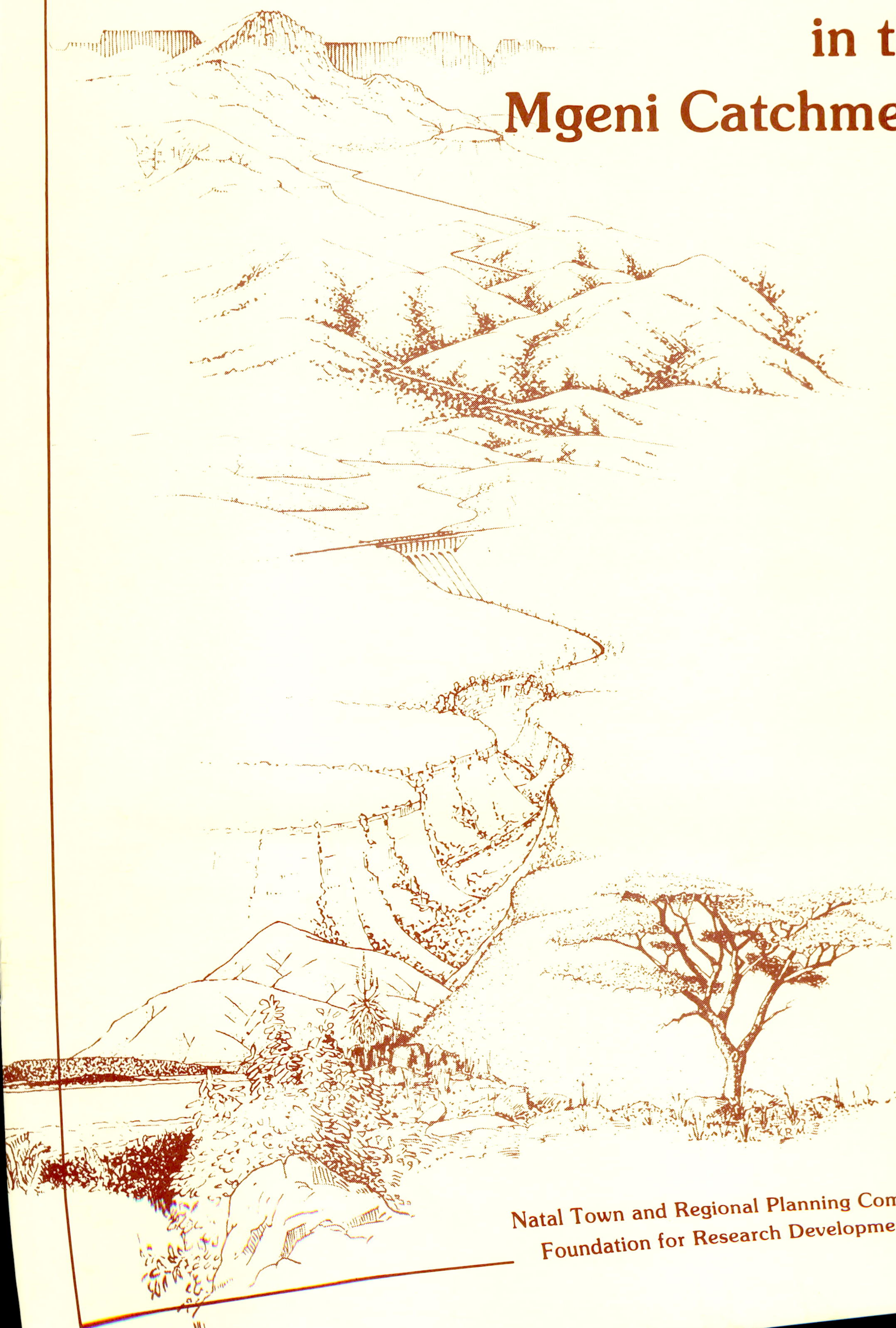
Water Quality Management in the Mgeni Catchment



Natal Town and Regional Planning Commission
Foundation for Research Development, CSIR

Water Quality Management in the Mgeni Catchment

Proceedings of a Workshop
held at the Holiday Inn, Durban
on 27 February 1985
under the auspices of
Natal Town and Regional Planning Commission
and
The Foundation for Research Development, CSIR

edited by

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The success of the Symposium and Workshop reflect the enthusiastic support and co-operation of many individuals and organizations. We are particularly grateful to them and to the participants who prepared the papers which stimulated lively discussion at the Symposium and Workshop. Their documents formed the basis of the synthesis presented here.

The response of organizations charged with the responsibility of managing the use, supply and quality of water was encouraging and we would like to thank them for their active support: the Natal Town and Regional Planning Commission, the Directorate of Water Affairs, the Umgeni Water Board, the City Corporations of Durban and Pietermaritzburg, the Department of Co-operation and Development, and The Natal Parks Board.

Much of the research on which this synthesis is based was conducted by The National Institute for Water Research, The University of Natal and The Hydrological Research Institute. This research has been partly funded for many years by the Natal Town and Regional Planning Commission and the National Programme for Environmental Sciences through the Committee for Inland Water Ecosystems.

Industry was also well represented at the Symposium and we would like particularly to thank the S A Abattoir Corporation for their interest and support.

It is a particular pleasure to acknowledge the members of the Organizing Committee. The smooth running and success of the deliberations was due to their hard work.

Mr W J Alexander, Mr A K Barnes, Dr H N Wiechers and Mr E Braune kindly provided valuable editorial comment.

Organizing Committee for the Symposium and Workshop on Water Quality Management in the Mgeni Catchment:

Professor C M Breen	— Chairman, University of Natal, representing the Committee for Inland Water Ecosystems, CSIR
Mr E Braune	— Hydrological Research Institute, Department of Water Affairs
Mr R A Bromley	— Natal Town and Regional Planning Commission
Mr D W Cherry	— Natal Town and Regional Planning Commission
Dr J Hemens	— National Institute for Water Research, CSIR.

Foreword

The Mgeni River is a vital water resource for the Province of Natal and consequently all activities and developments which might influence the quality of its water and usage require careful planning and coordination. The Town and Regional Planning Commission and the Inland Water Ecosystems Section of the CSIR's Foundation for Research Development have supported water quality-oriented research on the Mgeni River System for the past two decades.

This report contains the Proceedings of a Workshop, carried out under the auspices of the two organizations whose objectives were to evaluate the research findings and develop a regional planning strategy for the protection and management of water quality in the Mgeni Catchment. Attended by scientists, planners, engineers, water users and administrators, the workshop has made an invaluable contribution to regional planning and development in Natal, not only delineating critical areas of the catchment where urban and industrial development should be limited, but also by recommending procedures whereby successful coordination and management of the catchment can be achieved.

D V HARRIS
Chairman, Town and Regional Planning Commission

Executive Summary

The Mgeni River (Figure 1) is a vital water resource for both the Durban – Pietermaritzburg development axis and for the province of Natal. It provides water for some 45% of the province's population which produces *ca* 20% of the gross national product. Continued industrial and urban development will be dependent upon augmenting the supply of water by transfer of water from other catchments (e.g. Mooi and Mkomaas Rivers) and on the effective management of water quality as reclamation of effluents could play an important role in augmenting supplies.

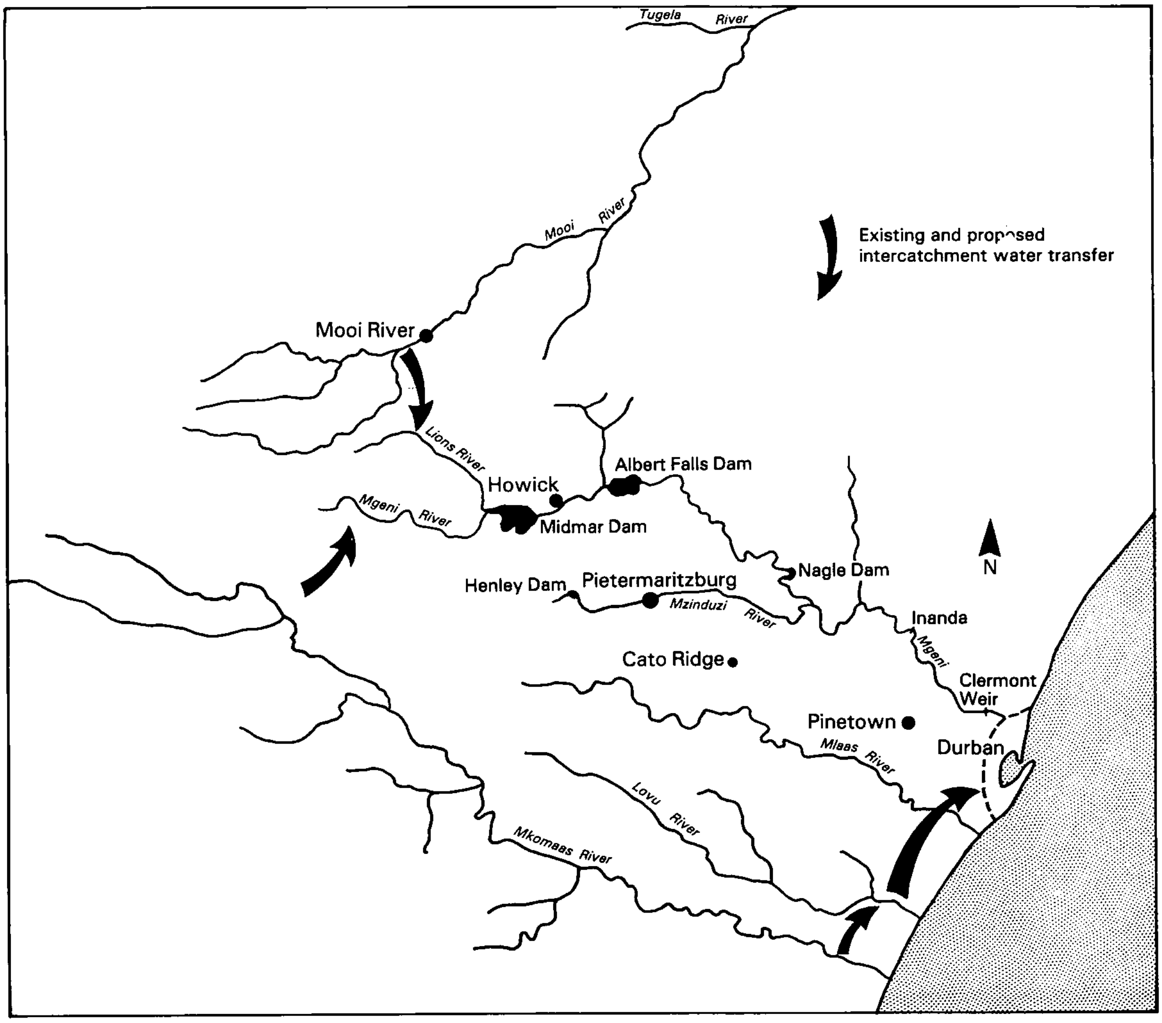

Figure 1. The Pietermaritzburg-Durban region showing urban development and the catchment of the Mgeni River. Also shown are those parts of the Mooi and Mkomaas catchments from which water may be drawn to augment supplies in the Mgeni.

A deterioration in the quality of the water supplies of a region is an inevitable consequence of urban, industrial and agricultural development within the river basins which supply the region. The adverse consequences of deterioration in water quality include: health risks, particularly to those who use water directly from local streams and rivers, and who use the rivers and dams for recreation purposes; higher water treatment costs and a reduction in the value of these rivers and dams for recreation purposes (more than 450 000 visitors per year make use of the Natal Parks Board's recreation resorts in the Mgeni catchment).

Research on the Mgeni River system has been undertaken by several research organizations for the past two decades, and a large amount of data has been collected during this period. Although further research is required and the data collection and monitoring activities will have to be continued, several important conclusions can be made, based on this information:

1. There is a significant health risk to those who use water directly from the rivers without treatment, and this risk will increase with time. This applies particularly to the rivers in the lower reaches of the catchment;
2. The continued development of spontaneous settlements in the Mgeni River catchment, without adequate water supplies, sewage disposal or storm water drainage systems, will not only create unhygienic conditions within these areas, but will also increase the health hazards in downstream rivers and dams;
3. It is unlikely that the high standards of effluent treatment that can be attained in the urban areas, will be achievable in these rural areas within the foreseeable future;
4. Eutrophication from both point sources and diffuse sources is likely to be an increasing problem which can possibly be brought under control in Zones 1 and 2 but which is perhaps already beyond control in Zone 3. (Figure 2)

Recommendations

1. The principle of protecting critical catchment areas by controlling the development within those areas has already been established. Certain mountain area catchments where no development is permitted have been proclaimed. However, none of these is within the Mgeni River catchment. In addition new afforestation for timber production is limited by legislation. This limitation has been applied to the Mgeni River catchment with a view to maintaining, at its present level, run-off from this catchment.

   Obviously it is not possible to curtail all development which will lead to the deterioration of downstream water supplies. Nevertheless, it is desirable to recognize 'development zones' in the catchment so that future urban and industrial development can be located in areas where it will have the least adverse effect on the system as a whole.

   Zone 1 The Mgeni River catchment upstream of Albert Falls Dam, which also includes Midmar Dam (Figure 2), produces more than half of the run-off that is generated within the system. This water is of an exceptional quality as there is relatively little urban and industrial development in the catchment. It is essential that every effort be made to preserve both the quantity of water generated in the catchment as well as the quality of this water. Urban development and the establishment of industries, particularly those which produce polluting effluents should be limited to an absolute minimum. This single action will have a major effect in ensuring the highest possible quality for all users of water from the Mgeni River system.

   Zone 2 does not produce a major proportion of the river flow in the system (Figure 2). Due to the spontaneous development (unplanned development, occurring in areas where structured planning is not enforced) that is taking place in this zone it is anticipated that there will be some deterioration in the water quality, and that it will not be possible to achieve high standards of effluent treatment in this area in the foreseeable future. However, while no specific recommendations can be made relating to the control of future development in this zone, it is recognized that without improved catchment planning and management, development here will adversely affect water quality reaching the Nagle and Inanda Dams.

Zone 3 which includes the Mzinduzi River catchment and the Mgeni River catchment downstream of Nagle Dam lies along the Durban – Pietermaritzburg axis. This area is already heavily populated and contains most of the industries that are located within the Mgeni River basin. It is recommended that new industrial development be concentrated in this area which already has the necessary infrastructure to support such development.

If the recommendations above regarding Zones 1 to 3 are accepted, the major degradation in water quality will occur in Inanda Dam, and the adverse changes in Midmar and Albert Falls Dams will be minimized. In-dam ameliorative measures such as possible aeration and destratification of the stored water will then be limited to this one dam only, as will the implementation of sophisticated water treatment technology. The total water treatment costs for the system as a whole will be minimized, and the quality of water from the whole system will be maximized.

2. It is strongly recommended that a Regional Water Authority be established as soon as possible. This Authority should liase with all organizations concerned with statutory control in the Mgeni River basin area with the purpose of gaining consensus and commitment to a coordinated approach to water quality management.

   The Regional Water Authority must be verted with powers of town planning veto in order to effectively implement appropriate policies directed at optimization of water use and water quality.

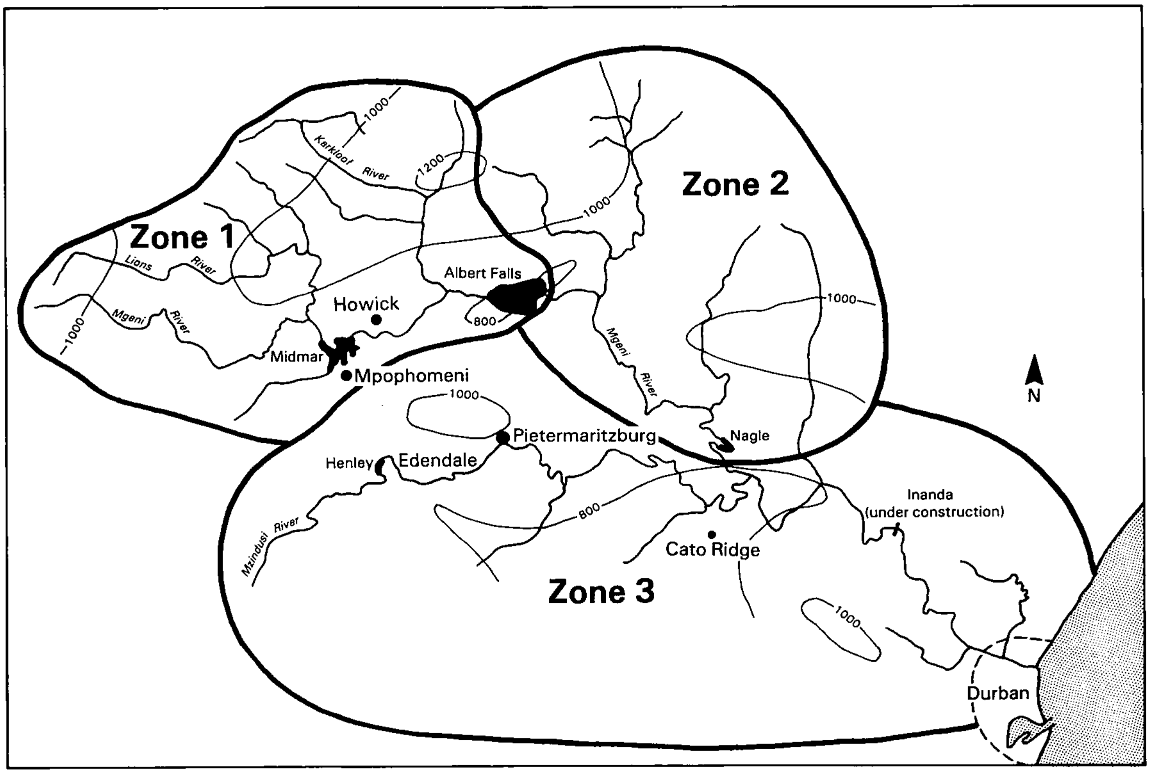

Figure 2. **The catchment of the Mgeni River showing existing impoundments and the Inanda Dam presently under construction. Also shown are the 'development zones' which are recommended for the management of water quality. These zones are delineated on the basis of run-off, present water quality and patterns of land use. Further details are given in the text.**

1. Introduction

Urban and industrial development along the Pietermaritzburg – Cato Ridge – Durban axis is largely dependent on water from the Mgeni catchment (Figure 1). In the, past with development focused in the Durban – Pinetown area, water quality problems resulting from the discharge of effluent were generally confined to the lower reaches of the Mgeni River. However, the Industrial Decentralization Policy has resulted in rapid industrial development higher up in the catchment (Cato Ridge and Pietermaritzburg) and water quality problems are now being experienced over a much greater part of the Mgeni system. It is confidently predicted that water which will be stored in the Inanda Dam, presently under construction, will be of inferior quality.

The Natal Town and Regional Planning Commission and the Committee for Inland Water Ecosystems having funded research on the Mgeni River system for a number of years recognized the need for the development of a policy for the management of water quality in the Mgeni catchment. They therefore sponsored a Symposium at which a wide range of interested parties including users, managers, and researchers, were able to express their opinions on the management of water quality in the catchment.

This report contains a synthesis of the proceedings of the Symposium which was prepared at a Workshop held immediately after the Symposium. It is the intention of this report to inform policy-makers of the developing water quality problems in the Mgeni River catchment and to suggest options for the management of water quality. However, since water quality reflects land-use practices in the catchment, management of water quality is contingent upon catchment management and this report therefore also addresses land-use practices in the catchment.

2. Regional Water Resources Planning

J C Perkins
J David

Development of the Mgeni River system as the principal supply of water for industrial and domestic use in the Durban – Pietermaritzburg region has required the construction of a number of impoundments.

In recent years the Umgeni Water Board has assumed responsibility for the supply of potable water to the greater Durban/Pietermaritzburg region. This includes some of KwaZulu, all of the North Coast area except Tongaat and Umhloti Beach and parts of the South Coast urban areas. At the present time the Mgeni River provides 90% of the requirements for this area but as development proceeds additional sources will have to be exploited.

Water demand

According to the 1980 census the population in the Umgeni Water Board supply area, which covers some 3085 square kilometres, was about 2,2 million. The dramatic increase in water consumption between 1951 (48 million cubic metres per year) and 1980 (250 million cubic metres per year) reflects largely the urban industrial growth which characterizes this area. Present demand (250 million cubic metres per year) is expected to increase to 550 million cubic metres per year by the year 2010 and to reach 920 million cubic metres per year by the year 2030. These projections include provision of water to densely populated areas of KwaZulu not supplied at present. It is obvious that the Mgeni River can not meet this demand and supplementary schemes (summarized in Figures 3 and 4) such as transfer from the Mooi River which was commissioned during the recent drought, will become a feature of the regional water supply system. Also obvious is that return flow, which threatens water quality, will become an increasingly significant component of the water resources.

Additional demands on the system are made by afforestation, agriculture and nature conservation.

- Afforestation in the catchment is controlled but it is estimated that it could reduce mean annual run-off by *ca* 8%.
- The Mgeni River downstream of Midmar Dam is a Government Water Control Area which means that additional irrigation development is subject to permit control by the Department of Water Affairs. Provision is made for 8,2 million cubic metres per year for riparian rights downstream of the Midmar Dam. Control should be extended to include the area above Midmar Dam.
- The National Research Institute for Oceanology of the CSIR has determined that about 18,2 million cubic metres per year is needed for flushing the Mgeni River Estuary and opening its mouth while a further 0,3 million cubic metres is needed to compensate for estuarine evaporation losses. Water quality in the lower Mgeni River will be poor and it is probable that this need could be met from return flow. The water would, however, have to be stored in order to achieve the required discharge pattern to effect flushing. There is a need to develop water quality criteria for conservation of the Mgeni Estuary and to assess whether conservation is a realistic goal.

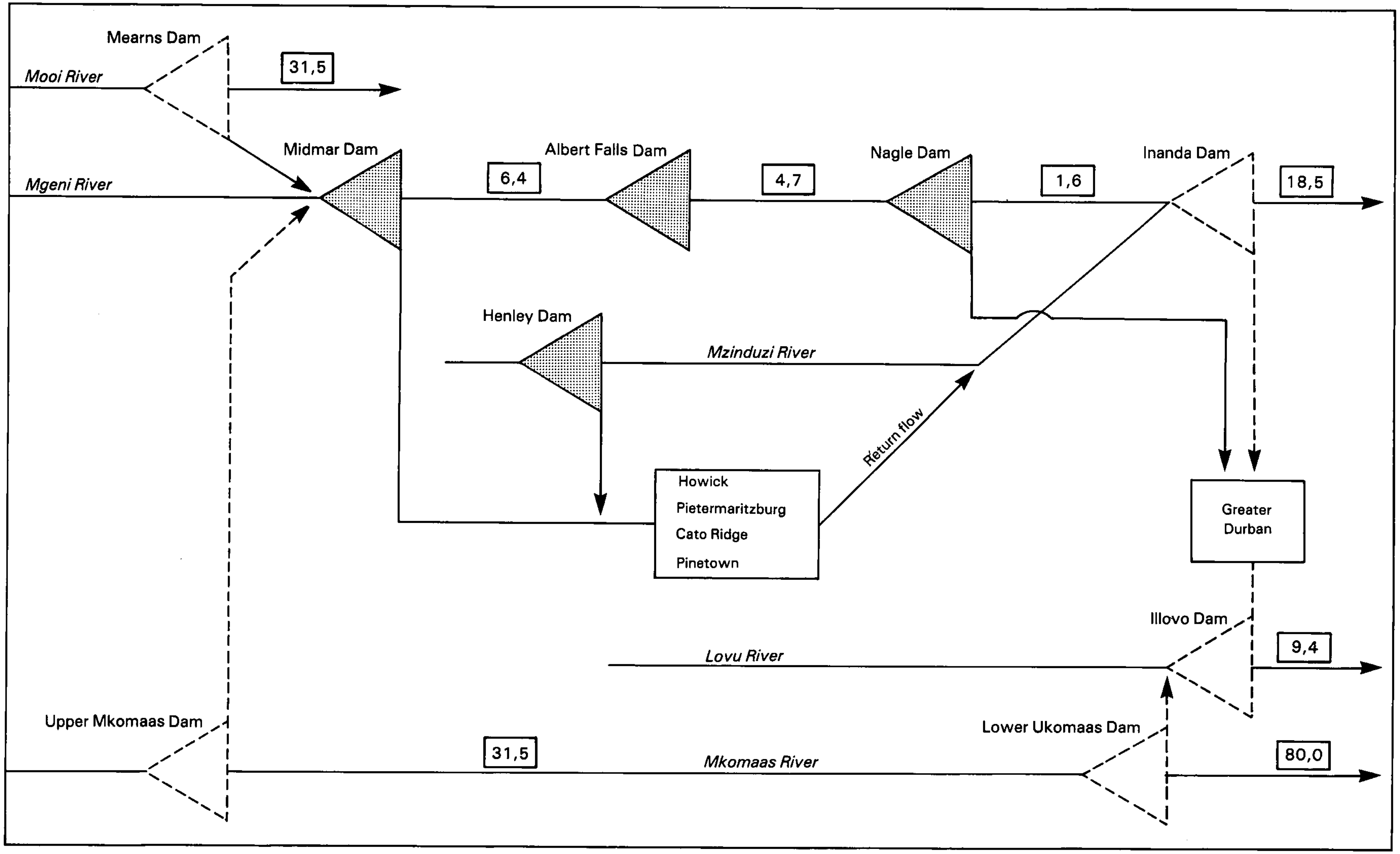

Figure 3. A schematic representation of existing and proposed water supply schemes for the Umgeni Water Board supply area. Existing supplies are indicated by solid lines and proposed schemes by broken lines. Volumes of water reserved for local use are depicted in the squares in million m^3 per annum.

Water resources

The principal options available for expanding the resources lie in abstracting water from adjacent river systems (Figures 3 and 4). These include:

- The Mooi River, from which diversion started in 1983. Water is pumped from a weir just above the confluence of the Mooi and Little Mooi Rivers to the Lions River which joins the Mgeni River upstream of Midmar. Some 50 million cubic metres per year can be imported into the Mgeni catchment at present but this can be increased by the construction of a dam at the pumping station site, to yield a total of 170 million cubic metres of which 31 million cubic metres is reserved for local use. However, the supply of water from this scheme will be regarded as temporary and its availability will be dependent on the demand for water by future development in the Mooi River catchment.
- The Mkomaas River. Diversion of the upper Mkomaas River into the Mgeni River above Midmar Dam can be effected under gravity by a 43 km tunnel from a site near Impendle village, increasing the yield of the system by 155 million cubic metres per year. The yield of this scheme can be increased by a further 144 million cubic metres per year by the construction of a large storage dam at this site. Existing supply infrastructure downstream of Midmar Dam will have to be expanded to accommodate the additional water.

  However, to utilize the Mkomaas River optimally, further storage will have to be created, lower down in the catchment. From the identified site water can be gravitated to the Lovu River from where it can be pumped to purification works and the reticulation system in the rapidly growing area south of Durban. Timing of the further changes are shown in Figure 4.

  Beyond the year 2040 the demand for water will exceed the supply of water from the Mgeni and Mkomaas River systems by which time alternative means of augmenting water supplies e.g. desalination of sea water and recycling of waste waters, will have to be utilized.

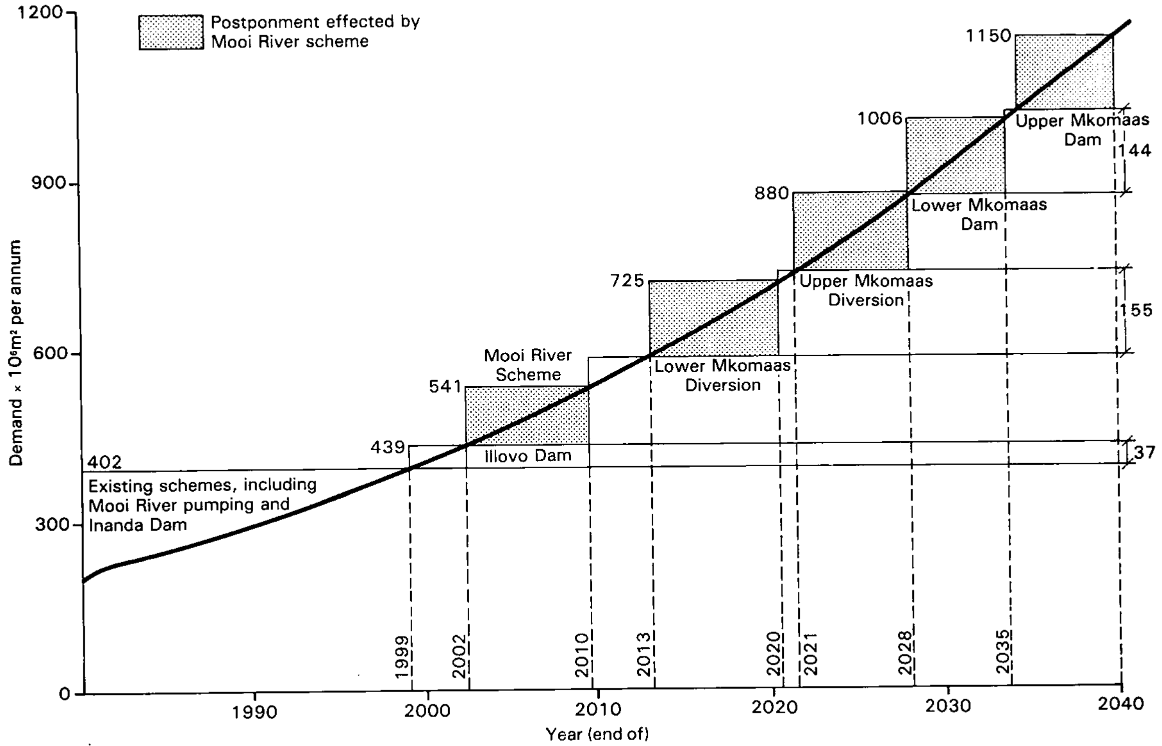

Figure 4. **A schematic representation of the sequence of implementation of new water supply schemes in relation to the projected demand.**

3. Factors Affecting Water Quality

C M Breen (Convenor)
E G J Akhurst
C A Bruwer
H Maaren
W Richards

There is no universally accepted definition of the term water quality since it means different things to many persons, depending on the purposes for which the water is used (e.g. potable, irrigation or recreation, see Kempster *et al* 1980). Water quality is determined by its physical, chemical and biological properties. It reflects also the interaction between natural processes and those associated with changing patterns of land use. Management of water quality should therefore be based on an understanding of how the system functions.

Natural processes

Rain transports soluble and insoluble matter from the atmosphere to the land. We are inclined to attribute little importance to this process but even in relatively undeveloped catchments a significant component of nutrient load derives from atmospheric fall out. Midmar for example receives 15 – 20% of its total annual phosphorus load (1 900 kg/y) in this way. With increased industrial development atmospheric pollution can become the major contributor to load e.g. 70% for Lake Mzingazi at Richards Bay. This observation stresses the need for policies governing the siting of industries and atmospheric pollution if water quality is to be effectively managed.

The catchment above Albert Falls has a high rainfall which results in the upper Mgeni, the Lions and Karkloof Rivers having a high mean annual run-off relative to the size of their catchments. As a consequence of the high run-off and the geological composition of the catchment, soils are highly leached and yield a soft water of good chemical quality which supports low levels of algal growth. Nevertheless, some users regard the water quality as problematic in that it enhances corrosion in reticulation systems. In addition, the soils have a very high phosphorus adsorption potential so that concentrations of phosphorus in run-off waters are maintained at low levels. At the present time therefore, algal growth which is the usual manifestation of enrichment of water with nutrients, is restricted to low levels by the supply of phosphorus.

Silt load in rivers and lakes largely reflects catchment erosion. Annual soil loss per unit area of the upper Mgeni catchment is low (105 kg/ha Scotney, 1970 cited in Johnston, 1985) when compared with the Mooi River (279 kg/ha) and the Mkomaas, both of which have their headwaters in the Drakensberg. This reflects the natural erodibility of the soils and the destruction of vegetal cover. It is principally for the latter reason that the Mzinduzi River which arises in similar landscapes to the Mgeni and Lions Rivers has such high levels of suspended solids.

Once water enters the river system, quality is further modified by in-stream biotic and abiotic processes. A significant part of the mean annual run-off is conditioned by passage through sponges and vleis in the upper catchment. Not only do these regulate discharge thereby attenuating floods downstream (e.g. Mgeni vlei) but they also provide natural filtering and purifying systems (e.g. Lions

River floodplain). Similar functions can be attributed to farm dams. The significance of these processes in the management of water quality increases under conditions of deteriorating catchment management and declining water quality, emphasizing the importance of conservation of sponges, floodplains and riparian vegetation.

The importance of the natural properties of the catchment as determinants of water quality is highlighted by the very small changes in water quality which are evident between Albert Falls and Nagle Dam (Archibald *et al,* 1980). Deterioration downstream of Nagle Dam results from anthropogenic rather than natural causes.

Anthropogenic effects

There are three principal ways in which man influences water quality: changing the pattern of land-use, discharging effluents and managing flow.

Land use patterns

It is fortunate that whilst most of the mean annual run-off arises in the upper catchment, intensive industrial development is largely confined to the lower catchment. Agricultural development is largely confined to the region upstream of Albert Falls and considerable opportunity exists for intensive crop production. It should be possible, using information available here and abroad, to predict the possible consequences of different levels of development for water quality, and to provide guidelines to reduce their impact. Agriculture in the upper catchment is not currently regarded as a problem for water quality management.

The National Institute for Water Research, in a survey nearly 20 years ago, stated that "No Class I waters have been found in the Mgeni catchment. Those waters of good enough chemical qualities to warrant falling in this class have ***invariably*** been found to be of too poor a bacteriological quality". This undoubtedly reflects patterns of land use and water use in rural and spontaneous settlement areas. Because people in these areas are still dependent on water drawn directly from rivers and streams, there is an attendant health risk. Incidence of cholera in the Mgeni catchment substantiates this view. Increasing attention will have to be paid to exploitation of groundwater resources in these rural areas.

Effluent discharge

Notwithstanding these problems, surveys indicate that point sources are more to blame than diffuse sources for the deterioration of water quality in the Mgeni system. There are more than 60 sewage treatment plants operating in the catchment most of which discharge substantial quantities of nutrients (nitrogen and phosphorus) into river courses. A common manifestation of a deterioration of water quality is increased algal and macrophyte growth which is stimulated by sewage discharges. It has been predicted by Archibald (1985) that the proposed Inanda Dam will be eutrophic and nuisance growths of algae and aquatic weeds are likely to develop. Problems currently being experienced with water hyacinth in the lower reaches of the Mgeni River substantiate this view.

Flow management

Water quality in a river is governed by interaction between the load and river processes which modify the load. Perhaps the most obvious modifier of response is dilution. Rivers are open systems in the sense that flow continuously displaces dissolved and suspended material downstream. In this way the concentration is diluted and the disturbance caused by a high chemical load is propagated downstream. Disturbance is greatest where the load enters and it decreases progressively downstream. The magnitude of the disturbance and time taken for recovery, are dependent upon the load and flow. Consequently, for a constant load (e.g. a sewage outfall) the consequences will vary both temporally and spatially with flow. The problem is complicated further by the temporal variability of the concentration of the river water immediately above the outfall. One can therefore easily appreciate the difficulties experienced when setting standards for water quality and the preferences for criteria based on the effluent at the point of discharge, rather than on the response of the river to the load.

Nevertheless, it is the quality of the water in the river that concerns users downstream and stresses the need for standards to relate to river water quality rather than effluent quality.

Storage of water in farm dams upstream of Midmar is likely to have a positive effect on water quality because of nutrient and sediment trapping. It will, however, modify dilution patterns and river flow particularly in the period immediately after drought. Since the area of land which can be irrigated is not permitted to expand, water consumption in the upper catchment is unlikely to significantly affect river processes. However, increased utilization of stored water from the large impoundments is likely to significantly reduce the capacity of the river system to dilute effluent loads and modify response downstream. Abstraction may also alter hydrodynamics in the estuary. Thus the quantity, pattern of supply, and quality of water reaching the estuary will determine its structure and functioning.

As flow in the riverine sections of the system (particularly those between impoundments) becomes increasingly regulated, water quality problems will become more evident in them. This is because flushing rates are decreased. The significance of flushing rate as a determinant of response to enrichment is evident from examination of most currently available predictive models. As more and more water is abstracted from the upper catchment, the extent of flushing will decline and the system will show accelerated response to enrichment. People drawing water from the rivers and streams will be faced with rapidly declining water quality, particularly in the Mzinduzi and downstream of Nagle Dam. Diversion of water from the Mooi and Mkomaas Rivers will increase flushing in the Mgeni River at least in the short term. The Mzinduzi will, however, receive increased effluent load by return flow.

Conclusions

Because of both the natural and anthropogenic influences on the water quality in the Mgeni catchment it is possible to delineate three zones of water quality (Figure 2).

Zone 1 — above Albert Falls where the high run-off coupled with soil type and land-use characteristics allow for a high quality water. More than 50% of the mean annual run-off in the system originates in this zone. Urban and industrial development should be directed away from this zone.

Zone 2 — this zone comprises the Mgeni River catchment between Albert Falls and Nagle because, at the present time, spontaneous settlements are increasing in this area. Water quality goals in this zone must be realistic and take cognizance of present and future development. Development should be directed away from Zone 1 and localized here and in Zone 3.

Zone 3 — this zone includes the Mzinduzi River catchment and the Mgeni River downstream of Nagle Dam, incorporating Inanda and the Mgeni estuary. In this zone discharges of sewage and industrial effluents will lead to a low quality water. Water quality in the upper Mzinduzi catchment is expected to deteriorate because of the spontaneous settlements above Henley Dam.

4. Water Requirements and Problems of Users

H N Wiechers (Convenor)
A K Barnes
L Gravelet-Blondin
C P R Roberts
R Wells

Water quality is evaluated in a number of ways, ranging from concentration of dissolved organic and inorganic compounds to aesthetic value judgments associated with recreational activities. Different users have different water quality requirements and it is logical to plan the apportionment of water for different uses so that those requiring highest quality water and having least impact on water quality, interact first with the water, i.e. these activities should be located in the upper reaches of catchments, and as water quality deteriorates downstream so the standards set for use and return flow are relaxed.

Users and uses of water

Responsibility for the provision of stored water rests with the Department of Water Affairs and the Umgeni Water Board is the bulk supplier of potable water to the urban and industrial areas. With the exception of agriculture and informal settlements which draw water directly from rivers and streams, the quality of water supplied to other users is the concern of the Umgeni Water Board. They and other organizations also have considerable interest in return flows and their effect on the quality of stored water resources. For example, the Natal Parks Board which controls conservation of aquatic flora and fauna and recreation on many of the impoundments (e.g. Midmar, which has *ca* 450 000 visitors each year), is concerned with water quality in the river system and in impoundments, before treatment. Although also concerned about the quality of river water as it influences stored water quality, the Umgeni Water Board is concerned with supplying water of potable quality. Different users may have different water quality requirements and goals.

Water quality requirements

Kempster *et al* (1980) have provided an excellent summary of existing water quality criteria for the different users of water including domestic, agriculture (e.g. livestock watering and irrigation) industrial (e.g. food processing, paper manufacture, textiles, iron and steel mills), recreation and conservation (e.g. protection of fish). It has been suggested that in providing water of a suitable quality for different users, the quality should match the minimum user requirement e.g. health requirements for rural communities and both volume and quality for conservation of the estuary, where this is economically viable. It seems that this philosophy could lead gradually to the acceptance of lower and lower water quality throughout the system, particularly where development occurs without adequate consideration of and planning for water quality. However, implementation of a system of development zones and improved effluent technology would ensure, as far as is possible, that development in supply areas is consistent with water quality goals. With such an approach the economic consideration associated with effluent treatment becomes less significant as a determinant of water quality criteria. For example: recreation, conservation and bulk water supply requirements are compatible and are presently met by existing land-use practices in the upper catchment. Downstream, at the proposed Inanda Dam site, it is predicted that inferior water quality could decrease the suitability of this impoundment for both recreation and conservation even though it will, after treatment, be suitable for bulk supply of potable water. The various needs of users can therefore only be met if urban and industrial development in the catchment is planned around both water quality and supply.

Present and expected problems

Occasional problems with water quality are already being experienced by major users drawing water from the Mgeni River. Little is known of the experiences of rural users, particularly those associated with informal settlements. The problems outlined below are expected to increase markedly in the foreseeable future as the rapidly growing population accelerates agricultural, urban and industrial development. This will make it more difficult to introduce standards which will be sufficient to maintain acceptable water quality. It is therefore urgent that the presently undeveloped key supply areas (upper catchments of the Mgeni, Lions and Karkloof Rivers) be immediately zoned for protection. The present and expected problems of different users are:

Bulk suppliers and domestic users

- High suspended solid concentrations occasionally present a problem which is aggravated by catchment degradation and is principally experienced downstream of Albert Falls. Diversion of Mkomaas water into Midmar may increase the problem
- Algal growth is occasionally problematical in Midmar and downstream impoundments and is likely to cause serious problems in the Inanda Dam where blooms of toxic algae may develop
- Increasing the storage capacity of Midmar by installation of crest gates may cause the lake to stratify thereby increasing the potential for water quality problems if nutrient load increases
- Increasing abstraction will alter flow patterns downstream and increase the probability of disease and other problems e.g. blackflies, plant encroachment into river courses (e.g. reeds and water hyacinth)
- Eutrophication may create chemical (e.g. manganese) water quality problems in Inanda Dam. Similar problems can be expected in other impoundments if they become eutrophied
- Eutrophication may cause health problems i.e. release of toxins into the water and the production of precursors for carcinogenic chlorinated hydrocarbons. Algal-laden eutrophied water may also give rise to undesirable taste and odour. Incidence of these problems will increase as return flow effluents contribute more to river flow and stored water. Problems can, however, be circumvented by the use of ozonation in place of chlorination as presently practiced at the Wiggins water treatment works
- Much of the water supplied for domestic use is not consumed. Consideration could therefore be given to reticulation of second-class water in a separate reticulation system. This poses both technical and health problems and may be economic only where a single large user or group of users can be supplied
- Present water supply and sanitation in informal settlement areas poses serious health risks
- Water causes corrosion in reticulation systems.

Industrial users

- Water supply and quality, as well as inexpensive effluent treatment has been taken for granted in the past. Water tariffs have been so low that they were not seriously considered in the planning, design and operation of industrial plants. However, should water tariffs rise inordinately high, industries who are the major water users in the Mgeni Catchment, may reclaim and re use water to such an extent that the reduction in industrial use would cause the unit cost to the domestic user to increase significantly

- Efficient in-house water use and the re use of effluent, may increase the costs of meeting acceptable effluent standards (e.g. 1 mg P/1). There is a need to consider standards based on load rather than concentration
- Industry is experiencing problems in complying with existing standards. If they could make use of second-class water thereby saving good quality water for potable purposes it would reduce the total amount of high quality water which is degraded
- Re use of effluent (second-class water) could elevate total dissolved solid loads in the middle catchment
- With increasing industrialization the danger of toxicant spills increases. Zonation so that industries are downstream of the principal supplies of potable water is advantageous.

Agriculture

- Increasing development of intensive agriculture in the upper catchment may cause a deterioration in water quality. If this is to be controlled, then agriculture in the area must be closely monitored. The transport of pollutants (nutrients, pesticides, silt etc.) to rivers and stored waters must be held within acceptable limits
- Catchment degradation, particularly of riparian wetlands and headwater sponges (e.g. Mgeni sponge) must be prevented otherwise the incidence of flooding will increase and water quality will deteriorate.

Conservation and Recreation

- Water quality above Albert Falls does not presently pose problems for conservation and recreation. Downstream water quality will become less suitable particularly at Inanda. Recreation is not currently being contemplated for Nagle Dam.
- Diversion of water from the Mkomaas will increase turbidity of Lake Midmar but this should not create serious problems
- Draw-down will increase during dry periods adversely affecting recreation
- Discharge downstream will be restricted. The pattern and timing of releases may be important for conservation and recreation downstream
- Problem growths of aquatic plants can be expected downstream of Nagle Dam.

Conclusions

Few problems are currently experienced in meeting the requirements of users. Protection of water quality in the upper catchment and importation of good quality water from the catchments of the Mooi and Mkomaas Rivers will significantly reduce problems experienced by bulk suppliers.

Industries are already experiencing difficulty in attaining effluent quality standards based on concentration. Exclusion of industrial and urban development from the upper catchment is desirable, and lower water quality in the downstream system will have to be accepted.

5. Policies and Criteria of Regulating Authorities

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The optimal utilization of water resources requires a system of management which ensures that the quality and quantity of water supply is maintained. Such management, through the establishment of policies and criteria, is able to meet the demands of water users. The present situation in the Mgeni catchment is complex with eight authorities regulating the use of water.

Regulating authorities

A number of organizations with different functions and with some degree of regulating authority have interests in the Mgeni catchment. These are:

- Local authorities (e.g. municipalities) who control the final stages of the use of water, mostly for domestic and potable purposes
- Umgeni Water Board which is responsible for purifying water to required standards and distributing it to local authorities. In some cases the Board distributes to end users
- Natal Parks Board which operates areas of conservation and recreation. Although the Board has jurisdiction over these areas it does not play a role in regulating the quality and quantity of water supplies. It is concerned principally with control of the use of the water surface of the storage dams, the immediate surrounds and law enforcement associated with conservation
- KwaZulu Government which manages water supply and effluent treatment in areas under its jurisdiction. Although presently operating under the same water laws as the South African Government this could change
- The Department of Co-operation and Development is responsible for water supply and treatment in KwaZulu Trust Lands
- The location of industries and utilization of areas within the catchment is controlled by Provincial Legislation, enacted on advice from the Natal Town and Regional Planning Commission
- Directorate of Water Affairs is responsible for the provision of water through construction and maintenance of the bulk storage reservoirs. It is also responsible for legislation and implementation of water quality standards
- Central Government can be considered a regulating authority in that it plans for the optimal use of water and for development in the catchment.

With so many organizations involved in the supply and treatment of water close coordination will be required if water quality is to be protected. In view of the close relationship between water quality and land-use, the catchment development plan must take due cognizance of the vital need for preserving water quality.

The Water Act

The Water Act which originated in 1956 has been amended many times over the years. It was originally conceived for the following purpose:

"To consolidate and amend the laws relating to the control, conservation and use of water for domestic, agricultural, urban and industrial purposes and to make provision for the control of certain activities on or in water in certain areas, and of activities which may alter the natural occurrence of certain types of atmospheric precipitation."

The policies of the local and regional authorities should be geared to comply with the requirements of the Water Act, i.e. the control that their policies afford over the users and discharges under their jurisdiction must be of such a nature that it will ensure that the qualities of the resulting effluents do comply with the Act. Stricter standards, exceeding the requirements of the Water Act, do not seem to be reasonable since the additional costs, cannot be easily justified. This observation emphasizes that it is better to zone sub-catchments (e.g. above Albert Falls) for agriculture than to allow urban and industrial "sprawl" to create water quality problems in all parts of the catchment.

Two sections to the Water Act are pertinent:

- Section 21 which prescribes legislation on the purification and disposal of industrial water and effluents
- Section 138 which deals with Water Boards and the regulations which govern their establishment and operation.

These sections of the Water Act have been used to define water quality standard (criteria) for the Mgeni catchment and to enforce their application.

Criteria

Water quality is influenced by point and diffuse sources of pollution. Point sources are represented by localized discharges of effluent (e.g. sewage outfall) and compliance with water quality criteria is more easily monitored and controlled than for diffuse sources which derive from run-off entering rivers and streams over an extended area. Diffuse and point sources in rural areas (e.g. above Midmar Dam) do not usually create water quality problems and natural river processes can maintain acceptable water quality. However, even where strict criteria are set for effluent from urban areas, diffuse loading may be sufficient to create water quality problems. It is evident therefore that attainment of high water quality standards below urban and industrial areas (e.g. Edendale/Pietermaritzburg) will incur considerable cost and may not, even then, be attained. In addition, since effluent criteria are based on concentration (e.g. mg P/1) in the effluent, as more effluent enters the river and as abstraction reduces flow, the water quality in the river will deteriorate even though all discharges comply with the standard. Safeguarding water quality will depend on controlling the total load by applying stricter standards and/or reducing the amount of effluent reaching the system.

Problems in complying with regulations

Available technology, standards and costs.

The Water Act prescribes standards which should be met by water treatment processes for the discharge of effluents into river courses. Adequate technology is available to meet most of the general and special standards. It should be realized that as new technologies become operational, stricter standards might become more feasible, and all new discharges should be required to meet the modified standard.

Treatment of water to the level of purity required by the consumer, is cost-related to the degree of pollution in the water. This cost is ultimately borne by the consumer from charges levied on the supply of water.

Two considerations are pertinent: should the cost of water supplied from the system be dependent on the quality/quantity of the effluent ? and should the effluent standard be related to the quality of the water supplied as well as to the quality of water receiving the effluent ?

The importance of the Mgeni system has led to its declaration as a catchment in which the special standards for effluents (Government Gazette No. 991, 18th May 1984) apply. Of particular interest is the standard for phosphate in effluents (1 mg P/1) which was established to control eutrophication. Whilst the technology exists to treat effluents to meet this standard, it is probable that many authorities will be unable to meet this standard until existing treatment plants have been upgraded to incorporate this technology. Fortunately most of these discharges are situated in Zones 2 and 3 (Figure 2). Those in Zone 1 (Mpophomeni and Howick) should be subject to urgent attention and strict control.

Policy revision and coordination

Present co-ordination in the setting of criteria and in enforcement of regulations pertaining to the Water Act is inadequate. For example, there is an urgent need for improved coordination between the KwaZulu Government and the other regulating authorities because most streams in the catchment flow through KwaZulu. Talks between the Minister and the President are being initiated to establish the proper channels of communication. In view of the complexity of the issues involved in maintenance of water quality it is suggested that a South African representative, seconded as an advisor to the KwaZulu Department of Water Affairs, could usefully contribute to coordinated planning for water quality management. Even within South Africa planning development in the catchment should be better coordinated. At present problems experienced in the maintenance of water quality only became evident long after the development was initiated. Rectification of the problem may require plant modification and be capital intensive which makes it difficult to justify. Water quality continues to deteriorate in the short to medium term while these modifications are made. With the present emphasis on industrial growth, attention must be directed at water quality.

If a clear statement of the policies and goals of the water management authorities was available, it would allow the orderly development of effluent treatment methods in the Mgeni catchment area, and coordinate advances to obviate untimely obsolescence of treatment processes, and to allow planned development, in stages, of effluent treatment systems. Goals should be established for this with clearly defined incentives to allow industry to plan and implement effluent treatments to comply with this policy.

In order to achieve this it is essential that a coordinating organization should address water quality management issues within the Mgeni catchment. The Umgeni Water Board, which is the main supplier of bulk water should play a leading role but, because the control of water quality and supply is dependent upon the implementation of a regional planning policy, the Umgeni Water Board should be closely consulted in the formulation of such a policy which should thereafter be enforced by The Natal Town and Regional Planning Commission. A recommendation for the protection of water quality in the Mgeni catchment, which will have to be sanctioned by the Minister, for the protection of water quality in the Mgeni catchment would be to vest the responsibility for monitoring and enforcement of the provisions of the Water Act in the Umgeni Water Board which is the body with the most direct interest in preventing pollution.

It is also felt that for the purposes of effluent treatment, water supply and long-term strategic planning the Board should contribute to the policy for controlling the establishment of new industries, growth areas, housing, afforestations, intensive farming activities, nature conservation, recreational areas, etc.

It is further recommended that all wastewater treatment installations in the area should be under the control of the Umgeni Water Board and that all wastewater treatment be financed as a component of the water tariff.

Such a policy would provide the flexibility for the Board to apply trade waste tariffs and to grant rebates to industry for pre-treatment.

6. Options for the Management of Water Quality

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Expansion of man's activities in river basins leads to both an increase in demand for water and an increase in return flow of effluent. Consequently, it almost always results in a deterioration of water quality. Water use and water pollution are so closely interrelated that the exploitation of water resources and manipulation of effluent wastes should be regarded as a single issue. The options available for management of water quality should therefore be integrated to form an overall strategy including economic, legal and organizational considerations for utilization and conservation of water quality in the Mgeni system as a whole.

Strategic considerations

The overall objective of water quality management in a river basin is to optimize water resource utilization and maximize the quality of life for its inhabitants. The costs of pollution and the value of recreation are difficult to assess mainly because they necessitate subjective (value) judgements by people with different expertise, experiences and responsibilies. Furthermore, economists have traditionally attached little value to the use of water so that it is regarded as a "free" commodity. As such, it is readily abused because on the input (water supply) side, production capacity is the principal limitation for the use of the commodity. On the output (discharge) side, water provides a convenient way for the disposal of unwanted by-products. Measures taken during the recent drought in Natal have shown that legislation, which incorporated economic incentives in the use of water, was highly effective in regulating the quantity of water abstracted from the Mgeni. Legislation should also be extended to incorporate incentives for water pollution control so that both quantity and quality can be optimized. Regulatory legislation on its own is inadequate for reaching optimal solutions for water quality management because:

- It does not recognize freshwater systems as dynamic integrated ecosystems which require ecologically-orientated planning and management
- It does not explicitly encourage the maintenance of standards with a minimum cost because there is no possibility of a trade-off. Thus, it does not motivate effort to find cheaper ways of reducing effluent loads, below the legal limit, through innovative technology.

More attention should be given to a price control system for water quality, even if it requires revision of legislation. There are available a variety of pricing strategies which could be incorporated into water quality management options.

Operational considerations

There are three principal operational options for the management of water quality:

- manipulation of bulk supply

- manipulation of pollution sources
- within-system manipulation

Manipulation of bulk supply

In systems such as the Mgeni where flow is regulated by a series of impoundments, water quality control can be optimized by drawing as much water as possible from the lowest (downstream) impoundment first, followed by the second lowest and so on. This has the particular advantage that the high quality water emanating from the upper Mgeni catchment can be used to improve water quality downstream. Considerable importance should therefore be attached to the maintenance of water quality in the upper catchment i.e. in Midmar and Albert Falls Dams.

Because of the regional distribution of demand, water stored in Midmar will be under-utilized for some years once Inanda takes over as an auxillary supply for the greater Durban area. Consideration has been given to releasing water from upstream dams to flush the lower impoundments (Albert Falls and Nagle Dams) thereby moderating the build-up of pollutants in these systems. However, the storage capacity of Midmar is much less than Albert Falls and Inanda and very large releases would be required to effect significant improvement. Thus before flushing can be considered as a regular management option it must be established that the water lost from the upper storage impoundments will not increase the risk of shortage beyond acceptable limits. Although the Mkomaas will provide additional water to the upper system the practice of flushing will require accurate projections of how the demand for water will change during the next twenty years. It seems improbable that flushing will be a viable option even during the initial years.

Manipulation of pollution sources

With the urban, semi-urban, industrial and agricultural expansion foreseen in the Mgeni catchment pollution loads will increase and pollution control measures will have to be revised if the quality of receiving water is to be acceptable. Forward planning should be based on projected changes in water quality and the implications of development should be assessed in the context of the catchment rather than at the local level. Recent amendments to the Water Act empower Water Boards to play an increasing role in the planning and operation of water and wastewater plants so the significance of their contribution will increase in the future. It is considered important to extend the boundaries of the statutory areas of supply to coincide with catchment boundaries, where practicable, in order that meaningful planning and control can be effected. Where inter-catchment transfers occur, Water Boards will have to coordinate planning so that compatible goals for water quality are set. Manipulation of pollution sources should have a high priority because:

- It offers the first line of defence against deteriorating water quality i.e. by zoning land-use control is directed at the cause rather than the symptom of deteriorating water quality
- It offers the most opportunities for control of water quality.

In order to reduce the impact of effluents on the river system, a number of effluent management options can be implemented. These range from process options in which the effluent is physically/chemically treated and then recycled, to river system options in which the "cascade" system is employed. In the latter scheme periodic discharges of water are cascaded down the river system in a series of steps. In the first step the users have a high quality water whilst subsequent steps (users) receive increasingly poorer quality water. The final step yields a relatively low volume of very poor quality water which can either be treated or discharged into the sea.

During the recent drought in Natal it became evident that introducing pricing control on bulk supply in the form of sliding scale water tariffs can also prevent the abuse of potable water. Approximately 25% – 30% reduction in water use by industry has been mainly achieved by "First Generation" water saving methods. However, with the rapidly increasing cost of potable water, and taking the cost of effluent discharge into account, "Second Generation" water saving methods can be regarded as propositions. These would include the utilization of recycled and/or reclaimed effluents in a cascade system. It should, however, be determined whether it is desirable for every industry to install a reclamation system or whether this could be done more efficiently and on a larger scale by a Water Board or Municipality. "Second-Class" water can be sold to industry at a more attractive price than potable water. An example of this type of reuse in the Mgeni catchment is the Mondi Paper Company near Durban which operates a 12 000 cubic metres per day renovation plant receiving activated sludge effluent from Durban's southern sewage works. Rapid progress is being made in reducing costs of desalination and advanced wastewater treatment, and these processes are being applied by industries to improve the water quality of processed water. However, their large-scale use will eventually create serious brine and final effluent disposal problems. A dual water supply system meeting the ideal of providing different grades of water in an industrial area has found application in Port Elizabeth, where final industrial effluents are discharged into the sea.

When there are a number of authorities discharging effluents into the same river system, in the absence of proper coordination, the overall goals for water quality in the catchment are easily ignored. Not only would a single regulating authority safeguard water quality but it could also be effective in pooling expertise and improving communication.

Sources of pollution are conveniently identified as either "point" or "diffuse" sources depending on whether they enter the river or lake at a point generally over a wide area, e.g. from the atmosphere or agricultural areas which are heavily fertilizor and irrigated. There are indications that cash crop agriculture is the most likely diffuse source of phosphorus in the upper Mgeni catchment. To be able to preserve the water quality, soil and nutrient loss from agricultural lands should be minimized by careful conservation practices. Cultivation of marginal lands and wetlands should be avoided or carried out with clear conservation guidelines.

The diffuse nutrient load from urban areas in the Mgeni can, as yet, not be differentiated from the point source contribution, and its significance is thus not clear. With the large investment in point source control, research should continue to quantify the diffuse load contribution.

Rapid agricultural, urban and industrial development is expected in KwaZulu. This could have a considerable effect on water quality because KwaZulu areas are located in the catchments of Midmar, Henley, Nagle, Hazelmere, Shongweni and the proposed Inanda Dam. The Mgeni River catchment includes the districts Mpumalanga, Vulindlela and part of Ndwedwe. The total rural population in these areas is estimated to be as high as 250 000 people who use untreated water resources. Here there are virtually no potable water or effluent treatment facilities. The rapidly expanding Mpophomeni township has a conventional bio-filter sewage works which will be linked to reedbeds for phosphate removal. It can be expected that the nutrient load from these areas is going to increase dramatically as effluent is collected, treated and discharged to the river. However, in the event of the effluent not meeting the required standards, it could be treated chemically or gravitated to Howick, thereby bypassing Midmar, but it would still hold significant implications for Albert Falls.

Within-system manipulation

There are a number of within-system water quality management techniques which could be considered in the Mgeni system:

- Bypass of low quality water: a highly successful floodwater bypass system exists at Nagle Dam which allows for silt-laden water to bypass the impoundment. Extremely turbid storm run-off can occur in the Mooi and Mkomaas Rivers and transfer of such water into Midmar during floods should be avoided. It may, however, not be practical to divert turbid water for storage in the lower Mkomaas Dam
- Selective discharge: low quality water from specific layers of a lake (e.g. anaerobic, nutrient-rich bottom waters), can be selectively discharged in order to improve overall water quality. This has been practised periodically at Shongweni and Midmar, but may become increasingly more important if crest gates are added at Midmar and thermal stratification becomes more significant. The impact of selective discharge on downstream Albert Falls Dam needs

evaluation. Facilities for selective discharge have been included in the design for Inanda Dam and operating rules should be drawn up to meet the requirments of the estuary downstream

- Aeration and/or destratification: this technique, which involves aeration of the water still needs to be proven in South Africa. Although the concept of re-oxygenating low quality anaerobic waters is sound, no attempts have been made to predict how effective it will be in the Inanda Dam. Experimentation with the technique is intended at Inanda Dam
- Control of aquatic weeds: water hyacinth and Kariba weed occur in the Mzinduzi River above the site of the Inanda Dam. Management options include the eradication of the plants from the river system (which implies a sustained effort for many years) or control of these plants by chemical spraying or physical removal
- Use of barrier screens, suspended from floats, around the offtakes of Inanda Dam could reduce problems experienced with filtration resulting from planktonic algae
- Controlled water release: in a system like the Mgeni the release of water from one impoundment to the next can have major implications on several facets of river ecology.
    - (i) Changed and stable water flow in the river system could create ideal conditions for growth of problem species such as reeds and black flies. Should problems arise, variation of flow releases or, biological and chemical control measures will have to be considered
    - (ii) There is some evidence that phosphates and algae are removed by in-river processes. Knowledge is needed on how to optimize these processes and to utilize pre-impoundments (structures which detain water or slow its flow thereby capitalizing on natural processes which improve water quality) as a means of enhancing phosphate losses and reducing sediment loads
    - (iii) The functioning of estuarine ecosystems is greatly affected by the availability of fresh water. The Mgeni estuary will require at least 18 million cubic metres per year but research should establish the frequency and timing of releases. In addition, the available water will almost certainly be of poor quality and the implications should therefore be assessed.
- General: it is doubtful whether other in-lake quality management strategies such as lake bottom sealing, dredging to remove bottom sediments and chemical precipitation will be considered in the Mgeni catchment in the foreseeable future.

Conservation and recreational management

Conservation can play an important role in the protection of water quality: vegetation stabilizes river banks, reduces erosion and helps to purify water. Thus, the vegetation of river banks, vleis and floodplains should be conserved irrespective of the fact that they may be unique habitats and support threatened species. Particular consideration should be given to defining the conservation needs in the catchment and assessing the extent to which these can be included in the overall development plan. There is good reason for conservation to be a priority goal above Albert Falls. Below Nagle conservation is seriously threatened by low water quality and the implications need to be assessed objectively so that goals can be formulated and recommendations made. There will ultimately be five impoundments on the Mgeni system (Midmar, Albert Falls, Nagle, Inanda and Henley) each of which will have differing water quality and thus differing conservation and recreational value. In the recreation planning for Inanda Dam attention should be given to the expected generally low water levels of the dam.

7. Information Requirements and Research Needs

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The object of research and monitoring of water quality in the Mgeni catchment has been twofold: to identify existing and potential problems and to promote land- and water-use practices which safeguard water quality. However, despite being one of the most intensively researched and monitored systems in South Africa there is at present, no clearly stated water quality policy for the Mgeni system and no single coordinating body is charged with maintenance of water quality through catchment planning and management. Thus the relevance of research and monitoring cannot be assessed and it is difficult to assign priority to research needs.

Water quality reflects the interactions between land-use practices and those which occur within the aquatic systems (rivers and dams). The information and research needs can therefore be identified at two levels: the broad catchment or system level, and the narrower sub-system level (e.g. town, farm, river, dam).

System research and information needs

A number of factors interact to determine how the system will change with time. These include broad regional policies e.g. the industrial decentralization policy and water supply development policy, which are formulated by a number of different organizations (e.g. South Africa and KwaZulu Governments). The implications of these policies need to be assessed if water quality is to be effectively managed. At the system level the most urgent need is for a synthesis of urban, industrial and agricultural trends in the catchment. This should include also an analysis of the probable water requirements (quantity and quality) and potential water quality problems (including atmospheric pollution).

The analysis should be structured in the form of a broadly based dynamic systems model which permits simulation of the probable effects of policy decisions (e.g. urban-industrial growth points, pricing controls, water quality criteria). This model would be based on sub-systems such as Pietermaritzburg/Edendale, Cato Ridge, Greater Durban, rural informal settlements and agricultural areas.

Sub-system research and information needs

A wide range of information is required to develop the understanding of how the sub-systems function and influence water quality. Much information is available, but it has not been synthesized in a form which permits analysis and solution of water quality problems and the formulation of guidelines for a water quality policy. For example, urban and industrial growth trends have been established for various areas in the catchment yet their implications for water quality have not been established. Without predicted trends in water quality it is impossible to foresee problems and institute appropriate controls or to set standards.

Water quality management requires both a conceptual framework and a range of "tools" or management options. Zoning the catchment provides a conceptual framework within which the efficacy of various options can be tested. A range of management options are available and their value needs to be assessed using presently available information. Once this has been done it will be possible to identify shortcomings in both the data base and the options, and research priorities can be defined accordingly.

This does not suggest that research and information needs cannot be identified now. They can, but it will be difficult to assign priorities. For example, water is already being supplied from the Mooi River yet that system is inadequately researched and monitored; the flushing requirements (volume of water) for the estuary are known yet how this should be supplied and the significance of water quality has not been established. It must be realised therefore that the list of research and information needs which follows is not structured in priority sequence, with the exception of that leading to development of the catchment simulation model.

List of research and information needs

Immediate needs

- Development of a dynamic systems model of the Mgeni catchment which links rural, urban and industrial trends to make broad predictions of water quality trends
- Formulation of water quality policies for the Mgeni catchment. These should be interactive with the model and in so doing will help to define research needs.

Longer term needs

- Compile a land-use map and development plan
- Assess the implications of inter-catchment water transfer
- Assess compensation needs (minimum flow and quality) for various purposes (farming, conservation, rural populations)
- Establish quantity and quality required for irrigation
- Investigate utilization of effluent for irrigation water
- Establish the implications of afforestation on water supply
- Establish flushing requirements for the estuary (quantity and quality)
- Assess possible consequences for river bank erosion caused by sudden releases from impoundments
- Formulate recreation and conservation goals and needs (including releases e.g. for 'Duzi marathon)
- Examine the desirability and implications of cascade reuse of effluents by industry
- Establish the relationship between land-use and nutrient/pollutant export
- Assess the efficacy of various operational procedures for water quality management
- Evaluate currently available water quality prediction models with a view to developing improved models
- Evaluate applicability of available ecosystem models to Mgeni impoundments
- Evaluate the implications of current water quality standards for the management of water quality
- Evaluate sites for urban and industrial development
- Develop appropriate technology for water quality management in rural informal settlement areas
- Evaluate whether the present monitoring network is adequate (number and location of stations and analysis)

- Elucidate importance of atmospheric loads as a determinant of water quality
- Develop predictive models for river and lake recovery processes
- Assess the implications for human health of zoning development in the catchment
- Prepare a bibliography of information of the Mgeni catchment
- Examine the feasibility of a common data bank.

8. Conclusions

The particular patterns of rainfall and urban and industrial development in the Mgeni catchment are such that it is possible to protect the quality of more than fifty percent of the mean annual run-off by judicious planning in a small part of the catchment, the area upstream of Albert Falls and Midmar Dams. It is therefore suggested that water quality be managed by controlling development and land-use in the upper catchment whilst in the remainder development would be encouraged. The emphasis would be on control of effluent quality and lake and river management.

The major threat to water quality is insidious development principally in the area above Albert Falls. Clearly therefore the hope for protection of water quality lies in the formulation and implementation of a catchment development and water quality policy. This requires establishment of a Regional Water Authority which ensures that land-use planning takes cognizance of water quality planning and vice-versa.

Once the policy has been formulated it will be possible to define catchment and water quality management goals; set appropriate water quality standards; implement a monitoring programme directed at goal attainment and identify information and research needs. The Regional Water Authority must periodically review whether goals are being attained so that either implementation can be modified or a more appropriate policy introduced. Because the future of water quality management is very closely linked to land-use planning it is suggested that the Natal Town and Regional Planning Commission and the Umgeni Water Board could coordinate the activities of interested organizations.

9. References

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10. Appendix

List of Symposium Papers

Opening Address: His Honour the Administrator of Natal – Mr R M Cadman

Urban and Rural Development Trends in Natal/KwaZulu: Mr A M Little, Natal Town and Regional Planning Commission

Water Quality Needs and Problems

Industrial Perspectives: Mr M Hartmann, South African Abattoir Corporation.

Agricultural Perspectives: Mr M Johnston, Department of Agriculture

Recreation and Conservation Perspectives: Mr R Porter, Natal Parks Board

Rural and Informal Settlements: Mr H Klem, Department of Co-operation and Development

Factors Affecting Water Quality

Overview of Water Quality: Ms D Richardson, Department of Water Affairs

Water Quality – Physical, Chemical and Biological: Interactions: Professor C M Breen and Professor J. Heeg, University of Natal

Application of Predictive Models to Water Quality Management: Mr C.G.M. Archibald, National Institute for Water Research, CSIR

Criteria for Regulating Water Quality

Prospects for Regulating Water Quality: Mr G Grobbelaar, Department of Water Affairs.

Application of Water Quality Regulations: Mr L Gravelet-Blondin, Department of Water Affairs

Management of Water Quality

Management of Water Supply: Mr J Perkins, Department of Water Affairs

Water Quality Management Options: Mr E Braune, Department of Water Affairs

List of Workshop Review Papers

Water Quality Requirements and Problems of Users: Dr H N Wiechers

Factors Affecting Water Quality: Professor C M Breen

Policies and Criteria of Regulating Authorities: Mr G Grobbelaar

Options for the Management of Water Quality: Mr E Braune

Critical Information Requirements and Research Needs: Dr J Hemens

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