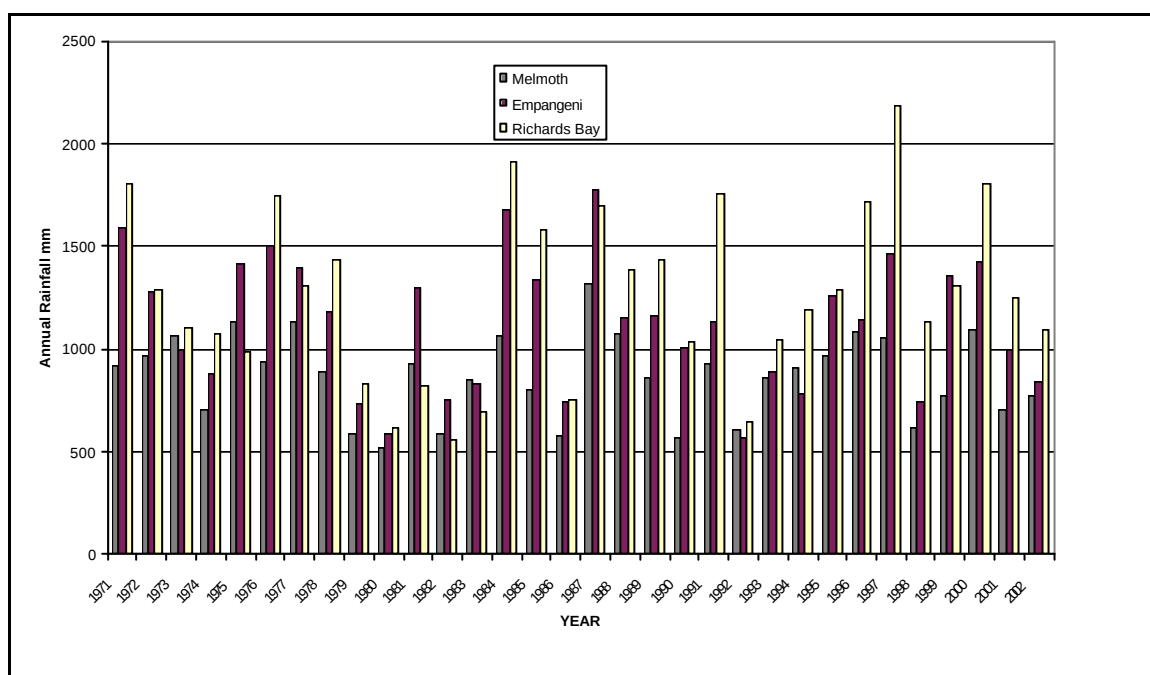


Figure 1: Annual rainfall at three stations in the Mhlathuze catchment.

9. Conclusions and Recommendations

It is highly unlikely that there are sufficient rainfall stations in any catchment for direct rainfall measurements to be used to give meaningful assessments of precipitation volume. This requires fairly sophisticated hydrological modelling for each catchment. This indicator is therefore not an easy one. Consideration should be given to using precipitation as a proxy indicator, which, combined with experience on operational criteria, will provide an indication of what levels of rainfall are required for water resource sustainability within the catchment. In view of the fact that rainfall is the main source of water to the catchment it is essential that this indicator is included in the core set for any catchment.

10. References

Department of Water Affairs and Forestry 2003. Water Resources Situation Assessment. Directorate of Water Resources Planning. Report No: P 06000/00/0101.

WB2: TOTAL WATER AVAILABLE PER CAPITA		
Water balance	Availability of water	State

- 1. Definition:** Amount of water available per person per year from both ground water and surface water resources ($\text{m}^3 \text{ capita}^{-1} \text{ a}^{-1}$).
- 2. Purpose:** To determine whether there is enough water in the catchment to ensure development on a sustainable basis.
- 3. Relevance to sustainable water resource management:** This is an internationally-accepted, basic indicator for water availability, and provides a good indication of the level of development that can be sustained in any catchment. The estimated minimum amount of water required for development is 1 000 $\text{m}^3 \text{ a}^{-1}$ per capita (2 700 l per person per day) according to Glieck (1993, cited by <http://www.cnie.org/pop/pai/water-12.html>). Obviously in catchments in more arid areas where this amount is not available other development strategies need to be developed.
- 4. Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Population change;
 - Inequity;
 - Sectoral water demand;
 - Water allocation;
- 5. Limitations and potential problems:** This indicator is method of assessing the richness of the water resource in comparison to the population, rather like GGP per capita is used to assess the “richness” of the economy. It does not take into account the demand for water nor the level of development of the resource.
- 6. Calculation of the indicator:**

$$\text{Total Water Available} = (\text{AR} + \text{IBT} + \text{GW} + \text{RF}) / P_T$$

Where:

- AR = Annual runoff ($\text{m}^3 \text{ a}^{-1}$)
- GW = Groundwater available ($\text{m}^3 \text{ a}^{-1}$)
- RF = Return flow amount ($\text{m}^3 \text{ a}^{-1}$)
- IBT = Inter-basin transfer volume ($\text{m}^3 \text{ a}^{-1}$)
- P_T = Total catchment population (number).

This indicator has been conceptually revised following discussion with parties. The original indicator utilised MAR, which is not a meaningful reflection of the actual available annual runoff, and did not include provision for groundwater, return flow or interbasin transfer volumes. These components have thus been added to the indicator.

7. Data for the Mhlathuze Catchment

Enquiries with relevant parties and examination of reports have yielded the following aspects relating to this indicator:

- It is not being used by decision-makers and has not been reported on in the recent catchment assessments done by Steyl *et al* (2000) and DWAF and Mhlathuze Water (2002).
- Several requests were made to DWAF and Mhlathuze Water for information on the historical record for annual runoff, groundwater, return flow and interbasin transfer volumes. No information was provided.

- Total catchment population was made available from the DWAF Water Services Information System (see Indicator SE1 of this set).

A rough estimate or ballpark figure can be obtained by dividing the value for the catchment's long-term "Available Yield" value, which is given as 271 million m³ per annum (DWAF and Mhlathuze Water 2002) by the population for a given year. Thus for the year 1996 (using the census population estimate) the total water available per capita was of the order of 708 m³ a⁻¹ per capita, which is below the minimum development level of 1000 m³ a⁻¹ per capita suggested by Gleick (1993). However, the significance of this value can only be assessed by following the long-term trend for the catchment and also by comparing this value with those of other catchments in South Africa. An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion		Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability		1
Cost of data		0
Confidence		1
Historical record		1
Temporal alignment of parameters		0
Spatial quality		0
Frequency of collection		1
Processing time/efficiency		0
Relatability/overlap with other indicators		0
Empirical status		1
	Total Score	5

8. Trends

It is not possible to provide indications of the trend apart from concluding that as population increases in the catchment, then the value will decrease.

9. Conclusions and Recommendations

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. Because of its relationship to per capita and not to water sector users, it is probably of limited use in routine decision-making. It therefore cannot rank as a priority indicator for a core set of catchment indicators. However, it is of concern that the information management system for the Mhlathuze catchment is unable to readily provide the historical record for the hydrological components of the indicator as these are highly relevant for routine decision-making. This confirms the statement by DWAF and Mhlathuze Water (2001) that the hydrological monitoring and reporting system requires upgrading in order to improve the reliability and availability of information.

10. References

DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Main Report. Prepared by consultants BKS (Pty) Ltd and Knight Piésold. DWAF Report No. PB W120-00 0999.

Gleick, P ed. 1993. Water in Crisis: A Guide to the World's Freshwater Resources. New York: Oxford University Press.

WB3: DEMAND AS A PROPORTION OF TOTAL AVAILABLE		
Water balance	Water balance	Pressure

- Definition:** Demand for surface water from all water-use sectors (domestic, mining, agriculture, commercial and industrial) as a proportion of the total available (anthropogenic and natural, %).
- Purpose:** To evaluate whether the current demand for water in the catchment exceeds the supply, or to what extent supply exceeds demand.
- Relevance to sustainable water resource management:** This indicator is an excellent core indicator of water balance. The sustainability of a catchment's water resources is dependent on the supply being greater than the demand. If demand nearing supply, action is required.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Population change;
 - Availability of water;
 - Sectoral water demand;
 - Water allocation;
 - Demand management;
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
- Limitations and potential problems:** Evaluation of demand for various management units can be time consuming, as all sectors have to be taken into account.
- Calculation of the indicator:**

$$WB3 = D / (IBT + RT + AR + GW) \times 100$$

Where:

- D = Total demand ($\text{m}^3 \text{a}^{-1}$)
- IBT = Inter-basin transfer volume ($\text{m}^3 \text{a}^{-1}$)
- RT = Return flow volume ($\text{m}^3 \text{a}^{-1}$)
- AR = Annual runoff ($\text{m}^3 \text{a}^{-1}$).
- GW = Groundwater available ($\text{m}^3 \text{a}^{-1}$)

7. Data for the Mhlathuze Catchment

Enquiries with DWAF and Mhlathuze Water, as well as examination of the recent reports on the catchment (DWAF & Mhlathuze Water 2001, 2002), have indicated that the ongoing estimates of the individual component volumes of this indicator are not reliable. Both DWAF and Mhlathuze Water were asked for information but were not able to provide a historical record of all the components.

A ballpark figure for this indicator can be obtained from the water user demand (estimated by DAWF and Mhlathuze Water (2001) as being $307 \times 10^6 \text{ m}^3 \text{a}^{-1}$ for 2003) and the available yield of the catchment ($271 \times 10^6 \text{ m}^3 \text{a}^{-1}$), which gives a value of approximately 113% indicating a stressed catchment as demand exceeds supply.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	0
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	0
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	0
Empirical status	1
Total Score	7

8. Trends

It is not possible to give any meaningful trend for this indicator because historical data are unavailable. DWAF and Mhlathuze Water (2002) have provided some rough projections of demand and supply, based on the constant figure for available yield and scenario projections of water users.

9. Conclusions and Recommendations

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. It is however, an extremely important indicator as it reflects the degree of water stress in the catchment based on sector water requirements and the available water to satisfy these requirements. It should therefore be included as a core indicator. However, as for other hydrological and water balance indicators within this tested set (see also indicators WB2, WB4, WB5, MN3, MN5, and MN7, it is of concern that the information management system for the Mhlathuze catchment is unable to readily provide the historical record for the hydrological components of the indicator. This confirms the statement by DWAF and Mhlathuze Water (2002) that the hydrological monitoring and reporting system requires upgrading in order to improve the reliability and availability of information.

10. References

- DWAF and Mhlathuze Water 2000 Mhlathuze System Ecological reserve (Quantity) Study. Report No. W120-001199.
- DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Hydrology Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Piésold. DWAF Report No. PB W120-00 0199.
- DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Main Report. Prepared by consultants BKS (Pty) Ltd and Knight Piésold. DWAF Report No. PB W120-00 0999.
- Steyl I, Versfeld D B and P J Nelson 2000 Strategic Environmental Assessment for Water Use: Mhlathuze Catchment. Department of Water Affairs and Forestry. Report No. SEA/ 01-2000.

WB4: PROPORTION OF GROUNDWATER UTILISED		
Water balance	Water balance	Pressure

1. **Definition:** Amount of ground water pumped as a percentage of safe yield (%).
2. **Purpose:** To assess use of water in underground aquifers. It is an assessment of the demand for underground water as a proportion of supply.
3. **Relevance to sustainable water resource management:** Groundwater can be a significant supply of water for domestic and agricultural use. A supply of groundwater where there is little surface water can allow for development where it might not be possible without it. If the demand for ground water is higher than the safe yield (the amount that the aquifer can yield on a sustainable basis), then usage of groundwater in the catchment will not be sustainable. The Mhlathuze catchment has several important groundwater systems that are of concern.
4. **Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Population change;
 - Availability of water;
 - Sectoral water demand, particularly domestic and agricultural;
 - Water allocation;
 - Demand management;
 - Habitat condition;
 - Social viability;
 - Inequity, and
 - Economic use value.
5. **Limitations and potential problems:** The greatest limiting factor at present is the lack of empirical data. It is assumed, with the registration and licensing of boreholes, that this information will become available in future. Additionally, the indicator will only be applicable in catchments with useable groundwater resources.
6. **Calculation of the indicator:**

$$WB4 = Q_p / Y_s \times 100$$

Where: Q_p = Amount of water pumped ($m^3 a^{-1}$)
 Y_s = Safe yield ($m^3 a^{-1}$).

7. Data for the Mhlathuze Catchment

Enquiries with personnel from DWAF and Mhlathuze Water indicated that there was little available information on either the safe yield or the amounts of water pumped from boreholes in the catchment. This was confirmed in discussions with University of Zululand who have conducted several studies in the catchment (Professor Bruce Kelbe, personal communication).

A groundwater study by DWAF and Mhlathuze Water (1999), which only focused on groundwater seepage and availability from the coastal lakes in the catchment, reports that “Due to the low confidence that has been placed on the estimates of the seepage from groundwater to the lakes it was decided to adopt a conservative approach and exclude this contribution when the yield analysis as described in the System Analysis Module Report was carried out. Additional studies are required to

improve the confidence in these particular groundwater models before a firm recommendation can be made with respect to the level of interaction between the groundwater and the lakes”.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to comment on the status of any trend in groundwater usage in the catchment in terms of the defined indicator.

9. Conclusions and Recommendations

In light of the perceived importance of groundwater to water resource management, particularly in the coastal zone of the catchment, it is important that there should be an indicator that monitors and assesses the contribution of groundwater to water usage and water balance. It appears as if the situation is not simply one of monitoring borehole abstractions, but the selection of a suitable indicator (s) for groundwater will require an improved quantitative assessment of the overall role of groundwater in the catchment.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 1999. Mhlathuze Operating Rules and Future Phasing. Groundwater (Coastal Lakes) Hydrology Module Report. Prepared by consultants BKS (Pty) Ltd, Knight Pièsold and the University of Zululand: Department of Hydrology. DWAF Report No. PB W120-00 0399.

WB5: WATER REQUIREMENTS PER SECTOR AS A PERCENTAGE OF TOTAL AVAILABLE

Water balance	Reserve/ International/Strategic/Sectoral Demand	Pressure
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- Definition:** Amount of water of water required for the Reserve, to meet international requirements, for strategic industries and to meet sectoral requirements (domestic, agricultural, industrial, mining and commercial) as a percentage of the total available (%).
- Purpose:** To assess the sectoral requirements for water, and includes the Reserve, international demands and the requirements of strategic industries (Eskom), as well as other sectors.
- Relevance to sustainable water resource management:** The National Water Act recognised four categories of water users in order of preference of water allocation, namely the Reserve (ecological and basic human needs), international water requirements (according to international agreements), strategic industries (such as electricity production) and other user sectors, such as mining, agriculture etc. The type of development in any catchment will determine the water use and availability, as well as influencing the characteristics of the catchment. These all impact on the water resource management approach in a catchment.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Population change;
 - Availability of water;
 - Water allocation;
 - Demand management;
 - Inequity, and
- Limitations and potential problems:** The water requirements of a sector are catered for by the water allocation process. However, the amount of water used might not be the same as that allocated. The closer the actual use is to the amount allocated the more accurate this indicator will be. There is also the technical problem of determining the actual amount of water that is available in the catchment.
- Calculation of the indicator:**

For each sector, the proportion can be calculated using the following equation:

$$WB5 = Q_R / (IBT + RT + AR + GW) \times 100$$

Where:

- Q_R = Water requirement for the sector ($m^3 a^{-1}$)
- IBT = Inter-basin transfer volume ($m^3 a^{-1}$)
- RT = Return flow volume ($m^3 a^{-1}$)
- AR = Annual runoff ($m^3 a^{-1}$).
- GW = Groundwater available ($m^3 a^{-1}$)

This indicator has been revised to improve the constituent variables to make it more meaningful both conceptually and dynamically. This has included the changing of Mean Annual Runoff (MAR), which is a constant, to Annual Runoff (AR), and including groundwater (GW) which was omitted.

7. Data for the Mhlathuze Catchment

Enquiries with DWAF and Mhlathuze Water, as well as examination of the recent reports on the catchment (DWAF & Mhlathuze Water 2001, 2002), have indicated that the ongoing estimates of the

individual component volumes of this indicator are either not available or not reliable. Both DWAF and Mhlathuze Water were requested for information, but were not able to provide a historical record of all the components. Consequently it is not possible to estimate the indicator. The status of this indicator is very similar to that of WB3 and MN3 (see discussion for MN3).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

Because of the lack of information for the various constituent variables, it is not possible to provide any reliable historical values for the indicator.

9. Conclusions and Recommendations

This indicator, which is made up of several water balance components, is exceedingly difficult to estimate because of its dependency on the status of the hydrological monitoring within the catchment. It is however, an extremely important indicator as, like indicators WB3 and MN3, it reflects the degree of water stress in the catchment based on sector water requirements and the available water to satisfy these requirements. It should therefore be included as a core indicator. However, there is a need to consolidate these indicators (WB3, WB5 and MN3), which are variants on the same theme. There is no doubt that there is a need to monitor the supply of water and to balance it with demand, as well as to assess the efficiency of the allocation process. It is felt that consolidation of the three indicators could consider the following:

1. An indicator that monitors actual supply in relation to the long-term available yield – thus showing how the catchment has deviated from the long-term. This is a water balance indicator.
2. An indicator that assesses sector usage in relation to the actual supply. This is a water balance indicator.
3. An indicator that assesses usage against the planned or agreed allocation, which is a management indicator.

In the case of the first two of the proposed indicators there is a need to improve the hydrological monitoring information management system for the Mhlathuze catchment, which is currently unable to readily provide the reliable values for the hydrological components of the indicators.

10. References

DWAF and Mhlathuze Water 2000 Mhlathuze System Ecological reserve (Quantity) Study. Report No. W120-001199.

DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Hydrology Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0199.

DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Main Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0999.

Steyl I, Versfeld D B and P J Nelson 2000 Strategic Environmental Assessment for Water Use: Mhlathuze Catchment. Department of Water Affairs and Forestry. Report No. SEA/ 01-2000.

WP1: AMOUNT OF SOLID WASTE GENERATED PER SQUARE KILOMETER		
Waste and pollution	Waste generation	Driving force

- Definition:** Amount of solid waste generated per square kilometre of catchment per year (tonnes km⁻² a⁻¹).
- Purpose:** To assess the pollution potential of the population and to provide an indication of the consumption of resources within the catchment. It also provides an indication of the sustainability of lifestyles within the catchment.
- Relevance to sustainable water resource management:** Waste is an inevitable consequence of development and must be systematically managed in order to conserve resources and protect the environment. Solid waste production increases annually due to population growth, inadequate services and non-sustainable lifestyles. Waste that is not disposed of properly may have adverse effects on ecosystem functioning and human health, and it is viewed as a major pollution threat to both surface and groundwater resources due to seepage from landfills and other waste disposal sites.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Population change;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
 - Water-borne diseases;
 - Inequity;
 - Water allocation;
- Limitations and potential problems:** The indicator provides an indication of consumption patterns, waste management requirements and lifestyle patterns, but gives no indication on the amount of waste reaching the water resources. It provides an estimate on the potential to pollute rather than the actual amount of pollution. In catchments with a large proportion of rural area it will be difficult to assess the waste that is generated because it is unlikely that such waste is collected in any formal way.
- Calculation of the indicator:**

$$WP1 = W_G / A$$

Where: W_G = Solid waste generated (tonnes a⁻¹).
 A = Total surface area (km²).

7. Data for the Mhlathuze Catchment

Enquiries with personnel in the DWAF Durban Regional Office (responsible for authorising waste dumpsites in the catchment) reveal that there are no readily available historical data on the annual quantity of solid waste that is generated in the catchment. The Department was only able to provide a list of the currently operating authorised landfill sites with approximate tonnages and volumes (see Table 1). On the basis of the available information, it is not possible to make any meaningful estimate of this indicator.

Table 1: List of currently operating landfill sites in Mhlathuze Catchment			
Municipality site/ Industry site	%Domestic, garden, industrial, de-listed waste	Tonnage/annum	Contact Details
Melmoth Dump Site (Mthonjeni Municipality)	60% Domestic, 30% Garden 10% Building rubble	± 6240 m ³ / annum	Herman de Waal (0836316501), Fax 035-450 3224
Inkandla Dump Site (Inkandla Municipality)		1 ton/annum	Mr. M.E. Ngonyama (035-8330067), Fax 035 833 0920
Alton Solid Site (City of Mhlathuze Municipality)		150,000 tons/annum	A.S. Steffens (035-901 5444)
Mondi Solid Waste site-Kwa Mbonambi	Organic waste papers, tins, scrap metals, plastics	• Mangwe sites - 144 tons/annum • Fairbreeze - 100 tons/annum	Tim Holm

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 2.

Table 2: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	1
Confidence	1
Historical record	0
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	0
Processing time/efficiency	1
Relatability/overlap with other indicators	0
Empirical status	1
Total Score	7

8. Trends

It is not possible to provide any comment on any trend in the generation of solid waste in the catchment.

9. Conclusions and Recommendations

This indicator suffers from the inherent problem that the conventional method for estimating the amount of waste that is generated is done by assessing the waste that is received at official dumpsites. Thus estimates are dependent on the records that are kept of the amounts received at the authorised dumpsites. In the case of the Mhlathuze catchment it is evident that there is not a good record of these amounts. In addition there is a high proportion of rural area where there is no waste collection. In

view of these critical deficiencies, as well as the fact that it is not possible to assess the actual impact of any of the dumpsites on water resources, it is felt that this indicator is not a critical one to be included in a set of core indicators for catchment assessment.

If the indicator is important for any specific catchment then it should be reformulated to measure the amount of waste that is “disposed of” rather than the amount generated.

10. References

Department of Water Affairs and Forestry 1998 Minimum Requirements for the Management of Solid Waste. Pretoria.

WP2: PROPORTION OF SOLID WASTE GENERATED PER SECTOR		
Waste and pollution	Generation of waste	Driving force

- Definition:** Proportion of solid waste generated per sector per year (%).
- Purpose:** To determine the contribution of each sector (industry and commercial, agriculture and forestry, mining and domestic) to waste generation in the catchment.
- Relevance to sustainable water resource management:** Solid waste has a high potential to contribute to contamination of surface- and groundwater resources. The type of solid waste generated in a catchment is dependent on the activities in the catchment. Some waste is more benign than others, whilst some requires stricter controls and management (e.g. hazardous waste). A catchment that has high industrial activity is likely to generate more waste, and this indicator should be seen as complementary to the previous indicator (WP1: Amount of waste generated per km²). It also provides a measure of the need to devote resources and attention to waste management.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Population change;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
 - Water-borne diseases, and
 - Economic use value.
- Limitations and potential problems:** The indicator provides an idea of the type of pollution problems that might be experienced in the catchment, but gives no indication on the amount of waste reaching the water resources. It provides an estimate on the potential to pollute rather than the actual amount of pollution. It requires that there should be a good record of all the solid waste that is generated by the different sectors. As part of routine general environmental management, many industries sectors are required to dispose of solid waste in an appropriate way, meaning that any waste generated by an industry never leaves the site of its generation.

6. Calculation of the indicator:

For each sector, the proportion can be calculated using the following equation:

$$WP2 = W_S / W_T \times 100$$

Where: W_S = Solid waste produced by the sector (tonnes a⁻¹)
 W_T = Total amount of solid waste produced by the sector (tonnes a⁻¹).

7. Data for the Mhlathuze Catchment

Enquiries with personnel in the DWAF Durban Regional Office (responsible for authorising solid waste dumpsites in the catchment) reveal that there are no readily available historical data on the annual quantities of solid waste that are generated by the different sectors in the catchment (see

comments on data for indicator WP1). On the basis of the available information, it is not possible to make any meaningful estimate of the waste generated per sector. An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

It is not possible to provide any comment on any trend in the generation of solid waste in the catchment.

9. Conclusions and Recommendations

This indicator requires a record of all of the solid waste generated by all of the sectors, even though the waste might have no impact on water resources. There is no available database or record of the waste amounts generated by the Mhlathuze sectors. In addition, this indicator is not currently being monitored or used for water resource decision-making. Consequently, it is felt that this indicator is not a critical one to be included in a core set for catchment assessment.

If the indicator is important for any specific catchment then it should be reformulated to measure the amount of waste that is “disposed” by the sectors rather than the amount generated.

10. References

Department of Environmental Affairs and Tourism 2003. Programme for the implementation of the national waste management strategy. www.environment.gov.za/

WP3: LIQUID WASTE DISCHARGED FROM POINT SOURCES AS A PROPORTION OF TOTAL WATER AVAILABLE		
Waste and pollution	Pollution	Pressure

- 1. Definition:** Amount of water entering the water resource from point sources of pollution as a proportion of total water available (%).
- 2. Purpose:** This indicator assesses the contribution of point sources to pollution in the catchment.
- 3. Relevance to sustainable water resource management:** Generation of liquid waste is an indicator of the level of the economic and domestic activity in an area. The amount of effluent discharged thus depends on industrial processes, as well as population size. Obviously the more liquid waste there is, the greater the cause for concern with regard to the assimilative capacity of the receiving system. If the amount of effluent generated is equal to a high proportion of the natural flow, there will be negative implications for the assimilative capacity of the receiving system.
- 4. Linkages:** This indicator may be linked to the following issues:
 - Human settlement
 - Population change;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
 - Water-borne diseases, and
 - Economic use value.
- 5. Limitations and potential problems:** For this indicator, it is assumed that point sources of pollution are synonymous with return flows. Thus return flows that, for instance, are relatively unpolluted are included with those that are not.

Industrial and domestic effluents differ in character and the way in which they are treated. The effects they have on the natural system also differ in character and impact. This indicator does not differentiate between the two.

In the case of the Mhlathuze catchment, which has access to the ocean, many industries are given permits to discharge their liquid wastes into the ocean environment, and such discharges therefore do not form part of the return flow volume, which is normally experienced in inland catchments.

6. Calculating the indicator:

$$WP3 = RT / (IBT + RT + AR + GW) \times 100$$

Where: IBT = Inter-basin transfer volume ($\text{m}^3 \text{a}^{-1}$)
 RT = Return flow volume ($\text{m}^3 \text{a}^{-1}$)
 AR = Annual runoff ($\text{m}^3 \text{a}^{-1}$)
 GW = Groundwater available ($\text{m}^3 \text{a}^{-1}$).

The formula for this indicator has been revised from the original so as to include all the components that make up the total available water in the catchment (both conceptually and dynamically). Thus, annual runoff has replaced MAR and groundwater has been added.

7. Data for the Mhlathuze Catchment

Discussions with the personnel from the DWAF Regional Office in KwaZulu-Natal revealed that there is no readily available information on the actual volumes of liquid waste discharged into the rivers of the Mhlathuze catchment. A request was made for a list of permitted discharge sites, their permitted discharge volumes, as well as actual volumes that have been discharged historically. The Regional office was unable to provide this information.

In light of the inherent problems with the hydrological record for estimating total water available, as well as the absence of available information on return flows, it is not possible to provide any estimate for this indicator.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to provide any comment on any trend in the liquid waste discharged from point sources in the catchment.

9. Conclusions and Recommendations

Discharges of liquid waste into watercourses have become an important part of South African water resource management not only because of their pollution impacts, but also because of their contribution to hydrology. This indicator is therefore considered to be an important one that should form part of a core indicator set. It is of particular concern that details on return flow volumes (for which permits are issued and for which details on discharge volumes are specified) are not readily available.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2002. Mhlathuze Operating Rules and Future Phasing. Water Quality Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0699.

WP4: LOADING OF P, N, POPS & TDS FROM AGRICULTURAL RUNOFF		
Waste and pollution	Pollution	Pressure

- Definition:** Loading of phosphorus, nitrogen, persistent organic pollutants and total dissolved solids entering the water system in the catchment from agricultural concerns (tonnes a⁻¹).
- Purpose:** To assess the contribution of agricultural runoff to pollution in the catchment.
- Relevance to sustainable water resource management:** Irrigation farming is considered to be of strategic importance to the socio-economic development of South Africa. However, water pollution is a recognised problem. Pollution is mainly in the form of salinisation and nutrient enrichment of runoff and stored water from irrigated areas, but can also occur in dry-land agriculture where fertilisers are used. Other pollutants in agricultural runoff include pesticides and herbicides that have been used for crop protection.
- Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
 - Water-borne diseases, and
 - Economic use value.
- Limitations and potential problems:** As with any non-point source of pollution, the amount entering the water resource will have to be estimated, probably using modelling techniques. It is highly unlikely that the exact contribution to return flows will be known. Additionally, quality control during data collection and monitoring needs to be ensured.
- Calculating the indicator:**

$$WP4 = V_{AR} \times C_p$$

Where: V_{AR} = Volume of agricultural runoff (m³ a⁻¹)
 C_p = Concentration of the pollutant (mg ℓ⁻¹ or µg ℓ⁻¹).

7. Data for the Mhlathuze Catchment

Discussions were held with staff from the DWAF Regional Office in Durban (Dixon-Paver, personal communication). The opinion was that there was that it would not be possible to make any estimates for this indicator as no data is available.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to provide any comment on any trend in the loading of P, N, POPS and TDS from agricultural runoff.

9. Conclusions and Recommendations

Although it would be desirable to have a measure of the impact of agricultural pollutants, it was felt that it was highly unlikely that technical monitoring of non-point sources is sufficiently developed to be able to yield reliable figures for decision-making purposes. In addition, this indicator calls for too many water quality variables (particularly non-conservative chemicals) and also is expressed as a loading figure that might be insignificant if the catchment was a large one with high volumes of water. For this reason it is felt that this indicator is not one that can be considered to be of high priority for a general catchment indicator set.

10. References

Department of Water Affairs and Forestry (DWAF) 1991 Water quality management policies and strategies in the RSA.

Department of Water Affairs and Forestry (DWAF) 1995 Procedures to assess effluent discharge impacts.

WP5: LOADING OF P & N FROM DENSE SETTLEMENTS		
Waste and pollution	Pollution	Pressure

- Definition:** Loading of phosphorus and nitrogen entering the water system in the catchment from dense settlements (tonnes a⁻¹).
- Purpose:** To assess the contribution of runoff from dense settlements to pollution in the catchment.
- Relevance to sustainable water resource management:** Densely populated human settlements inevitably produce large quantities of waste. This waste, if left unchecked, can pollute rivers, streams and even groundwater resources. These problems are at their worst in the larger more densely populated settlements, many of which are poorly serviced. Unfortunately, many communities in South Africa are still labouring under the burden of an unjust past, and are unable to afford high levels of services, or to maintain those services that have been put in place. In some cases this has lead to severe pollution of nearby surface and groundwater resources, and has impacted on the quality of life in these settlements. This threatens the sustainable use of our water resources (DWAF 1999).
- Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Human settlement;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change;
 - Social viability, and
 - Economic use value.
- Limitations and potential problems:** As with any non-point source of pollution, the amount entering the water resource will have to be estimated, probably using modelling techniques. It is highly unlikely that the exact contribution to return flows will be known. Additionally, quality control during data collection and monitoring needs to be ensured.
- Calculating the indicator:**

$$WP5 = V_{DS} \times C_p$$

Where: V_{DS} = Volume of runoff from dense settlements (m³ a⁻¹)
 C_p = Concentration of the pollutant (mg ℓ⁻¹ or µg ℓ⁻¹).

7. Data for the Mhlathuze Catchment

Discussions were held with staff from the DWAF Regional Office in Durban (Dixon-Paver, personal communication). The opinion was that there was that it would not be possible to make any estimates for this indicator, as no data were available.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to provide any comment on any trend in the loading of P, N, POPS and TDS from agricultural runoff.

9. Conclusions and Recommendations

Although it would be desirable to have a measure of the impact of pollutants from dense settlements, it was felt that it was highly unlikely that technical monitoring of non-point sources is sufficiently developed to be able to yield reliable figures for decision-making purposes. This indicator is expressed as a loading figure that might be insignificant if the catchment was a large one with high volumes of water, and high loadings from other sources. For this reason it is felt that this indicator is not one that can be considered to be of high priority for a general catchment indicator set.

10. References

Department Of Water Affairs And Forestry. 1999. Managing the Water Quality Effects of Settlements: The National Strategy, First Edition. DWAF, Pretoria. 65 pp.

WP6: LOADING OF TDS & SO ₄ FROM MINE DRAINAGE		
Waste and pollution	Pollution	Pressure

- Definition:** Loading of total dissolved solids and sulphate entering the water system in the catchment from mine drainage (tonnes a⁻¹).
- Purpose:** To assess the contribution of mine drainage to pollution in the catchment.
- Relevance to sustainable water resource management:** The mining industry is vital to the economy of South Africa. However, due to the depth of mineral deposits and, therefore, mining activities, mines are generally forced to dewater underground workings and to discharge the mineralised water to the surface sources. This can cause salinisation of surface waters as well as acidification.
- Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Waste management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- Limitations and potential problems:** In some cases, such as closed mines, the amount of mine drainage may not be accurately estimated.
- Calculating the indicator:**

$$WP6 = V_{MD} \times C_p$$

Where: V_{MD} = Volume of mine drainage (m³ a⁻¹)
 C_p = Concentration of the pollutant (mg ℓ⁻¹ or µg ℓ⁻¹).

7. Data for the Mhlathuze Catchment

Discussions were held with staff from the DWAF Regional Office in Durban (Dixon-Paver, personal communication). The opinion is that mining activity in the catchment is not of the type that causes acid mine drainage, therefore no data were available and indicator is irrelevant for the Mhlathuze. It is therefore not possible to provide any estimates for this indicator, as no data was available.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to provide any comment on any trend in the loading of TDS and sulphate from mine drainage.

9. Conclusions and Recommendations

This indicator is more specific for catchments which have a high level of mining activities that cause acid mine drainage (e.g. coal mining and gold mining). In such catchments it will be important to have an estimate of the loading due to acid mine drainage. The indicator is expressed as a loading figure that might be insignificant if the catchment is a large one with high volumes of water, and high loadings from other sources. Therefore, in order to assess the significance, water resource managers will also need to know the total loading of TDS and sulphate from other sources. For these reasons it is felt that this indicator is not one that can be considered to be of high priority for a countrywide general catchment indicator set. It should rather be one that is used in specific catchments where mining is suspected to have a significant impact.

10. References

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP7: CONDUCTIVITY AT THE LOWEST POINT IN THE GEOGRAPHICAL CATCHMENT		
Waste and pollution	Salinisation	State

- 1. Definition:** Median conductivity of the water exiting the catchment, measured over a year (mS m^{-1}).
- 2. Purpose:** This indicator is a measure of the dissolved inorganic salts in the water. The downstream point has been chosen as being representative of the sum of all activities in the catchment.
- 3. Relevance to sustainable water resource management:** Although dissolved salts occur naturally to varying degrees in aquatic systems, human activities in a catchment may severely increase the levels. Typical effluents, which have an effect on conductivity, are saline industrial effluents, agricultural runoff and acid mine water. Although increases in conductivity may not have a large influence on aquatic fauna, the level of salinity in the water may have other, more significant economic effects for other users (e.g. water treatment and domestic users).
- 4. Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- 5. Limitations and potential problems:** The downstream point has been chosen as a reflection of all the activities in the catchment. This not only includes polluting activities, but also the natural clean-up processes of the ecosystem. It is, therefore, not only an indicator of pollution, but also all activities in the catchment.
- 6. Calculation of the indicator:** Conductivity measured at the downstream point over a year can be analysed to provide the median value, which can be used for comparative purposes. The statistical median is the middle number of the conductivity values that have been arranged in order by size. If there is an even number of values, the median is the mean of the two middle numbers.

7. Data for the Mhlathuze Catchment

The DWAF monitoring network has station W1HO32 in subcatchment W12F as its lowest water quality monitoring point. Water quality data has been collected monthly at this station since September 1999. Conductivity data were readily obtained on request from the water quality database at the DWAF Water Quality Institute at Roodeplaat (Ms M. Erasmus).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	2
Historical record	1
Temporal alignment of parameters	2
Spatial quality	1
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	0
Empirical status	2
Total Score	16

8. Trends

There is only a short record for conductivity values at this station (see Table 2) making it impossible to comment on any long-term trend. Available values provided by DWAF are given as mean values and not median, however median values can be calculated from the base data, which unfortunately were not available for this study.

Table 2: Mean conductivity values for station W1HO32 on the Mhlathuze River.

<u>Year</u>	<u>Mean Conductivity</u> <u>mS m⁻¹</u>
1999	64.7
2000	47.6
2001	58.3
2002	45.3
2003 to date	46.3

9. Conclusions and Recommendations

This indicator is a useful one for keeping a check on the general dissolved mineral content of the water that flows out of a catchment, thus providing a useful early warning signal for deterioration in water quality. It therefore merits inclusion in any core set of catchment indicators. The indicator is being monitored and data is readily available.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2002. Mhlathuze Operating Rules and Future Phasing. Water Quality Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0699.

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP8: P & N CONCENTRATIONS AT THE LOWEST POINT IN THE GEOGRAPHICAL CATCHMENT		
Waste and Pollution	Eutrophication	Impact

- Definition:** Mean phosphorus and nitrogen concentrations at the downstream point, measured over a year ($\text{mg } \ell^{-1}$).
- Purpose:** To provide an indication of eutrophication or nutrient enrichment in the catchment.
- Relevance to sustainable water resource management:** Eutrophication, or enrichment of water systems by plant nutrients, is a world-wide water quality problem. It has far-reaching economic and social costs, and is the single largest problem for South African water resource managers. Anthropogenic activities in a catchment increase phosphate and nitrogen levels in surface waters and the suitability of surface water for various uses is severely affected by eutrophication (with toxic algae, excessive macrophyte growth, odours, taste and blocked filters are common problems). Ecosystems are also severely affected due to anoxic conditions, increased turbidity and toxic algae.
- Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- Limitations and potential problems:** Although P & N are indicators of the nutrient enrichment in a catchment, eutrophication is also affected by other factors, such as temperature and light penetration in a water body. P & N alone, therefore, do not reflect the true extent of the water quality problems. In addition, there are problems associated with which are the forms of P & N which best reflect eutrophication status.
- Calculation of the indicator:** Standard methods are used to determine N and P concentrations ($\text{mg } \ell^{-1}$).

The mean annual concentration for each parameter is calculated as:

$$\text{WP8} = \left(\sum_{i=1}^k C \right) / k$$

Where: C = Concentration of nutrient ($\text{mg } \ell^{-1}$)
k = Total number of samples per annum.

7. Data for the Mhlathuze Catchment

The DWAF monitoring network has station W1HO32 in subcatchment W12F as its lowest water quality monitoring point. Water quality data has been collected monthly at this station since September 1999. Data for both P (orthophosphate) and N (total inorganic) were readily obtained on request from the water quality database at the DWAF Water Quality Institute at Roodeplaat (Ms M Erasmus).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	15

8. Trends

There is only a short record for N & P values at this station (see Table 2) making it impossible to comment on any long-term trend.

Table 2: Mean N & P concentration values for station W1HO32 on the Mhlathuze River.

<u>Year</u>	<u>Mean Ortho-Phosphorus</u> <u>Mg/l</u>	<u>Mean Total Dissolved</u> <u>Nitrogen</u> <u>Mg/l</u>
1999	0.335	0.023
2000	0.337	0.031
2001	0.297	0.029
2002	0.332	0.027
2003 to date	0.304	0.025

9. Conclusions and Recommendations

This indicator is a useful one for keeping a check on the general nutrient content of the water that flows out of a catchment, thus providing a useful early warning signal for deterioration in water quality and for potential eutrophication problems. It therefore merits inclusion in any core set of catchment indicators. The indicator is being monitored (although not actually measuring total P & N) and data are readily available.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2002. Mhlathuze Operating Rules and Future Phasing. Water Quality Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Piësold. DWAF Report No. **PB W120-00 0699**.

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP9: FAECAL COLIFORMS IN THE MAJOR WATER RESOURCE FOR DOMESTIC AND RECREATIONAL USE		
Waste and pollution	Microbiological contamination	State

- 1. Definition:** Proportion of time that the concentration of faecal coliforms in the major water resource for domestic and recreational use, measured over a year (number per 100mℓ) exceeds guideline values.
- 2. Purpose:** To measure the microbiological contamination of the major drinking water and recreational resource in the catchment, particularly due to untreated sewage.
- 3. Relevance to sustainable water resource management:** The indicator provides a measure of the effectiveness of sanitation practices in the area above the receiving water body, as well as potential health risks for recreational users. Although most sewage is sent to water care works for purification before it enters the water resource, in areas where sanitation facilities are not available raw sewage may present a problem. Occasionally, sewage may overflow from a water care works due to a capacity overload or a breakdown in treatment facilities. A high level of organic enrichment leads to high treatment costs for potable water, as well as potential health risks in a catchment.
- 4. Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Poverty/vulnerability;
 - Population change;
 - Inequity;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change,
 - Water-borne diseases, and
 - Economic use value.
- 5. Limitations and potential problems:** The major water supply reservoir has been chosen as a reflection of the activities in the catchment. In cases where the geographical catchment is not defined as the catchment for the major dam, this might provide problems with comparisons to other water quality indicators.
- 6. Calculation of the indicator:**

WP9 = % of time that faecal coliform count exceeds recreational/domestic guidelines.

7. Data for the Mhlathuze Catchment

Contact was made with Mhlathuze Water and it was established that the organisation does not monitor faecal coliforms in the Goedertrouw Dam, the major water resource for domestic water supply (Vic Botes, personal communication). The organisation does however monitor faecal coliforms in treated water prior to distribution to domestic users.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to comment on any of the trends for this indicator.

10. Conclusions and Recommendations

This indicator is a useful one for keeping a check on the general health condition of water in the main storage reservoir. It merits inclusion in any core set of catchment indicators only if the public have access to the particular water body and there is a need to have an indication of potential health risks. It is not a difficult indicator to measure and monitor.

10. References

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP10: DAPHNIA TOXICITY TEST AT THE LOWEST POINT IN THE GEOGRAPHICAL CATCHMENT		
Waste and Pollution	Harmful toxic substances	State

- Definition:** Toxicity test for the survival of *Daphnia* sp. at the lowest point in the geographical catchment (% lethality after 48 hours).
- Purpose:** To determine whether there are any toxic elements present in the water at the lowest point in the geographical catchment, as an indicator of the sum of all activities in the catchment.
- Relevance to sustainable water resource management:** One of the major problems caused by industrial pollutants is the introduction of trace metals into freshwater ecosystems. Many of these have toxic effects on the natural fauna (Be, Co, Ni, Cu, Zn, Sn, As, Se, Te, Pd, Ag, Cd, Pt, Au, Hg, Tl, Pb, Sb and Bi) and can be concentrated up the food chain to present a health hazard to humans and higher order animals. They require strict management and a policy of pollution abatement generally applies to these elements. The toxicity effects of water at the downstream point will provide a good indication of whether abatement in the catchment has been effective or not.
- Linkages:** This indicator may be linked to the following issues:
 - Land use change;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Water-borne diseases;
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- Limitations and potential problems:** No one test can satisfy a comprehensive coverage of all toxic effects, and the *Daphnia* toxicity test is only an indicator of possible problems.

The downstream point has been chosen as a reflection of all the activities in the catchment. This not only includes polluting activities, but also the natural clean-up processes of the ecosystem. It is, therefore, not only an indicator of pollution, but also all activities in the catchment.

- Calculation of the indicator:** The acute 48-hour definitive toxicity test will be used for this indicator. The methodology for this test is documented in detail in EPA (1985). The final results are presented as % lethality after 48 hours.

Mean annual average is calculated as:

$$WP10 = \left(\sum_{i=1}^k L_{48} \right) / k$$

Where: L_{48} = Lethality after 48 hours (%)
 k = Total number of samples per annum.

7. Data for the Mhlathuze Catchment

Contact was made with Mhlathuze Water and it was established that the organisation does not monitor toxicity in the Mhlathuze River. There is therefore no information or data available for this indicator.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Table 1: Summary Evaluation of the Indicator		
Criterion		Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability		0
Cost of obtaining data		0
Confidence		0
Historical record		0
Temporal alignment of parameters		0
Spatial quality		0
Frequency of collection		0
Processing time/efficiency		0
Relatability/overlap with other indicators		0
Empirical status		0
	Total Score	0

8. Trends

It is not possible to comment on any trend for this indicator.

9. Conclusions and Recommendations

This indicator is a useful one for monitoring the general health condition of water with respect to toxicity to invertebrate organisms, especially if it is suspected that there are potentially toxic discharges occurring upstream. It is not a difficult or expensive test to carry out. However it is felt that it does not merit inclusion as a priority indicator. It is the felt that it merits inclusion only if it is suspected that toxic discharges are impacting on the water resource.

10. References

Environmental Protection Agency. 1985. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. EPA/600/4-85/013, Environmental and Support Laboratory, Office of Research and Development, US EPA, Cincinnati.

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP 11: TURBIDITY AT THE LOWEST POINT IN THE GEOGRAPHICAL CATCHMENT OR THE INFLOW TO THE MAIN RESERVOIR		
Resource condition	Sedimentation	State

- Definition:** Turbidity of the water at either the lowest point in the geographical catchment or at the inflow to the main reservoir (NTU).
- Purpose:** To provide an indication of sediment yield and change in sediment yield due to land uses in the catchment.
- Relevance to sustainable water resource management:** Large quantities of sediment are carried downstream in South Africa's rivers each year. In many cases, anthropogenic activities have increased erosion in the catchment, with the result that more sediment enters the rivers each year. However, much sediment is also deposited in reservoirs causing a loss in storage capacity. The net effect of all catchment activities on sediment yield will be apparent at the downstream point.
- Linkages:** This indicator may be linked to the following issues:
 - Climate and catastrophic events;
 - Human settlement;
 - Population change;
 - Land use change;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- Limitations and potential problems:** This indicator is not detailed enough to provide the full picture with regards to sedimentation and sediment yield within the catchment. If erosion increases at the top of the catchment, the sedimentation in reservoirs may increase, without a significant change occurring at the downstream point. Turbidity is also affected by other factors, such as the presence of algal blooms.
- Calculation of the indicator:**

Turbidity measured at the downstream point over a year can be analysed to provide the median value, which can be used for comparative purposes. The statistical median is the middle number of the turbidity values that have been arranged in order by size. If there is an even number of values, the median is the mean of the two middle numbers.

7. Data for the Mhlathuze Catchment

The DWAF national monitoring network has station W1HO32 in subcatchment W12F as its lowest water quality monitoring point and water quality data has been collected monthly at this station since September 1999. Data for turbidity were readily obtained on request from the water quality database at the DWAF Water Quality Institute at Roodeplaat (Ms M Erasmus). Turbidity has only been included as a fortnightly water quality variable at this station since March 2003 (meaning that at the time of request only 6 values were received).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	1
Historical record	0
Temporal alignment of parameters	2
Spatial quality	1
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	0
Empirical status	2
Total Score	14

8. Trends

As there were only six values for turbidity covering a three-month period it is not possible to show any meaningful trend for this indicator. Turbidity values are not exceptionally high and indicate relatively low quantities of suspended material (Table 2).

Table 2: Turbidity values at station

<u>Date</u>	<u>Turbidity (NTU)</u>
4 th March 2003	15.4
18 th March 2003	23
1 st April 2003	10.8
15 th April 2003	40.2
6 th May 2003	13.1
20 th May 2003	8.7

9. Conclusions and Recommendations

This indicator is a useful one for assessing the relative amounts of suspended material in the water and giving an indication of potential erosion and (or) the impacts of turbid waste discharges. It is not a difficult or expensive test to carry out. It is felt that it merits inclusion in a long-term core indicator set.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2002. Mhlathuze Operating Rules and Future Phasing. Water Quality Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. **PB W120-00 0699**.

Department Of Water Affairs And Forestry (DWAF). 1996. South African Water Quality Guidelines. Volumes 1-6. DWAF, Pretoria.

WP12: PROPORTION OF BOREHOLES CONTAMINATED		
Waste and Pollution	Well head protection/ Groundwater quality	State

- Definition:** Proportion of boreholes contaminated by water of poor quality to the extent that they are unusable for domestic or agricultural use (%). A well is considered contaminated if one of the following apply (DWAF 1996):
 - $EC > 450 \text{ mS m}^{-1}$
 - Total coliforms $> 5/100\text{ml}$
 - $N > 10 \text{ mg l}^{-1}$.
- Purpose:** To determine the extent of underground water contaminated by pollutants, and the success of well-head protection policies.
- Relevance to sustainable water resource management:** Groundwater supplies are particularly important in more arid areas of South Africa. In some areas ground water is almost the sole water supply. If these water sources become contaminated future development will be negatively affected. One of the problems facing water resource managers is the protection of well-heads, particularly from the watering of livestock. Other influences on groundwater quality are seepage from landfills, mine water drainage and agricultural seepage.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Population change;
 - Land use change;
 - Pollution (all types);
 - Water quality (eutrophication, salinity, harmful toxic substances and microbiological contamination);
 - Social viability;
 - Inequitable access to services;
 - Habitat condition, and
 - Economic use value.
- Limitations and potential problems:** Currently the definition of “contaminated” is based on the DWAF Water Quality Guidelines for domestic use. These are more stringent than those for agricultural use. The level at which a borehole is contaminated should be determined according to its use.
- Calculation of the indicator:**

$$WP12 = W_C / W_T \times 100$$

Where: W_C = Number of boreholes in the catchment that are contaminated
 W_T = Total number of boreholes in the catchment.

7. Data for the Mhlathuze Catchment

Water quality data for registered boreholes in the Mhlathuze catchment were obtained from DWAF in Pretoria (Mr E Bertram). There are 1136 boreholes from this catchment on the DWAF database and some of these have been rated according to their potability (but not based on their level of contamination as defined for this indicator). For some of these boreholes there are once off analyses for nitrate and conductivity. The available information thus does not allow for any estimation to be made of the degree of contamination of boreholes or for any changes in contamination over time.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

On the basis of the available information it is not possible to describe any trend in borehole contamination.

9. Conclusions and Recommendations

Groundwater is a water resource that could have increasing importance in terms of augmenting the supply of surface water. It is therefore important that groundwater sources be monitored and assessed, particularly in terms of contamination that affects fitness for use. This indicator thus merits inclusion within the set of core indicators. There is a need to upgrade the monitoring system for groundwater in the Mhlathuze catchment.

10. References

Department Of Water Affairs and Forestry (DWAF). 1996. South African Water Quality Guidelines. Volume 1: Domestic Use. DWAF, Pretoria.

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 1999. Mhlathuze Operating Rules and Future Phasing. Groundwater (Coastal Lakes) Hydrology Module Report. Prepared by consultants BKS (Pty) Ltd, Knight Pièsold and the University of Zululand: Department of Hydrology. DWAF Report No. PB W120-00 0399

RC1: PERCENTAGE CATCHMENT AREA COVERED BY NATURAL VEGETATION AND BY ALIEN VEGETATION		
Resource condition	Land use/Habitat condition	State

- Definition:** Proportion of land in the catchment covered by natural vegetation and proportion of land in the catchment covered by alien vegetation (%).
- Purpose:** To provide an indication of the extent of natural habitat in the catchment, as well as the green areas dominated by alien vegetation (including forestry);
- Relevance:** The land use in a catchment determines the character of the water resource. Certain land uses are beneficial to aquatic ecosystems and thus the water resource (e.g. natural green areas), others are detrimental (areas dominated by alien vegetation). Resource condition is affected by the level of human activity in the catchment. The higher the proportion of natural green areas, the less impacted the water resource is likely to be. High levels of alien invasion might affect the amount of water available in the catchment, as well as damaging the ecosystem integrity of the catchment.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land use change;
 - Availability of water;
 - Altered ecosystem functioning;
 - Habitat condition;
 - Biodiversity change, and
 - Economic use value.
- Limitations and potential problems:** Much of the land use information available in South Africa is derived from satellite imagery. Unless groundtruthing has been done, it is difficult to accurately differentiate between natural and alien vegetation.
- Calculation of the indicator:**

Percentage cover for each land use can be calculated using the following equation:

$$RC1_{VT} = A_{VT} / A \times 100$$

Where: $RC1_{VT}$ = Percentage covered by vegetation type
 A_{VT} = Area covered by land use (km²)
 A = Total surface area (km²)

7. Data for the Mhlathuze Catchment

The status of this indicator is rather similar to that of the other indicator in this set (SE8: Percentage land use under different economic land uses) in that changes in land use and alien vegetation have not been monitored on a regular basis, nor done at the level at which natural vegetation can be separated from other land uses. On the basis of the “unspecified” component of the catchment land use (approximately 55%), the proportion of natural vegetation is probably quite high.

Enquiries with the DWAF Working for Water Programme indicate that alien vegetation has not been mapped for the catchment (Kasu Rezaa, personal communication). As part of an investigation into the water operating rules for the catchment, a ballpark rapid assessment was done of the extent of alien vegetation in the catchment during 1999 (DWAF & Mhlathuze Water 2001). The area under

alien vegetation, in the Mhlathuze Catchment, was estimated at 634 km², which has a presumed impact of 92 million m³ per annum on runoff. It is stated in the report of DWAF that “The figures quoted in the report on alien vegetation are not robust and that in order to determine reliable figures for the effect of alien vegetation on the yield from the system, further studies will need to be undertaken. Not only will it be necessary to determine the areas under alien vegetation, but also to define the water used by the various species of the alien vegetation compared to that used by indigenous vegetation. Much field-work would be required over at least one wet season making it unlikely that reasonable figures could be obtained in less than a year”.

On the basis of the available information it can be surmised that the proportion of the catchment under natural vegetation could be as high as 50% and that the proportion occupied by alien vegetation is of the order of 15%.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

On the basis of the available information it is not possible to provide any indication of trends in natural vegetation cover and only a rough assessment can be given of the extent of alien vegetation in the Mhlathuze catchment.

9. Conclusions and Recommendations

Vegetation has a significant impact on a landscape as it provides cover that reduces erosion and also impacts on runoff. However, there is a need for this indicator to be simplified to deal with either the issue of land cover or the issue of alien vegetation. In the case of the Mhlathuze catchment, where alien vegetation could be significant it possibly merits the inclusion of two indicators; one which assesses the extent of aliens, and the other which deals with natural vegetation cover (as part of land use). Both indicators would merit inclusion within the set of core indicators. There is an urgent need to introduce vegetation monitoring in this catchment.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Water Demand Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0299

RC2: SOUTH AFRICAN SCORING SYSTEM (SASS) SCORES AT SELECTED SITES		
Resource condition	Biodiversity change/Ecosystem functioning	State

1. **Definition:** Invertebrate fauna measured using the South African Scoring System (SASS and ASPT, average score per taxon) at selected sites within the river system.
2. **Purpose:** To provide an indicator of the health of the river, and the diversity of invertebrate fauna.
3. **Relevance to sustainable water resource management:** Aquatic fauna and flora respond in a predictable manner to changes in the physical and chemical nature of the water. If a water body is polluted or severely degraded, certain sensitive species will be unable to live there, whilst less sensitive species may thrive. Changes in the structure of aquatic invertebrate communities reflect changes in overall river conditions. Invertebrate faunal assemblages, which the SASS system has been designed for, are affected by water quality changes over a relatively short period if compared to fish or vegetation assemblages. They do, however, reflect a longer-term quality than do once-off water samples.
4. **Linkages:** This indicator may be linked to the following issues:
 - Climate and catastrophic events;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (all parameters), and
 - Habitat condition.
5. **Limitations and potential problems:** The SASS system was originally developed as a tool to evaluate water quality. It has since become a tool to determine general river health as the faunal assemblages are also dependent on habitat available, distance downstream and catastrophic events (e.g. floods), but the scoring system still reflects sensitivity to water quality.

In general SASS data should be interpreted in conjunction with other factors that may influence the score (e.g. habitat type). Because of this, the indicator is much more useful as part of a time series for a single site, than a once-off assessment. There is also the problem with site selection as these should be representative of zones that might be impacted by changes in water quality and or disturbance.

6. **Calculation of the indicator:** It is recommended that the standard SASS methodology (currently SASS5) be used to collect the data (see Dickens & Graham 2002). The data collected are presented as the SASS score (as calculated using the standard scoring sheet) and the average score per taxon. Sampling should be during the dry season (e.g. spring and autumn in the summer rainfall areas). The mean value may be used, where two or more samples are taken at a site per annum.

The boundaries defined by Chutter (1998) can be used as a guide for interpreting SASS scores (see Dickens and Graham 2002),

- **For non-acidic streams:**
 - o SASS >100, ASTP >6 water quality natural, habitat diversity high;
 - o SASS <100, ASTP >6 water quality natural, habitat diversity reduced;
 - o SASS >100, ASTP <6 borderline between water quality natural and some deterioration in water quality, interpretation based on extent by which SASS exceeds 100 and ASTP is <6;
 - o SASS 50-100, ASTP <6 some deterioration in water quality;
 - o SASS <50, ASTP variable major deterioration in water quality.

- **For acidic streams**

- o SASS >125, ASTP >7 water quality natural, habitat diversity high;
- o SASS <125, ASTP >7 water quality natural, habitat diversity reduced;
- o SASS >125, ASTP <7 borderline between water quality natural and some deterioration in water quality, interpretation based on extent by which SASS exceeds 125 and ASTP is <7;
- o SASS 60-125, ASTP <7 some deterioration in water quality;
- o SASS <60, ASTP variable major deterioration in water quality.

7. Data for the Mhlathuze Catchment

Communication was made with the national River Health Programme (www.csir.co.za/rhp) and discussions were held with personnel from the Durban Regional Office (Hugh Dixon Paver, personal communication). Contact was made with researchers who have conducted studies in the Mhlathuze catchment (Professor Digby Cyrus, personal communication). The following feedback from Professor Cyrus was obtained:

- There are some data sets, of varying lengths most of which were closed down in 1998, for SASS at selected sites;
- SASS estimates were done in 1996, 1997 and 1998 for about 5 stations as part of the Reserve and RDM studies of DWAF (DWAF and Mhlathuze Water 2002);
- At this point in time without going back to the data bases or the field sheets it is not possible to say for how many sites or for how long each sequence runs for. Some it would at least be for two or more years, some are on a monthly basis and some on a quarterly basis;
- Some of the industries are monitoring SASS in selected river sections where forestry occurs.

SASS has therefore been conducted primarily for the purposes of assessing the Ecological Reserve, and not for the purpose of any long-term monitoring system.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

On the basis of the available information it is not possible to provide any indication of trends in SASS for the Mhlathuze catchment.

9. Conclusions and Recommendations

SASS is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

10. References

Dickens CWS & Graham PW. 2002. The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. *African Journal of Aquatic Science* **27**: 1-10.

Chutter F M 1998. Research on the Rapid Biological Assessment of Water Quality Impacts in Streams and Rivers. WRC Report No. 422/1/98.

Vos P, Wepener, V & Cyrus, D P 2002. Efficiency of the SASS4 rapid bioassessment protocol in determining river health: A case study on the Mhlathuze River, KwaZulu-Natal, South Africa.

RC3: FISH ASSEMBLAGE INTEGRITY INDEX (FAII) IN SELECTED REACHES		
Resource condition	Biodiversity change/Ecosystem functioning	Impact

- 1. Definition:** Ratio of observed fish diversity to diversity that would have been expected in the absence of human impacts (FAII score).
- 2. Purpose:** To assess the change in biodiversity of the river system in the medium- to long- term.
- 3. Relevance to sustainable water resource management:** Fish communities are good indicators of the general condition of a river. They are particularly good medium- to long-term indicators, whilst invertebrates tend to be short-term indicators. If an ecosystem is not functioning properly, changes in fish communities will occur, most often leading to a loss in biotic diversity, ecosystem functioning and rivers health.
- 4. Linkages:** This indicator may be linked to the following issues:
 - Climate and catastrophic events;
 - Water availability;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (all parameters);
 - Habitat condition, and
 - Social viability.
- 5. Limitations and potential problems:** This indicator becomes less effective in a river with naturally poor diversity.
- 6. Calculation of the indicator:** The standard FAII methodology should be used (Kleynhans 1999; <http://www.csir.co.za/rhp> 2002) at selected reaches in the river at yearly intervals.

Interpretation of FAII scores is outlined in Kleynhans (1999) as follows:

- FAII = 90-100 Unmodified, or approximates natural conditions;
- FAII = 80-89 Largely natural with few modifications – a change in community characteristics, but species richness and presence of intolerant species indicate little modification;
- FAII = 60-79 Moderately modified – a lower than expected species richness and presence of most intolerant species; some impairment of health at the lower limit of the class;
- FAII = 40-59 Largely modified – lower than expected species richness and absence or much lowered presence of intolerant species; impairment of health is more evident at the lower limit of the class;
- FAII = 20-39 Seriously modified – a strikingly lower than expected species richness and general absence of intolerant species; impairment of health is evident;
- FAII = 0-19 Critically modified – extremely lowered species richness and absence of intolerant and moderately intolerant species; may have complete loss of species at the lower limit of the class; impairment of health very evident.

7. Data for the Mhlathuze Catchment

Communication was made with the national River Health Programme (www.csir.co.za/rhp) and discussions were held with personnel from the Durban Regional Office (Hugh Dixon Paver, personal communication). Contact was also made with researchers who have conducted studies in the Mhlathuze catchment (Professor Digby Cyrus, personal communication). The following feedback from Professor Cyrus was obtained:

- There are some data sets, of varying lengths most of which were closed down in 1998, for FAII at selected sites;
- Five sites in the river were monitored monthly (April 1996 to March 1997) and four of these again in April & July 1998 for Reserve Determination (DWAF and Mhlathuze Water 2002);
- At this point in time without going back to the data bases or the field sheets it is not possible to say for how many sites or for how long each sequence runs for. Some it would at least be for two or more years, some are on a monthly basis and some on a quarterly basis;

FAII has therefore been conducted primarily for the purposes of assessing the Ecological Reserve, and not for the purpose of any long-term monitoring system.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	1
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	10

8. Trends

On the basis of the available information it is not possible to provide any indication of trends in SASS in the Mhlathuze catchment.

9. Conclusions and Recommendations

FAII is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

10. References

Kleynhans CJ. 1999. Development of a fish index to assess the biological integrity of South African rivers. Water SA 25(3): 265-278.

RC4: INDEX OF HABITAT INTEGRITY (IHI) IN SELECTED REACHES		
Resource condition	Habitat condition/Ecosystem functioning	Impact

- Definition:** Condition of the riparian zone and in-stream habitats in rivers (habitat integrity classes)
- Purpose:** To assess riparian and instream habitat integrity of the river system.
- Relevance to sustainable water resource management:** Habitat availability and diversity are major determinants of aquatic community structure and functioning. Loss of habitat is regarded as the single most important factor that has contributed to the extinction of species all over the world. Degradation of aquatic habitats in South Africa includes physical destruction of habitats due to river regulation (e.g. dams and IBTs) and infrastructure development (e.g. bridges), as well as the deterioration in water quality.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land-use change;
 - Water availability;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (all parameters), and
 - Biodiversity change.
- Limitations and potential problems:** The methodology is time consuming and requires extensive resources.
- Calculation of the indicator:** The standard IHI methodology should be used (Kleynhans 1996; <http://www.csir.co.za/rhp>) at selected reaches at yearly intervals. The final score is determined by scoring criteria that are indicative of those aspects of habitat integrity which, when modified anthropogenically, causes degradation in the river health. The assessment of the severity of impact is based on six descriptive classes:

SCORE	IMPACT CLASS	DESCRIPTION
0	None	No discernable impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.
1-5	Small	The modification is limited to very few localities and the impact on habitat quality, diversity and variability are also very small.
6-10	Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are limited.
11-15	Large	The modification is present with clearly detrimental impact on habitat quality, diversity, size and variability.
16-20	Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.
21-25	Critical	The modification is present overall, with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined area are influenced detrimentally.

7. Data for the Mhlathuze Catchment

Communication was made with the national River Health Programme (www.csir.co.za/rhp) and discussions were held with personnel from the Durban Regional Office (Hugh Dixon Paver, personal communication). Contact was made with researchers who have conducted studies in the Mhlathuze catchment (Professor Digby Cyrus, personal communication). The following feedback on the Index of Habitat Integrity (IHI) was obtained from Professor Cyrus:

- “We may also have some data which would give Index of Habitat Integrity in selected reaches.
- At this point in time without going back to the data bases or the field sheets it is not possible to say for how many sites or for how long each sequence runs for. Some it would at least be for two or more years, some are on a monthly basis and some on a quarterly basis”.

It is therefore understood that IHI has not yet been formally done in the Mhlathuze catchment and does not form part of any long-term monitoring system.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

On the basis of the available information it is not possible to provide any indication of trends in IHI in the Mhlathuze catchment.

9. Conclusions and Recommendations

IHI determinations are part of an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of ecological river health and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core indicator set. There is a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of ecological change.

10. References

Kleynhans CJ. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). *Journal of Aquatic Ecosystem Health* 5: 41-54.

RC 5: RIPARIAN VEGETATION INDEX IN SELECTED REACHES		
Resource condition	Habitat condition/Ecosystem functioning	State or impact

- Definition:** Status of riparian vegetation within river reaches based on the qualitative assessment of vegetation removal, cultivation, construction, inundation, erosion, sedimentation and alien vegetation in the riparian zone (% deviation from natural).
- Purpose:** To provide a qualitative assessment of the conservation status of riparian vegetation of a water resource
- Relevance to sustainable water resource management:** The riparian zones are the interfaces between freshwater and land systems. They maintain channel form and serve as filters for light, nutrients and sediment. If they are damaged, degradation of the freshwater system often occurs, including changes in the ecosystem functioning, increased sedimentation, increased water usage etc. In the past, riparian activities of some landowners in South Africa have lead to extensive degradation of the riparian zones of rivers, and irreparable damage to river ecosystems.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land-use change;
 - Water availability;
 - Waste generation and management;
 - Pollution (all types);
 - Water quality (all parameters), and
 - Biodiversity change.
- Limitations and potential problems:** The methodology is time consuming and requires extensive resources.
- Calculation of the indicator:** The standard RVI methodology, as documented in Kemper (2001), should be used at selected sites on an annual basis.

The RVI provides a final score out of 20, which may be interpreted as follows (Kemper 2001):

- RVI = 19-20 Unmodified, natural;
- RVI = 17-18 Largely natural with few modifications – a small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged;
- RVI = 13-16 Moderately modified – a loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are predominantly unchanged;
- RVI = 9-12 Largely modified – a large loss of natural habitat, biota and basic ecosystem functions have occurred;
- RVI = 5-8 The loss of natural habitat, biota and basic ecosystem functions are extensive;
- RVI = 0-4 Modifications have reached a critical level and the system has been modified completely, with an almost complete loss of natural habitat and biota; at worst the basic ecosystem functions have been destroyed and the changes are irreversible.

7. Data for the Mhlathuze Catchment

Communication was made with the national River Health Programme (www.csir.co.za/rhp; Dirk Roux, personal communication) and discussions were held with personnel from the Durban Regional

Office (Hugh Dixon Paver, personal communication). Contact was made with researchers who have conducted studies in the Mhlathuze catchment (Professor Digby Cyrus, personal communication). The RVI has not been formally used to describe the status of riparian vegetation on any reaches in the Mhlathuze catchment and there is no available data on this indicator.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of obtaining data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

On the basis of the available information it is not possible to provide any indication of trends for RVI in the Mhlathuze catchment.

9. Conclusions and Recommendations

The RVI is an accepted monitoring approach (see National Rivers Health Programme - www.csir.co.za/rhp) that provides a measure of the change that has occurred in the riparian zone of rivers and is therefore a useful indicator for assessing ecological changes. It is felt that this indicator should form part of a core catchment indicator set. There is however a need for a systematic long-term monitoring programme to be introduced to the Mhlathuze catchment with a focus on selected sites that provide the most relevant indication of change to the riparian zone.

10. References

Kemper NP. 2001. RVI – Riparian Vegetation Index. Final Report. WRC Report No. 850/3/01. WRC, Pretoria. 21 pp.

RC6: PERCENTAGE WETLAND AREA		
Resource condition	Habitat condition	Impact

- Definition:** Catchment area covered by wetlands divided by the total catchment area (%).
- Purpose:** To determine the extent of wetlands in the catchment. Over time this can be converted into the percentage wetlands lost to other land use types.
- Relevance to sustainable water resource management:** Wetland systems are some of the most endangered ecosystems in South Africa. Their numerous uses make them invaluable as natural assets and to sustainable development. An estimated 50% of all South Africa's wetlands have been lost, affecting the functioning of the aquatic systems of which they are a part. The extent of wetlands in a catchment gives an indication of the value of wetlands in the catchment, and can be used to track future wetland loss.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land-use change;
 - Poverty/vulnerability;
 - Population change;
 - Availability of water;
 - Sectoral water requirements;
 - Waste generation and management;
 - Water quality (all types);
 - Pollution (all types);
 - Altered ecosystem functioning;
 - Biodiversity change;
 - Social viability;
 - Inequity, and
 - Economic use value.
- Limitations and potential problems:** The greatest limitation seems to be the methodology used, as well as the large variety in wetland types which contribute to wetland area. Determining wetland area can be extremely time consuming and costly.
- Calculation of the indicator:** Wetland area can be estimated using satellite imagery, but requires expert interpretation. The equation to determine the proportion of the total is:

$$RC5 = A_W/A_T \times 100$$

Where: A_W = Area covered by wetlands
 A_T = Total catchment area.

7. Data for the Mhlathuze Catchment

Discussions were held with personnel from the Durban Regional Office (Hugh Dixon Paver, personal communication) and contact was made with persons involved in land use, and wetland research and management (Deon Marais, DEAT; Steve Mitchell, WRC). There has not yet been any evaluation of the wetland cover in the Mhlathuze catchment that would allow for this indicator to be calculated.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of obtaining data	0
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	9

8. Trends

On the basis of the available information it is not possible to provide any indication of trends in percentage wetland area for the Mhlatuze catchment.

9. Conclusions and Recommendations

This indicator is an extremely difficult one to measure and monitor because of the large variety of water resource types that are classified as wetlands, and which make up total wetland area (Cowan 1998). It is therefore unlikely that a technically acceptable value could be made available to decision-makers. Consequently, it is felt that this indicator should be modified to make it easier. A suggested indicator could be “the amount of land per annum that has been converted from a wetland category into other land use types”. This means that rather than measuring total wetland area, resource managers would measure only that portion that has been converted from wetland.

10. References

Cowan GI and Marneweck GS 1996. South African National Report to the RAMSAR Convention. Department of Environmental Affairs and Tourism.

Walmsley R D and Boomker EA 1988 Inventory and Classification of Wetlands in South Africa. FRD Occasional Report No.34.

MN1: INDEX OF LEVEL OF CMA ESTABLISHMENT IN THE CATCHMENT		
Management	Management capacity	Response

1. **Definition:** Description of Catchment Management Agency (CMA) establishment in the catchment (rating system).
2. **Purpose:** To determine the level of institutional development for the catchment area. This should be viewed as a temporary indicator until such time as CMAs have been established for all Water Management Areas. Thereafter an indicator of CMA viability can be developed.
3. **Relevance to sustainable water resource management:** The foundation for the National Water Act (No.36 of 1998) is Integrated Water Resources Management (IWRM) at a catchment level. In order to institute this 19 Water Management Areas have been recognised, for which Catchment Management Agencies will be established. The establishment of each CMA is a complex process that includes integration of the current DWAF regional offices, development of the roles of various water management authorities and water boards and extensive stakeholder participation. Forum establishment is one of the first steps towards CMA development, and it is envisaged that forums will be included in the development of CMAs throughout the country. The development of each CMA will have to follow a defined business process involving social, political, and financial negotiations all of which will have progress milestones that can be monitored. Another key is the development of a catchment management system, which must be in harmony with the national water strategy, and should set the principles for allocating water taking into account matters relevant to the protection, use, development, conservation, management and control of water resources.
4. **Linkages:** This indicator may be linked to the following issues:
 - Human resource capacity;
 - Institutional capacity;
 - Financial viability;
 - Social viability, and
 - Monitoring and reporting.
5. **Limitations and potential problems:** The process of CMA establishment will differ depending on the characteristics of each Water Management Area. This Index is based on the key elements for establishment of every CMA, without expanding on the details of each.
6. **Calculation of the indicator:** The indicator is in the form of an Index, based on a set of 10 criteria that have to be met for CMA establishment to be successful (National Water Act 1998; DWAF 1998). The Index is presented as a simple score out of 10. The criteria include:
 1. Has a Catchment Management Forum been established in the catchment?
 2. Has a Catchment Management Committee been established in the catchment?
 3. Has a CMA proposal been submitted to the Minister (Section 77(1))?
 4. Has the Minister published the establishment of the CMA in the Government Gazette?
 5. Has a governing board been established for the CMA?
 6. Has a catchment management strategy been developed?
 7. Have resource quality objectives been established for the catchment?
 8. Has a water allocation plan been established for the catchment?
 9. Has an information management and decision making system been established?
 10. Is the CMA financially independent of DWAF?

7. Data for the Mhlathuze Catchment

Discussions with personnel at DWAF indicate that the Mhlathuze catchment has only progressed to achieve the first criterion of the index, thus currently has a value of 1 out of a possible 10. Examination of the draft DWAF national water resource strategy document indicates that the status of a fully independent CMA will probably only be achieved by the year 2010.

The information on this index is extremely easy to obtain as the process of CMA development is an open and transparent one with regular notices appearing on the DWAF website (www.dwaf.gov.za).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	2
Historical record	2
Temporal alignment of parameters	2
Spatial quality	2
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	20

8. Trends

The trend for this index is easily followed from 1998 following the promulgation of the National Water Act, which first outlined the intention of the government to establish CMAs (see Figure 1). This indicates that a fully independent CMA will be in place by the year 2010.

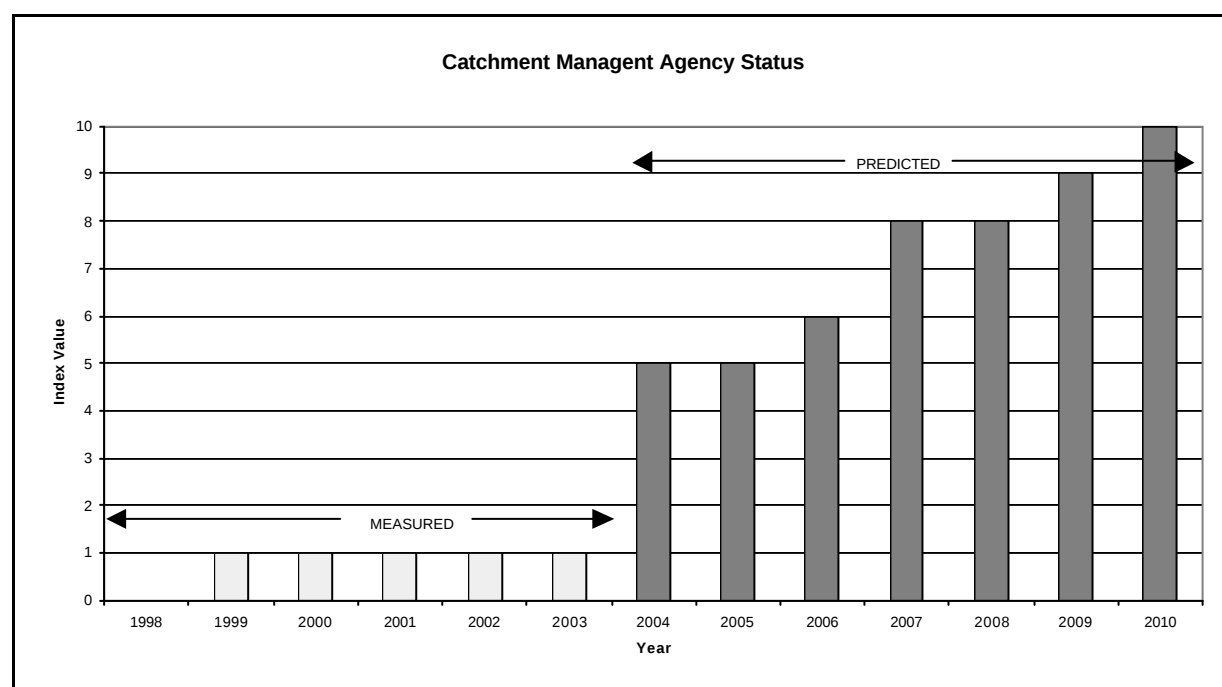


Figure 1: Measured and predicted values of the CMA index

9. Conclusions and Recommendations

This indicator is one of the few that has been given a high rating based on the criteria of evaluation. This is because the information that is required for its calculation is readily available from the DWAF website (www.dwaf.gov.za), and requires no technical or electronic storage, or personnel to process it.

In view of the importance of CMA development for the implementation of the National Water Act it is felt that this management indicator is a priority for all catchments.

10. References

Department Of Water Affairs And Forestry. 1998. Water Law Implementation Process, A Strategic Plan for the Department of Water Affairs and Forestry to Facilitate the Implementation of Catchment Management in South Africa. DWAF, Pretoria.

MN2: STATE OF SATISFACTION		
Management/Social	Social viability	Response

- Definition:** Composite index that quantifies the level of satisfaction of the catchment population with the management of the water resources and sanitation systems.
- Purpose:** To evaluate the level of satisfaction of the catchment population (all socio-economic levels) with regard to the provision of water and sanitation, and water resource quality. It provides and indication of the social success of catchment management strategies.
- Relevance to sustainable water resource management:** Public opinion often influences the behaviour of individuals or groups of people. The level of co-operation of the community in water resource management and conservation depends, along with other factors, on their satisfaction with water management in their area. For instance, people unhappy with the present level of service provision, together with other external variables, may be less likely to pay for water provision. This indicator could be considered to be one of the best to assess the impact of water resource development activities as well as ultimate performance of management institutions and programmes.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Poverty/Vulnerability;
 - Population change;
 - Waste generation and management;
 - Water balance;
 - Domestic demand for water;
 - Inequity;
 - Institutional capacity;
 - Financial viability, and
 - Monitoring and reporting.
- Limitations and potential problems:** The greatest limitation would be the manpower and resources required to collect information for each catchment. In addition, there could be numerous problems if surveys for the indicator were conducted through a national system as each catchment would be different. The questionnaire should therefore best be done as part of service providers marketing intelligence and be conducted at the local level rather than through a national system.
- Calculation of the indicator:** A structured questionnaire, of about 30 questions, can be used to obtain input on the perceptions of different socio-economic groups of the general population (see questionnaire from Rand Water 2000). Information that will need to be gathered includes the availability of water, the reliability of the water, water quality aspects, general water and sewerage service provision as well as general catchment management issues (see attached questionnaire). Based on this questionnaire, a composite index (averaged scores, %) of satisfaction can be calculated (Rand Water 2000).

QUESTIONNAIRE

- What is your main source of water (municipal, water service provider, boreholes, river, well, etc)?
- Group of questions in order to determine LSM levels (socio-economic levels).
- How satisfied or dissatisfied are you with each of the following aspects in the area where you live?

	Very dissatisfied	Dissatisfied	Just as dissatisfied as satisfied	Satisfied	Very satisfied	Not applicable
Municipal (water service provider) water provision services in general	0	1	2	3	4	*
Municipal sewerage systems	0	1	2	3	4	*
Availability of water	0	1	2	3	4	*
Reliability of water supply	0	1	2	3	4	*
Mineral quality of tap water	0	1	2	3	4	*
Colour of tap water	0	1	2	3	4	*
Taste of tap water	0	1	2	3	4	*
Smell of tap water	0	1	2	3	4	*
Turbidity of tap water	0	1	2	3	4	*
Health aspects of water	0	1	2	3	4	*
Water quality of dams/ivers	0	1	2	3	4	*
Water quality of boreholes/wells, underground water	0	1	2	3	4	*

7. Data for the Mhlathuze Catchment

Discussions with personnel from DWAF and Mhlathuze Water indicate that there have not been any surveys of this nature in the catchment. There is consequently no data for estimation of the level of user satisfaction with water services.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	0
Cost of data	0
Confidence	0
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	0
Total Score	0

8. Trends

It is not possible to comment on any trends for the Mhlathuze catchment as surveys to determine the general level of satisfaction have not been carried out on the required scale.

9. Conclusions and Recommendations

This indicator is one that provides feedback from the public and stakeholders on how they are experience the delivery of water services and their rating of how water resources are being managed. There is a need for such feedback to be monitored and reacted on. It is felt that an indicator on the level of stakeholder satisfaction should be included in a core catchment indicator set.

10. References

Rand Water. 2000. Catchment Diagnostic Framework: Prototype Catchment Diagnostic Index – User’s Manual. Rand Water, Johannesburg. 53 pp.

MN3: VOLUME OF WATER USED AS A PROPORTION OF TOTAL WATER ALLOCATED		
Management /Water balance	Human resources/Institutional capacity	Response

- 1. Definition:** Amount of water used by consumers as a proportion of total water allocated through compulsory and other licensing procedures (%).
- 2. Purpose:** To determine the success of the allocation policies and administration, and the water quantity management in the catchment.
- 3. Relevance:** The implementation of the National Water Act (No. 36 of 1998) depends largely on the allocation of scarce water resources within every Water Management Area. Water is allocated in a hierarchical fashion, in the following order: Reserve, international requirements, strategic industries and sectoral requirements. The amount of water allocated is a measure of the success of the administrative procedures within the catchment. Additionally, the allocation of water in South Africa is not as simple as just issuing licenses. It includes establishment of the Reserve and conformation with RDM procedures. Thus, the indicator has relevance far wider than just the physical process of licensing.

This indicator was originally entitled “Volume of water allocated as a proportion of total water available” which is almost the same as the water balance indicator WB3 “Demand as a proportion of total water available”. Because demand is almost synonymous with allocation it was felt that the success of allocation policies is better reflected by the ratio of the actual volume of water used to that which was agreed to in the allocation process. Such a ratio thus provides a measure of success of the planning and allocation process.

- 4. Linkages:** This indicator may be linked to the following issues:
 - Population change;
 - Sectoral demand for water;
 - Institutional capacity;
 - Human resource capacity;
 - Financial viability;
 - Social viability and
 - Monitoring and reporting.
- 5. Limitations and potential problems:** The indicator has many aspects to it, when one considers the implementation of allocation policies in South Africa. Interpretation of the indicator is, thus, and important aspect of its use.
- 6. Calculation of the indicator:**

$$MN3 = (V_u) / (V_A \times 100)$$

Where: V_u = Volume of water used ($m^3 a^{-1}$)
 V_A = Volume of water allocated ($m^3 a^{-1}$)

7. Data for the Mhlathuze Catchment

Examination of the recent reports on the catchment (DWAF 2001, 2002), have indicated that this indicator does form part of ongoing resource management, and there is a relatively good record of water used and water allocated for the period 1994 through to 2000. Up to date records were requested from DWAF and Mhlathuze Water, but the organisations were not able to provide this.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	2
Confidence	2
Historical record	1
Temporal alignment of parameters	2
Spatial quality	2
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	18

8. Trends

The available data indicate that there is a large discrepancy between the water actually used and that allocated (see Figure 1 below) with usage being almost 50% of that allocated. It is believed that these figures have resulted in major revisions to the water allocation policy and procedures in the catchment, as well as to the previous perception that the catchment is a water-stressed one because demand exceeds supply.

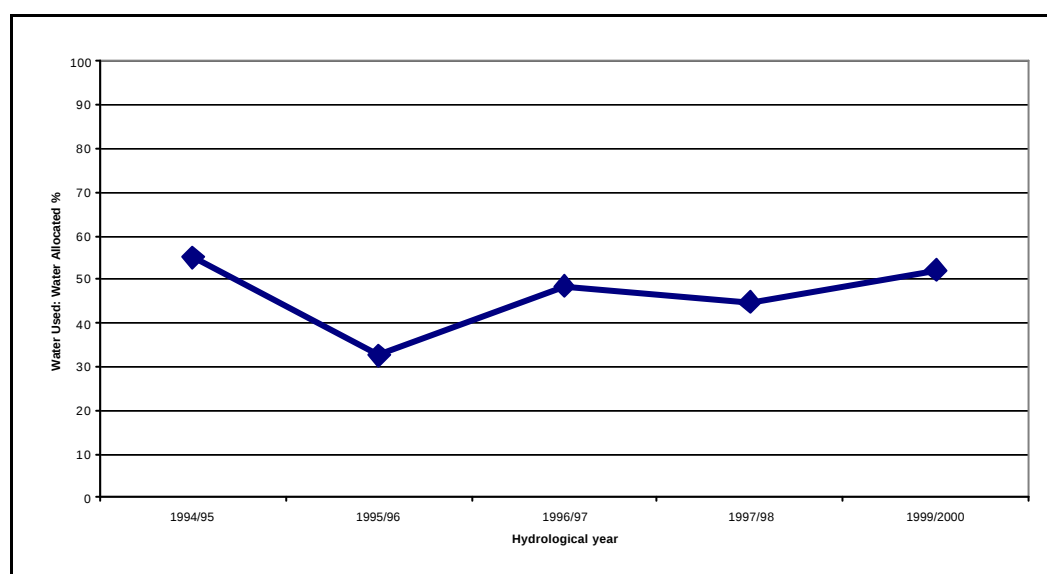


Figure 1: Plot of the proportion of water used against that allocated for the Mhlathuze catchment for the period 1994 through to 2000 (data obtained from DWAF & Mhlathuze Water 2001).

9. Conclusions and Recommendations

This indicator is already being used and monitored in the catchment and obviously forms an important part of water resource decision-making. It therefore merits an automatic inclusion into a core indicator set. It is of concern however that this study was not able to obtain up to date values.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Water Demand Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0299.

MN4: WATER USE EFFICIENCY FOR DIFFERENT SECTORS		
Management	Water use efficiency	Response

1. **Definition:** Amount of production (Rands) from one cubic meter of water for agricultural, mining and industrial production in the catchment ($R\ m^{-3}$).
2. **Purpose:** To determine the level of water use efficiency within different sectors within the catchment (agriculture, industry and mining), as an indication of the efficiency in demand management strategies over time. It also indicates the perceived value of water in the country.
3. **Relevance:** In the past, South Africa relied largely on supply-side management to ensure that there was enough water for economic and domestic use in the country. However, most of the water resources in the country have been developed to capacity. The Department is currently encouraging demand management through pricing structures, and education and awareness. A Water Conservation/Demand Management Strategy has been developed as part of the National Water Resource Strategy to ensure the proper implementation of this philosophy. The efficiency of water use is one method to measure its success.
4. **Linkages:** This indicator may be linked to the following issues:
 - Land-use change;
 - Availability of water;
 - Sectoral demand for water, and
 - Water allocation.
 - Economic productivity
5. **Limitations and potential problems:** Currently this indicator includes agriculture, mining and industry. However, the use of water will depend on the economic use of the water in the catchment. This may include other uses such as forestry or tourism. This will need to be determined for each catchment separately. In the case of the Mhlathuze this indicator has limitations because the efficiency of water consumption, as reflected by Rand per cubic metre of water used, is not a good comparative indicator (see Dallimore 2000). This is because, amongst others:
 - a. It is too simplistic as there are wider issues to be considered.
 - b. The price paid for water by the respective industries is not the same. In the case of the Mhlathuze the price varies between R 0.0167 and R 5.35 per cubic metre.
 - c. There is a lack of an economic framework upon which the efficiency of water use by the defined sectors can be comparatively valued according to accepted economic benefits (e.g. employment, externalities, positive and negative environmental effects etc).
 - d. Some industries are more water-dependent than others and the processes of water use are different.
 - e. The range of efficiencies is so wide that it does not allow for meaningful comparison across industries.
6. **Calculation of the indicator:**

For each economic water use, water use efficiency can be calculated as follows

$$MN4_{WU} = R_{WU} / V_{WU}$$

Where: R_{WU} = Annual economic return for each water use ($R\ a^{-1}$)

V_{WU} = Volume of water used by that economic water use sector ($m^3\ a^{-1}$)

7. Data for the Mhlathuze Catchment

Enquiries with relevant parties and examination of reports have indicated that there is a no agency or institution that is routinely gathering information on the efficiency of water use by the sectors. Dallimore (2000), as part of a Strategic Environmental Assessment published in 2000 has provided some values for sectors that indicate that there is a wide range of values for the efficiencies with the Heavy Machinery Sector having the highest efficiency and agriculture having extremely low efficiency (see Table 1).

Table 1: Efficiency of water use in Rand output per cubic metre for several industries in the Mhlathuze catchment area (from Dallimore 2000).

<u>Industry</u>	<u>Efficiency</u> <u>(Rand output per cubic metre)</u>
Paper Pulp	84
Aluminium	2332
Heavy machinery	18359
Fertilisers	169
Mining	106
Dryland sugar (small farmers)	7.7
Irrigated sugar (small farmers)	0.65
Dryland sugar (commercial)	12.72
Irrigated sugar (commercial)	0.74
Citrus	2.74
Forestry	2.23

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 2.

Table 2: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	0
Confidence	1
Historical record	1
Temporal alignment of parameters	1
Spatial quality	1
Frequency of collection	1
Processing time/efficiency	1
Relatability/overlap with other indicators	1
Empirical status	1
Total Score	9

8. Trends

It is not possible to provide any trend for this indicator.

9. Conclusions and Recommendations

This indicator has been used for analysing the efficiency of certain sectors in the catchment, albeit in a once off basis. As an indicator, it has merits if it is used with caution to compare the performance of the separate sectors over time rather than as an inter sector comparison. It therefore merits inclusion as a core indicator.

10. References

Dallimore A. 2000. Water Use and Dependency in the Mhlathuze Catchment: A Macro Economic and Sectoral Analysis. DRA-Development Report, 2000/05. In: Appendix E: Strategic Environmental Assessment for Water Use: Mhlathuze Catchment – Kwazulu-Natal. Department of Water Affairs and Forestry. Report Number: SEA-01/2000.

MN5: PERCENTAGE OF UNACCOUNTED-FOR WATER IN THE CATCHMENT		
Management /Water balance	Management capacity/Water use efficiency	Response

- Definition:** Amount of water lost during distribution from source to the end user (%).
- Purpose:** To evaluate the management of distribution systems, by determining loss of water as it is distributed from the source to the end user. It also indicates the perceived value of water in the country.
- Relevance to sustainable water resource management:** Water is a precious resource in an arid country such as South Africa and any loss away from a recognised user is important from the point of view of both the resource, and the added cost to supply water. Maintenance of infrastructure is a key to efficient water distribution, and lack of maintenance reflects on the management capacity in the catchment.
- Linkages:** This indicator may be linked to the following issues:
 - Human settlement;
 - Land-use change;
 - Poverty/vulnerability;
 - Availability of water;
 - Inequity;
 - Human resources;
 - Financial viability;
 - Institutional capacity;
 - Monitoring and reporting.
- Limitations and potential problems:** Problems exist in trying to quantify the indicator at a catchment level. The indicator is reliant on information from municipalities, some of which are not restricted by catchment boundaries. The final figure is likely to be an estimate. The estimation of the indicator at a catchment level presents difficulties because of the many users and the different ways in which water is distributed. The indicator is possibly best used for determining the efficiency of the domestic situation where water is metered and volumes can be assessed. It is also complicated by the differing ways in which water can be lost in the distribution process.
- Calculation of the indicator:**

$$MN5 = (V_A - V_{EU}) / (AR + RT + IBT + GW) \times 100$$

Where: V_A = Volume of water abstracted from the resource ($m^3 a^{-1}$)
 V_{EU} = Volume of water provided to end users ($m^3 a^{-1}$)
 AR = Annual runoff ($m^3 a^{-1}$)
 IBT = Annual inter-basin transfer volume ($m^3 a^{-1}$)
 RT = Annual return flows ($m^3 a^{-1}$).
 GW = Ground water abstracted from the resource ($m^3 a^{-1}$)

7. Data for the Mhlathuze Catchment

Enquiries were made to DWAF and Mhlathuze Water for information on the indicator and its constituent variables. The response was that there was little available information on this indicator for the catchment. Examination of the reports by DWAF & Mhlathuze Water (1999) does however provide some information on unaccounted water, but only for domestic water users via the municipalities. On the basis of estimates made in 1999, the following points are pertinent:

- The total unaccounted-for water in the domestic/urban sector is estimated to be in the order of 6.1 million m³/a, representing over 20% of this sector's total water use in 1999.
- It is estimated that approximately 20% of the UAW is apparent losses through domestic meter error, illegal use and billing errors although this figure will have to be confirmed during a subsequent detailed WDM study. The apparent losses are therefore estimated to be approximately 1.2 million m³/a or 4% of this sector's 1999 input.
- The real losses represent approximately 5 million m³/a (16% of this sector's 1999 input).
- Approximately 3.2 million m³/a can be saved through more efficient system operation most of which is in the Esikhaweni and Empangeni areas.
- Richards Bay, Eshowe, Ngwelezane and Melmoth appear to be reasonably well managed and there seems to be little scope for improvement with regards to the operation of the system.

There is no information on the situation prior to, or after, 1999. The report by DWAF and Mhlathuze Water (1999) does call for a more detailed evaluation to be done of unaccounted water in the Mhlathuze catchment.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	0
Confidence	1
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	1
Total Score	3

8. Trends

It is not possible to provide any trend for this indicator.

9. Conclusions and Recommendations

This indicator has been used for analysing the efficiency of certain sectors in the catchment, albeit in a once off basis. As an indicator, it has merits if it is used with caution to compare the performance of the separate sectors over time rather than as an inter sector comparison. It therefore merits inclusion as a core indicator.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 1999. Mhlathuze Operating Rules and Future Phasing. Water Demand Management Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Piésold. DWAF Report No. PB W120-00 0499.

MN6: RATIO OF SUB-CATCHMENTS FOR WHICH THE ECOLOGICAL RESERVE HAS BEEN SET TO TOTAL NUMBER OF SUB-CATCHMENTS		
Management	Reserve	Response

- Definition:** Number of sub-catchments (quaternary) for which the Ecological Reserve has been established in comparison to the total number of sub-catchments.
- Purpose:** To establish whether resource directed measures are being implemented in the catchment. (This is an interim indicator until resource quality objectives, against which performance can be measured, have been set).
- Relevance:** The National Water Act (No.36 of 1998) requires that the Reserve (comprising volumes of water to satisfy basic human needs and ecological requirements) is formally set for each catchment in the country through promulgation in a White Paper endorsed by government. The component of the Reserve which requires the most effort to determine, is the Ecological Reserve. Once the Ecological Reserve has been determined, RQOs can be set and water resources allocated according to the management class of the resource.
- Linkages:** This indicator may be linked to the following issues:
 - Poverty/Vulnerability;
 - Population change;
 - Inequity;
 - Availability of water;
 - Water allocation;
 - Human resources;
 - Financial viability;
 - Social viability;
 - Institutional capacity, and
 - Monitoring and reporting.
- Limitations and potential problems:** As pointed out above, this is an interim indicator until such time as all catchments have resource quality objectives set. Although implementation of RDM is proceeding, it is uncertain when this indicator will become redundant. It is also doubtful if estimates of ecological reserve can be made to any high level of confidence for all quaternary catchments in the country. This is because the Reserve estimate will also be dependent on a management class designated to the specific river system. This classification system is in the process of being developed by DWAF and consequently the Mhlathuze has not yet received a designation for its management class.
- Calculation of the indicator:**

$$MN6 = SC_R : SC_T$$

Where: SC_R = Sub-catchments for which the Ecological Reserve has been set
 SC_T = Total number of sub-catchments

7. Data for the Mhlathuze Catchment

Enquiries with relevant parties and examination of reports have yielded the fact that a rough estimate of the Ecological Reserve for the overall Usuthu to Mhlathuze Water Management Area has been done (estimated at a volume of 1 192 million m³ per annum, Bill Rowston, personal communication). DWAF and Mhlathuze Water (2000) published the findings of an Ecological Reserve study that gave

preliminary estimates for the Mhlathuze River (below Goedertrouw Dam), the lakes in the catchment, and the estuary. The report does not specify how this relates to all the sub-catchments, but it is interpreted that the study includes subcatchments W12D, W12E, W12F, W12H and W12J (some of which include the coastal lakes) making a total of five out of the nine subcatchments for which a preliminary estimate has been made. However, the National Water Act (Section 12-16) stipulates that a determination of the Reserve can only be undertaken and set when the system for classifying water resources has been prescribed (that is, by Regulation), and the resource has been classified in terms of the Resource Classification System. On the basis of the fact that the Mhlathuze has not yet received such classification it can be concluded that the Ecological Reserve has not yet been formally set for any of the subcatchments. The indicator value thus stands at **zero**. It is not known when exactly the Classification will be in place or when comprehensive Ecological Reserve estimates will be done (Ash Seetal, personal communication).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	2
Historical record	2
Temporal alignment of parameters	2
Spatial quality	2
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	
20	

8. Trends

Changes to this indicator will be dependent on water resource management authorities initiating and supporting the required once-off Reserve estimates on each of the subcatchments. It is not known when this will be done consequently a trend cannot be predicted.

9. Conclusions and Recommendations

Setting of the Ecological Reserve is a key component of South African water policy for all of the Water Management Areas. This indicator therefore has a high relevance in terms of progress towards implementation of policy and regulations. It therefore merits inclusion as a core indicator. This indicator requires further development to incorporate the various levels of Reserve determinations which DWAF has introduced in order to implement the management of the Reserve.

10. References

DWAF and Mhlathuze Water 2000 Mhlathuze System Ecological reserve (Quantity) Study. Report No. W120-001199.

Steyl I, Versfeld D B and P J Nelson 2000 Strategic Environmental Assessment for Water Use: Mhlathuze Catchment. Department of Water Affairs and Forestry. Report No. SEA/ 01-2000.

MN7: RATIO OF SUB-CATCHMENTS FOR WHICH RELIABLE HYDROLOGICAL MONITORING DATA ARE AVAILABLE TO TOTAL NUMBER OF SUB-CATCHMENTS		
Management	Monitoring	Response

- 1. Definition:** Number of sub-catchments (quaternary) for which adequate hydrological monitoring data are available in comparison to the total number of sub-catchments.
- 2. Purpose:** To evaluate the extent and success of the hydrological monitoring network, which provides information on water quantity in the catchment.
- 3. Relevance to sustainable water resource management:** Continual monitoring of the water resources is important for immediate management. Rainfall in South Africa is irregular over many catchments, and constant surveillance needs to be kept on the amount of water available in the catchment. Both flood control and drought relief are important aspects of water resource management in South Africa.
- 4. Linkages:** This indicator may be linked to the following issues:
 - Climate and catastrophic events;
 - Availability of water;
 - Water allocation;
 - Financial viability;
 - Institutional capacity, and
 - Reporting.
- 5. Limitations and potential problems:** This indicator does not necessarily give the full picture with regard to hydrological monitoring. For instance, it does not take into account the difference between strip recorders and satellite weirs, or the level of accuracy of the weirs. Establishing what is reliable and what is not, requires detailed technical evaluation and might be subjective.
- 6. Calculation of the indicator:**

$$MN7 = SC_H : SC_T$$

Where: SC_H = Sub-catchments for which adequate hydrological monitoring data are available
 SC_T = Total number of sub-catchments

7. Data for the Mhlathuze Catchment

Information on the number of hydrological stations and their record was readily obtained from DWAF (Mr H Botha, personal communication). This shows that hydrological monitoring was initiated in 1921, but there have been many changes to the network over the years. A record of the number of subcatchments, which have had hydrological stations since 1948, is shown in Figure 1. It is beyond the scope of this study to carry out an investigation of whether these stations were reliable or not. However, it is noted that at the present time only four out of the nine subcatchments have active hydrological monitoring in place. Much of the focus over the years has been on hydrological monitoring of the main Mhlathuze River channel and discharges from the Goedertrouw Dam.

The study by DWAF and Mhlathuze Water (2001) makes numerous recommendations for improving the hydrological network for the catchment.

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	0
Historical record	2
Temporal alignment of parameters	2
Spatial quality	2
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	18

8. Trends

Over the years, there has been considerable variation in the extent of the hydrological network in the Mhlathuze catchment (see Figure 1). At present only three of the subcatchments have active monitoring stations, which is a decrease from the peak of six subcatchments in 1998.

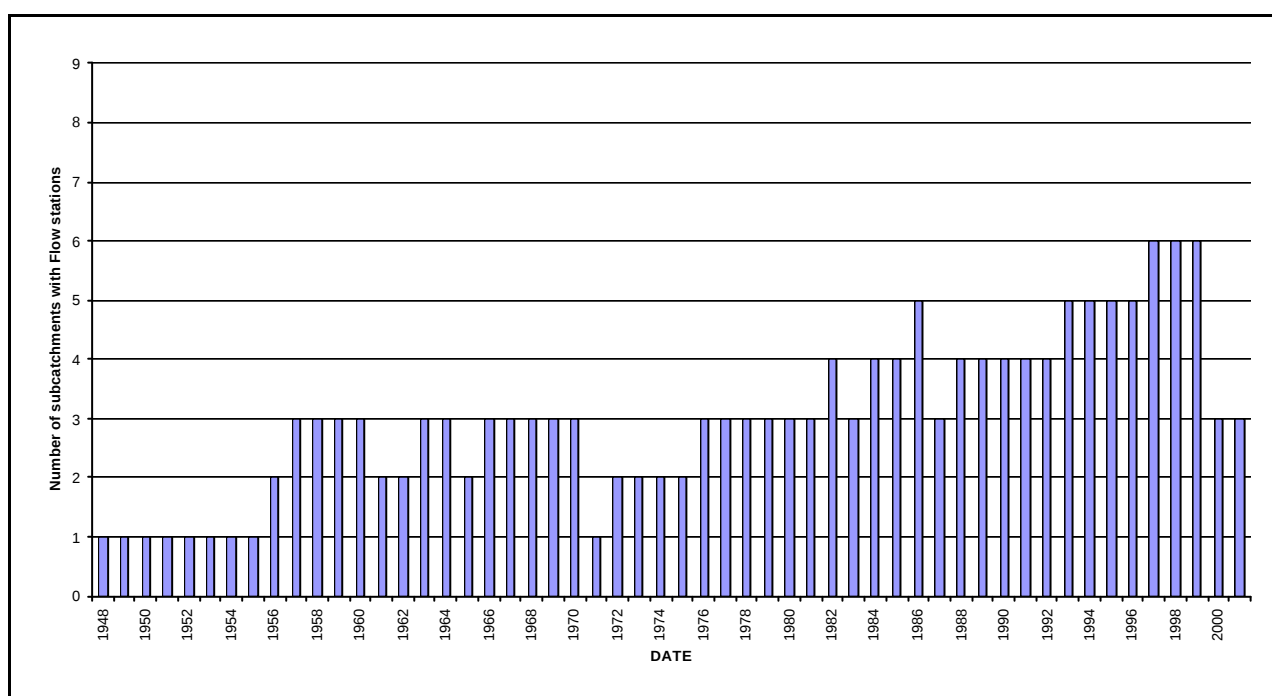


Figure 1 Number of subcatchments in the Mhlathuze catchment that have had active hydrological monitoring stations (for the period 1948 through to 2003 – information provided by DWAF- Hanno Botha, personal communication).

9. Conclusions and Recommendations

The presence of active and reliable hydrological monitoring stations in any catchment is important as it provides historical information on the surface water and flow patterns in the catchment. It also allows for verification of modelling predictions upon which water allocations are made. The indicator

is thus a priority one to be included in a core set of catchment indicators. There is a need for monitoring of this indicator to include a methodology for assessing reliability of these stations.

10. References

DWAF and Mhlathuze Water 2000 Mhlathuze System Ecological reserve (Quantity) Study. Report No. W120-001199.

DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Hydrology Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0199.

DWAF and Mhlathuze Water. 2001. Mhlathuze Operating Rules and Future Phasing. Main Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0999.

Steyl I, Versfeld D B and P J Nelson 2000 Strategic Environmental Assessment for Water Use: Mhlathuze Catchment. Department of Water Affairs and Forestry. Report No. SEA/ 01-2000.

MN8: RATIO OF SUB-CATCHMENTS FOR WHICH RELIABLE WATER QUALITY MONITORING DATA ARE AVAILABLE TO TOTAL NUMBER OF SUB-CATCHMENTS		
Management	Monitoring	Response

- 1. Definition:** Number of sub-catchments (quaternary) for which adequate water quality monitoring data are available in comparison to the total number of sub-catchments.
- 2. Purpose:** To determine the extent and success of ambient water quality monitoring activities in the catchment (not effluent monitoring).
- 3. Relevance to sustainable water resource management:** Water quality information is important for the ongoing evaluation of the physical, chemical and biological characteristics of water resources in terms of their fitness for use for specified users. It therefore forms part of an early warning system for both long-term changes, as well as short-term changes due to chemical spills and/or activities where temporary non-compliance is experienced.

In the case of the Mhlathuze, where there is a relatively high degree of agricultural and forestry activity in the catchment, monitoring of water quality is useful in monitoring and assessing the impacts of non-point source pollution.

- 4. Linkages:** This indicator may be linked to the following issues:
 - Waste generation and management;
 - Pollution (all types);
 - Inequity;
 - Water quality (all parameters);
 - Financial viability;
 - Institutional capacity, and
 - Reporting.
- 5. Limitations and potential problems:** This indicator may be a reflection of poor water quality in the catchment, rather than the efficiency of the management. It should be evaluated in conjunction with the water quality indicators. There is also a problem with defining what constitutes “reliable” as a reliable monitoring system could be in place, but yet still be missing some of the critical and important water quality issues.

6. Calculation of the indicator:

$$MN8 = SC_Q : SC_T$$

Where: SC_Q = Sub-catchments for which adequate water quality monitoring data are available
 SC_T = Total number of sub-catchments

7. Data for the Mhlathuze Catchment

Information on the historical record for water quality monitoring in the catchment (station siting, number of samples, and duration of record) was obtained from the Institute of Water Quality Studies (DWAF). In addition, the detailed report by DWAF and Mhlathuze Water (2002) on water quality was consulted.

The historical record for the Mhlathuze extends back to 1967 when water quality monitoring was first initiated on the main river channel in subcatchment W12D (station W1H009 – see Table 1). At

present there are three subcatchments that do not have any form of water quality monitoring (W12A, W12E and W12G).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating Non-existent = 0; Intermediate = 1; Good = 2
Availability	2
Cost of data	2
Confidence	0
Historical record	2
Temporal alignment of parameters	2
Spatial quality	2
Frequency of collection	2
Processing time/efficiency	2
Relatability/overlap with other indicators	2
Empirical status	2
Total Score	18

8. Trends

The historical record since 1965 for the number of monitoring stations in each subcatchment is presented in Figure 1. This shows that from 1967 to 1984 there was an extension of the catchment's monitoring system, but this was decreased after 1989. Since 1996 only six of the nine subcatchments have had monitoring stations in them.

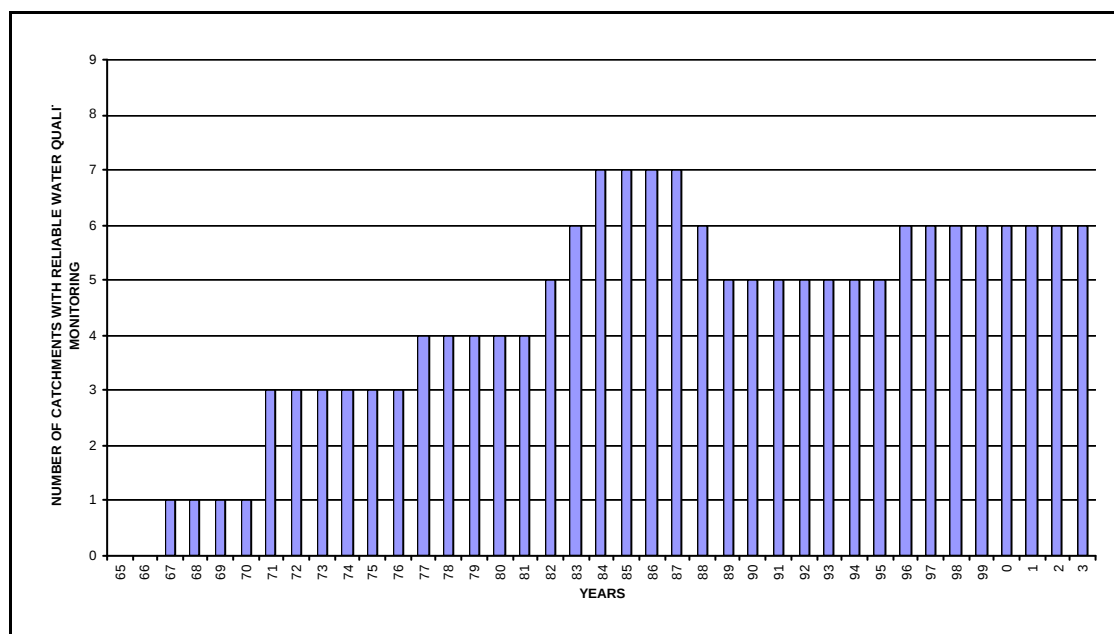


Figure 1: Historical record of the number of sub catchments in the Mhlathuze catchment that have had water quality monitoring stations (1965 to 2003).

It has not been possible in this study to personally assess whether the monitoring data for each of the stations can be termed reliable. However, more detailed studies indicate that water quality data for the catchment requires upgrading. This is illustrated by the statement by DWAF and Mhlathuze Water (2002) that notes “There is a general lack of water quality data, especially for the rivers. It is

recommended that the sampling network for this river system be expanded, and the inflow to the lakes and dams sampled, in such a manner that the ability to observe changes in the catchment be enhanced". Discussions with personnel from the DWAF Durban Regional Office also support the opinion that the current water quality monitoring network is not adequate to meet the current and future management requirements of the catchment (H Dixon Paver, personal communication).

9. Conclusions and Recommendations

The presence of active and reliable water quality monitoring stations in any catchment is important as it provides valuable historical information on the quality of the surface water and allows for the identification of possible sources of pollution. The indicator is thus a priority one to be included in a core set of catchment indicators. There is however a need for monitoring of this indicator to include a methodology for assessing the reliability of these stations in terms of delivering the most relevant and accurate assessment of water quality.

10. References

Department of Water Affairs and Forestry, South Africa and Mhlathuze Water. 2002. Mhlathuze Operating Rules and Future Phasing. Water Quality Module Report. Prepared by consultants BKS (Pty) Ltd and Knight Pièsold. DWAF Report No. PB W120-00 0699.

MN9: NUMBER OF OFFICIAL RESOURCE CONDITION REPORTS		
Management	Reporting	Response

1. **Definition:** Level of reporting on the condition of the water resources of the catchment (number).
2. **Purpose:** To evaluate the extent to which value is added to the data gathered for the catchment.
3. **Relevance to sustainable water resource management:** Information only becomes valuable when it is presented in a way that is understandable to managers. The raw data are obviously essential to the knowledge base, but unless adequate analysis takes place, the data are useless. Reporting is an essential part of information transfer and capacity building within an organisation.
4. **Linkages:** Reporting should be linked to all aspects of catchment management, and should thus be linked to all other issues. The most important linkages include:
 - a. Human resources;
 - b. Institutional capacity, and
 - c. Monitoring.
5. **Limitations and potential problems:** Reporting can take different forms, and the number of written reports may not reflect the extent of reporting in the catchment. The exact nature of the reporting at catchment level needs to be decided upon. For instance, reporting within a CMA may differ from reporting in DWAF. This indicator should, perhaps, only evaluate reporting at a catchment level to DWAF. In addition, it is difficult to attach a time period to this indicator (e.g. per annum, monthly, etc.)
6. **Calculation of the indicator:** Reporting occurs at many levels, local, provincial and national. For the purpose of this project, it is the number of official reports produced by the Regional offices.
7. **Data for the Mhlathuze Catchment**

This indicator is considered to be rather vague in terms of providing a quantitative value that is comparable. There are few official reports on the Mhlathuze catchment that have been generated by the DWAF Regional Office in Durban. Most of the reports that are available have been commissioned from DWAF Head Office in Pretoria.

If the proviso that official reports should emanate from the Regional Office is used then the number of reports is zero (Hugh Dixon Paver, personal communication).

An overall assessment of the indicator, based on the evaluation criteria, is given in Table 1.

Table 1: Summary Evaluation of the Indicator

Criterion	Rating
	Non-existent = 0; Intermediate = 1; Good = 2
Availability	1
Cost of data	2
Confidence	1
Historical record	0
Temporal alignment of parameters	0
Spatial quality	0
Frequency of collection	0
Processing time/efficiency	0
Relatability/overlap with other indicators	0
Empirical status	4
Total Score	4

8. Trends

It is not possible to provide any meaningful comparative indication of trends in the publication of official reports on the Mhlathuze catchment.

9. Conclusions and Recommendations

This indicator is considered to be too vague in terms of what it is actually measuring. Official reports are products that emerge from an information system that caters for the information requirements of water resource decision-makers. As a management indicator it would be more useful to have an indicator that quantifies the combined status of the catchment's information system and includes:

- i. Water quality monitoring
- ii. Hydrological monitoring
- iii. Databases
- iv. Regular reporting based on an agreed core indicator set.

Such an indicator would require development in collaboration with the stakeholders involved in the catchment's information management system.

10. References

List of reports produced by DWAF and Mhlathuze Water (2001):

Hydrology Module Report: PB W120-00 0199
 Water Demand Module Report: PB W120-00 0299
 Groundwater (Coastal Lakes) Hydrology: PB W120-00 0399
 Water Demand Management Module Report: PB W120-00 0499
 System Analysis Module Report: PB W120-00 0599
 Water Quality Module Report: PB W120-00 0699
 Phasing Analysis Module Report: PB W120-00 0799
 Operating Rules Module Report: PB W120-00 0899
 Main Report: PB W120-00 0999