South African
Water Law
Review Process

# The Philosophy and Practice of Integrated Catchment Management:

## Implications for Water Resource Management in South Africa

Department of Water Affairs
and Forestry

and

Water Research Commission

WRC Report No TT 81/96

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# FOREWORD

South Africa is a semi-arid country whose scarce water resources are not equitably distributed in geographical terms. The Department of Water Affairs and Forestry has recognized that naturally occurring water can only be effectively and efficiently managed within a river basin or catchment area. Thus, the Department recognizes and accepts that an integrated catchment management approach is necessary in South Africa.

This approach will help to achieve a balance between the interdependent roles of resource protection and resource utilization. However, our situation is complicated by the facts that provincial and other political or administrative boundaries often divide catchments, and that inter-basin transfers allow water to cross catchment boundaries.

Water and the management and development of water resources are regarded as the responsibility of the National Government, in particular the Department of Water Affairs and Forestry, as these functions are not specified as functional areas in Schedules 4 and 5 of the Constitution, which sets out the legislative competencies of provinces.

The sustainable protection, utilisation and management of South Africa's water resources must be based on sound principles of natural resource management. This means that the Department's responsibilities with regard to protection of the resource relate to the management of all aspects of water quantity, water quality and the physical and structural characteristics of the resource. It is also important to understand that land, water and air quality degradation, together with their subsequent impacts on land and water users, cannot easily be separated or managed independently of one another. Therefore, co-ordinated planning and action is required at all levels, from national government through provincial authorities to local authorities and communities, as well as individual landowners and water users.

This need to link together the activities and priorities of many different agencies and Government departments is reflected in the several initiatives which are currently underway in South Africa. These initiatives include the development and application of Strategic Environmental Assessment protocols, as well as the initiation of Integrated Pollution Control principles and practices.

The role of central government in integrated catchment management must be one of leadership, aimed at facilitating and co-ordinating the development and transfer of skills, and assisting with the provision of technical advice and financial support, to local groups and individuals. Where specific areas of responsibility fall outside the mandate of a single government department, appropriate institutional arrangements are needed to ensure effective inter-departmental collaboration. In this process, individual landholders and communities are recognized as competent partners. Where these individuals may lack the necessary skills for full participation, the lead agencies must take responsibility for assisting with their development and application.

As custodian of our water resources, the Department of Water Affairs and Forestry also plays a leading role in the development of guidelines and procedures for water resource management. The Department is also responsible for ensuring that the needs of water users can be met, in perpetuity. Here, the often controversial issue of water allocation to different water users is based

on the principles of social equity and justice.

Responsibility and accountability must accompany any statutory power to manage a catchment. The successful execution of such responsibility requires appropriate levels of skills, expertise and judgement. Thus it is essential that government agencies at national and provincial level should provide leadership which will help to co-ordinate the development and implementation of appropriate policies and strategies, facilitate negotiation and conflict resolution processes, provide technical advice and financial support, and transfer skills to catchment organizations.

The Department recognized the importance of drawing on the water resource management experiences of other nations in order to develop the best possible practical approaches for South Africa. This need prompted the Water Research Commission and the Department jointly to initiate a project which reviewed local and overseas experiences and put forward suggestions as to how the Department should incorporate the principles of integrated catchment management in its management of the country's water resources. The joint project, which also benefited from a financial contribution from the Finnish Development Corporation, culminated in the production of this discussion document.

The Department has accepted that the principles of integrated catchment management form an important central component of the comprehensive review of South Africa's Water Law that is now in progress. Nevertheless, the Department recognises that many of the procedures and practices of integrated catchment management are still evolving. This is a discussion document which records our current thinking and I therefore wish to use this opportunity to invite anyone who wants to contribute to further development of our approaches to water resource management in South Africa to comment on the issues that have been described. Your comments and/or proposals should be sent to The Director: Water Quality Management, Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001. Fax number (012) 323-0321.

Kader Asmal

**Professor Kader Asmal, MP**
**Minister: Department of Water Affairs & Forestry**

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## 1. PREFACE

The Department of Water Affairs & Forestry has recognized that naturally occurring water usually can be effectively and efficiently managed only within a river basin or catchment area, because of the need to manage, or at least account for, all aspects of the hydrological cycle. Thus, the Department recognizes and accepts that an integrated catchment management (ICM) approach will be adopted in South Africa (DWAF, 1986).

This approach is seen to facilitate the achievement of a balance between the interdependent roles of resource protection and resource utilization. However, the situation is complicated by the facts that provincial and other political or administrative boundaries often divide catchments, and that inter-basin transfers allow water to cross catchment boundaries.

However, despite the recognition of water as a strategic national resource which is not equitably distributed in geographic terms, water resource management has not yet been defined as a national function in the Constitution. Water and the management and development of water resources are regarded as the responsibility of the National Government, in particular the Department of Water Affairs & Forestry, as these functions are not specified as functional areas in Schedules 4 and 5 of the Constitution, which sets out the legislative competencies of provinces.

Against this background, it is important to recognize that a water resource includes not only the water but also the structural components (morphology, riparian and instream habitat) and the biotic components of the aquatic ecosystem. The resource is an ecological system, the sustainability of which is to a large extent dependent on the ecological interactions between the physico-chemical attributes and the biotic attributes of the resource.

Therefore, it follows that protection, utilisation and management of the resource must be based on ecological principles. This means that the Department's responsibilities with regard to protection of the resource relate to the management of the water quantity, water quality and physical and structural characteristics of the resource, so

as to provide an appropriate abiotic template which will ensure the integrity of the biotic component of the resource.

On the basis of these management responsibilities, a water resource can be defined as follows (DWAF, 1996).

- A water resource includes the three components of habitat (sediments, instream and riparian), aquatic biota and water, as well as the physical, chemical and ecological processes which link these components of the aquatic environment.

It is also important to recognize that land and water degradation, together with their subsequent impacts on land and water users, cannot easily be separated or managed independently of one another. This implies that co-ordinated planning and action is required at all levels, from national government through provincial authorities to individual landowners.

The role of central government in ICM should be one of leadership, aimed at facilitating and co-ordinating the development and transfer of skills, and assisting with the provision of technical advice and financial support, to local groups and individuals. Where specific areas of responsibility fall outside the mandate of a single government department, appropriate institutional arrangements are required to ensure effective inter-departmental collaboration.

At a lower level in this process, individual landholders and communities must be recognized as competent partners. Where these individuals may lack the necessary skills for full participation, the lead agencies must take responsibility for assisting with their development and application.

Five basic principles for effective ICM can be defined. These are:

- A systems approach which recognizes the individual components as well as the linkages between them, and addresses the needs of both the human and natural systems.
- An integrated approach, rather than a comprehensive approach, in which attention is directed towards key issues of concern identified by all stakeholders in the process.
- A stakeholder approach which recognizes the importance of involving individual citizens and landowners, as well as government agencies, in a participatory process to define all decisions around the conservation and use of natural resources which affect their lives.

- A partnership approach which promotes the search for common objectives, and defines the roles, responsibilities and accountabilities of each agency and individual who participates in the process of decision making.
- A balanced approach where close attention is given to decisions designed to achieve a sustainable blend of economic development, protection of resource integrity, whilst meeting social norms and expectations.

A basic tenet of ICM is that responsibility and accountability must accompany any statutory power to manage a catchment. Clearly, successful execution of such responsibility requires appropriate levels of skills, expertise and judgement. Thus it is essential that government agencies at national and provincial level should provide strong leadership which will help to co-ordinate the development and implementation of ICM policies and strategies, facilitate negotiation and conflict resolution processes, provide technical advice and financial support, and transfer skills to catchment organizations.

The concepts embodied within the term Integrated Catchment Management (ICM) contain the critical central issues on which water resource management is based. Accordingly, it is essential that there is a clear understanding of the meanings that are given to each of the three issues and the ways in which they are applied, namely: "catchment", "integrated" and "management". These issues are outlined, individually, below:

## 1.1 Catchment

The Water Law Principles support the idea that effective management of water resources encompasses management of the entire hydrological cycle. The hydrological cycle includes water in all its aspects:

- atmosphere (quantity, quality and distribution of precipitation, including rain, hail, dew and snow);
- subsurface water, including water in soil moisture storage and groundwater reservoirs;
- surface water (rivers, lakes, wetlands, impoundments);
- estuarine zone;
- coastal marine zone.

A river basin boundary would be that which includes water in all aspects of the hydrological cycle, through precipitation, into subsurface storage and along drainage

lines, to the sea. The land area included in a river basin should include land through or over which water moves, and land on which human activities or disturbances create impacts which affect the quantity, quality or distribution of water in any of the aspects of the hydrological cycle.

A river basin could be made up of several catchments, either contiguous or nested within each other, which would cover the hydrological cycle from precipitation, through or over land to surface drainage lines which converge to a single point, at which the water exits to another catchment or to the sea. Again, the land area of the catchment includes the land through or over which that water flows, and/or the land from where impacts can be generated which affect quantity, quality or distribution of water.

## 1.2 Integrated

A catchment is a living ecosystem, which means that it is a large, interconnected web of land, water, vegetation, structural habitats, biota and the many physical, chemical and biological processes which link these. This is different from the more engineering-related idea of a set of components in series or parallel or a combination of these, linked at clearly defined points by clearly defined processes. Such a situation could exist, for example, where complex water transfer systems such as the Lesotho Highlands Water Project have been constructed.

A true systems approach means recognising that a disturbance made at a place in the system will be translated to other parts of the system. Sometimes the effect on another part of the system may be indirect, and may be damped out due to natural resilience to disturbance; sometimes the effect will be direct, significant and may increase in degree as it moves through the system.

For example: the effects of land use, such as urban development, may cause changes in the quality of surface water resources. Degradation of water quality due to urban development, with its associated runoff pollution and treated wastewater discharges, may lead to impacts on other land uses downstream, such as irrigation. If the impacts on irrigation are negative, and lead to reduced agricultural returns, this may then lead to adverse economic impacts on the original urban development.

An integrated approach to catchment management entails:

- seeing the catchment and the associated water as one system, using the sense of the word system as discussed above;

- acknowledging both the direct and indirect effects that actions in one part of the system, whether the land, water or atmospheric aspects, may have on other parts;
- ensuring that actions taken by an agency or responsible body in one part (land, water or atmosphere) of the catchment are not taken in isolation from, or in conflict with, the actions of other agencies;
- ensuring that actions are taken with due attention to the needs of other stakeholders in the catchment who may be affected, either directly or indirectly, by such actions.

## 1.3 Management

If the idea of a catchment as an integrated system is accepted, in the sense described above, then management of the catchment would entail the planning and execution of actions designed to maintain the system at a particular agreed status (of water quantity, quality and distribution), within an accepted range of variability and reliability.

Management actions could be focused on land, to constrain the impacts of land-based activities on water resources, as well as on the water itself, to ensure adequate storage, distribution and rehabilitation where necessary. Typically, stakeholders would have participated in the debate around preferred sequences of actions and their consequences. The selected series of management actions would then be documented as a catchment management plan which required the formal approval of the Minister of Water Affairs. Responsibility for implementation of the catchment management plan could rest with a legally constituted catchment authority that represented the interests of all stakeholders.

A catchment management plan would include a set of numerical and/or narrative water environment objectives, which would be derived such that the agreed status of the catchment water resources can be maintained. The plan would cover management of land-based impacts as well as the management of the water in the catchment; responsibility for management actions may be devolved to various agencies, authorities or individual stakeholders.

# 2. BACKGROUND INFORMATION

## 2.1 Introduction

The ability of all nations or societies to develop and prosper is tied directly to their ability to properly develop, utilize, protect and sustain their water resources. Ultimately, the achievement of these objectives is dependent on the implementation of an appropriate management system that ensures the long-term sustainability of both the water resources and the uses that are made of them.

In this context, well-managed water resources allow industrial development, transportation of goods, agricultural production, protection of public health, enhancement of recreational opportunities and production of energy, whilst environmental degradation is minimized. Therefore, one of the highest priorities of all countries should be the development and maintenance of the most effective and efficient water resource management systems that are possible.

Competing demands for equitable access to, and sustained use of, water resources can often result in acrimonious disputes and even open conflict. This is particularly evident in the more arid regions of the world which experience frequent water shortages, and where key water resources (such as rivers) cross or coincide with political boundaries. Therefore, another important goal of water resource management is to ensure that conflicts between different users are resolved or minimized.

The scarcity and variability of the available water resources in South Africa, coupled with the country's need for economic growth and development, as well as social upliftment, presents water resource managers with a number of significant challenges. The situation is further complicated by the deterioration in the quality of South Africa's water resources as a result of both past and current developments.

More recently, sweeping socio-economic and political changes have occurred in South Africa. Previous "command and control" approaches to water resources management, imposed unilaterally from a central government body, are no longer widely accepted by the general public. People now feel a growing need to participate in, and contribute to, decision making processes, partly due to their lack of trust in previous delivery systems. Related to this, it has become evident that the end users of any resource development project need to be closely involved in both the planning and

management aspects to ensure that their concerns are taken into account and they get appropriate delivery of the resource.

Whilst people should accept responsibility and accountability for participation in water resource management issues, it is necessary for the Department to be capable of taking up the responsibility for leadership and guidance, rather than control. As a consequence, water resource management processes need to become more people-oriented, rather than being dominated by technical considerations as in the past.

## 2.2 Current developments

The growing complexity of the situation, and the scale of the problems that need to be addressed as a matter of urgency, require the development and implementation of new approaches by South African water resource managers. It will be essential that these new approaches incorporate a detailed understanding of the resources available as well as the needs and aspirations of the user communities. Technical, economic, social, political, legal and environmental considerations will have to be taken into account in the management process. This is only possible if a systems approach is followed which integrates engineering skills, socio-economic concerns, and environmental constraints within a multi-disciplinary decision-making process.

In a given area, each component of the hydrological cycle is influenced by, or influences, other components in the cycle; none can be viewed in isolation. Water resources therefore need to be administered and managed in a way that recognizes the entire hydrological cycle as an indivisible continuum. This requires an increased appreciation of the individual roles and interactions between atmospheric precipitation, evaporation, infiltration, seepage, runoff and erosion.

Similarly, each use that is made of a particular water resource also influences, or is influenced by, the actions of all other water uses. Therefore, it is important to recognize the requirements of individual water uses, the value of each alternative use of water, and the consequences of not being able to meet some or all of these requirements. Effective water resource management thus requires the simultaneous integration of all relevant factors, processes and uses within a single system.

In the context of water resources, the river basin or catchment is now widely accepted as the best management unit which will enable this to be achieved. However, the definition of a water resource does not include the land area of the catchment. Whilst

it is recognized that land-based activities impact on water resources, these can be managed through co-operation with the relevant authorities within the framework of an integrated catchment management system.

An integrated catchment management (ICM) approach implies that water and associated land resources will be managed in harmony so as to gain the full benefits of multipurpose use and to co-ordinate the activities of various agencies and other bodies involved in water resource utilization and protection.

A number of overseas countries have accepted and adopted ICM as the most practical approach to water resource management. Over several years, these countries have implemented very similar water resource management strategies and, despite some significant differences in their processes of public participation and in the day-to-day implementation of operational management functions, some significant successes have been achieved along with some failures.

It is important to note that these approaches to water resource management did not occur overnight but were the result of many years of research, testing and learning in the field. In the case of most European countries, for example, their water resource management practices have evolved over several centuries. Therefore, it must be realized that ICM is an evolutionary process; one that has already started in South Africa but needs to be driven more urgently and systematically.

It is clearly unnecessary for South African water resource managers to duplicate this long-term evolutionary process. Rather, it is more appropriate that we should learn from the overseas experiences and adopt only those components of the process which are likely to be successful in a South African context.

## 2.3 The issue of sustainability

The process of water resource management involves managing the complex inter-relationships and interactions between ecological systems, land use activities and water which control and characterize the water resource. The people who use the resource, as well as the people and institutions who are responsible for developing and managing the resource, have to be included in the process. Current international trends towards policies of "sustainable development" and "sustainable resource management" reflect a growing commitment to the principle of stewardship at all levels of strategic and operational management (MacKay *et al.*, 1996). The principle

of stewardship implies a responsibility to consider the welfare, needs and aspirations of the current generation, without prejudicing those of future generations.

The Draft Principles put forward to guide the revision of Water Law in South Africa make several references to the need for sustainability (DWAF, 1996a). Accordingly, it is accepted that the principles of sustainability will form the basis for water resource management in South Africa.

There are many definitions of sustainability, both in terms of the development or utilization of a resource, and in terms of maintaining the integrity of a resource. Whilst each definition reflects the particular viewpoint of the author of the definition, they almost always share a common theme, namely: that utilization or development of the resource should be regulated such that the characteristics and integrity of the resource in question are protected and maintained within agreed limits.

In the context of water resources, the concept of sustainable resource use is one where, with effective management, the rate of resource withdrawal, use, consumption or depletion should always be balanced (or preferably exceeded) by the rate of resource replenishment. In the process, the selected and agreed characteristics of the resource (e.g. water quality, biological diversity, degree of resilience to external disturbance or change) should also be maintained.

The general principle that the development and use of water and other natural resources should take place in a manner which ensures sustainability of the resource has become one of the central objectives of international natural resource and environmental policy since 1980. Clearly, sustainable development should not be confused with zero growth. Rather, it entails achieving a balance or compromise between protecting the ecological resource base and allowing economic growth to take place through a rational and carefully managed use of the available resources. This does not imply merely setting limits on economic activity in the interests of preserving the environment, but is instead an approach to development which emphasizes the fundamental importance of open participation and equity within the economic system.

Sustainable development can be defined in broad terms as development which meets the needs of the present without compromising the ability of future generations to meet their own aspirations and needs. Four recurring elements comprise the key concepts embodied in sustainable development:

- the need to take into consideration the needs of present and future generations;

- the acceptance of limits placed upon the level of use and exploitation of natural resources, on the grounds that this is the only way to protect the capability of the resource for use and exploitation in the long-term;
- the role of equity principles in the allocation of rights and obligations, which also imply that the access to, and use of a resource, made by one user must take into account these needs of other users; and
- the need to ensure that environmental considerations are integrated into economic and other development plans and that development needs are taken into account in setting environmental objectives.

Sustainable development of water resources implies the adoption, in an iterative fashion, of three successive steps in water management:

- *identification* of the system characteristics, which involves the specification of the characteristic features of the water resource system relevant to the different problems encountered. These features consist of the bio-physical, economic, social and environmental characteristics of the system;
- *prediction* of the behaviour of the system, which corresponds to determining how the system will respond to certain actions taken by man, (including pollution discharges into water bodies, urbanization, changes in agricultural practices, the building of works and structures which confine or condition the behaviour of water resources within the system, implementation of management actions); and
- *management* of the system, which involves selection and implementation of the best strategy to attain certain objectives, where management decisions are based on the previous steps of identification and prediction.

## 2.4 Purpose of this document

This document forms an important part of the background information required by the Department of Water Affairs & Forestry for its comprehensive review of South Africa's Water Law. The usefulness of the ICM approach has been accepted as fact and the Department intends to continue with, and refine, its current initiatives in implementing ICM throughout South Africa.

The document has been written primarily for water resource managers within the Department of Water Affairs & Forestry. It aims to provide these managers with an up-to-date and concise overview of the variety and complexity of the issues which affect and control ICM. The scope of this document is described in **Section 3.2**.

Whilst this document focuses mainly on water resource management issues, a number of other concerns, such as land use management and institutional arrangements, are also examined because they impact on water resources and influence management decisions. The final report from this study will serve as a basis for linking together the different water resource management functions within the Department and will also form the background for additional policy development.

## 3. BACKGROUND TO THE PRESENT STUDY

During 1993 and 1994, staff of the CSIR's Division of Water Technology conducted several studies on catchment management processes and undertook visits to Australia, the USA and the United Kingdom to evaluate overseas experience in a variety of water resource issues, including ICM. This was followed by interactions with other Australian, American and British practitioners, where additional insights were obtained as to their respective approaches and the successes achieved.

In response to the growing demand for clarity as to the nature of ICM and how it could be applied successfully in South Africa, the Water Research Commission (WRC) launched a one year desk-top study in 1995 to draw together and evaluate appropriate overseas experience. This study was designed to provide an overview of current approaches and offer suggestions as to which of those practices could be applied in South Africa. This study would also provide a strategic overview of the directions for any additional South African research which should be conducted on different aspects of ICM.

Also in 1995, the Department of Water Affairs & Forestry initiated a comprehensive review of the country's water law, with the aim of drafting a new Water Act that is consistent with the new constitution and the Water Law Principles. This process includes a significant emphasis on wide public participation in identifying and rectifying past inadequacies. A central component of this water law review is the acknowledged need to manage the country's water resources on the basis of economic, social and environmental sustainability. Therefore, the principles of ICM are important in the water law review process.

At the request of the Department of Water Affairs & Forestry, the WRC agreed to expand the study on overseas practices to include an evaluation of current South African practices and to identify the essential links with other water resource management functions. Funding for the WRC study was supplemented by the

Department and the study was designed to proceed in parallel with a number of other law review initiatives launched by the Department.

The present study therefore focuses on the principles and practices of ICM, both locally and overseas. The study aims to provide a concise overview of the current thinking and experience on the best ways in which to implement an ICM approach to water resources management. This will allow the Department of Water Affairs & Forestry to select appropriate options which could form the basis for management decisions and legislation relating to the implementation of ICM in South Africa. The overall objective of this process is to ensure that South Africa's water resources are managed on a sustainable basis.

## 3.1 Approach followed in this investigation

Given the constraints of the relatively short time frame of the study, the project has been focused on the compilation and interpretation of information produced by local and overseas agencies and individuals. No attempt has been made to invent or put forward new approaches. It was considered appropriate to concentrate on the successes and failures that have been experienced and, wherever possible, to identify the factors responsible for such success or failure. Accordingly, the following approach was adopted:

- Overseas visits were undertaken to selected institutions in Australia, the United Kingdom and the USA, in order to meet individuals responsible for water resource management issues and involved in the planning and implementation of ICM plans and actions.
- Verbal discussions and written communications were exchanged with overseas specialists who have been, or still are, responsible for the development of catchment management policies and plans.
- Personal and telephonic interviews were conducted with South African water resource managers and practitioners, including key staff within the Department and water boards, as well as consultants engaged in the production of reports on a variety of catchment studies. Verbal discussions took place over an extended period from January 1993 and were supplemented by personal interviews and interactive discussions at workshops and symposia.
- A wide variety of documents and electronic information from international sources was retrieved via the Internet.

- Copies of study reports and policy documents were obtained from local and overseas institutions and agencies. The information in these documents was then critically reviewed to assess its usefulness.
- Personal interviews were conducted with water resource managers and strategic planners within the Department of Water Affairs & Forestry.

## 3.2 The scope of this report

The report arising from this investigation has been designed primarily to meet the information needs of water resource managers within the Department of Water Affairs & Forestry. This document has therefore been structured to provide a systematic review of the philosophy and practice of ICM, followed by a series of suggestions and recommendations for implementation in South Africa.

This report outlines the philosophy and practice of ICM, with a particular focus on the South African situation and our requirements. The existing situation in South Africa is examined and possible reasons for the successes or failures that have been achieved to date are highlighted. Much of the information contained in this report is based on an evaluation of the appropriateness and possible applicability of overseas experience (Australia, United Kingdom, United States of America, Europe, Africa) to the South African situation.

The core concepts contained within the ICM approach are examined, together with the processes and institutional arrangements required for success. The report evaluates and comments on the ways in which a flexible ICM process links together all of the different stakeholders, helps to identify critical issues, and then directs appropriate attention to these issues. The interplay between environmental, social and economic issues is emphasized, together with the institutional, practical, legal and information requirements that are necessary for success. An important component of this report is the brief overview of the need for proper institutional arrangements; this has been designed to complement the more detailed, parallel studies on institutional structures conducted by Mr Andrew Tanner of Ninham Shand Inc.

This report synthesizes the local and international information on ICM. Specific references to individuals and literature sources have largely been omitted from the main text of the document. Instead, a full list of the individuals consulted and the written materials studied is included in the list of references.

A detailed review of Australian approaches to water resource management has been compiled by Dr H.M. MacKay. Her entire report has been attached as an appendix to this document. A searchable run-time version of her references plus notes has been made available to the Department on diskette, together with copies of all the published references consulted.

# 4. THE DEPARTMENT OF WATER AFFAIRS & FORESTRY

## 4.1 The role of the department

The water resources of South Africa are recognized as a critically important national asset (DWAF, 1986). Accordingly, they must be managed effectively and efficiently so as to bring maximum long-term benefit to the country as a whole. The Department of Water Affairs & Forestry (DWAF) is recognized as the custodian of these resources and has a national responsibility to ensure that both the basic (survival) needs of the people are met, together with those additional needs for water required to sustain the current needs of users and the anticipated growth in the national economy.

The role of the Department in relation to the water sector can be segmented into two distinct, but closely related, functional areas:

- Providing equitable access to the resource to ensure optimal economic and social development, including access to water and sanitation services for all citizens. This is the Department's main priority and takes precedence over any economic development objectives; and
- Managing the resource, as well as the demands made on the resource, both to protect the resource and to ensure sustainable and equitable use by current and future generations. This is reflected in the Department's mission statement of "ensuring some for all, ... forever".

The Department has an important leadership role and responsibility to set in place national strategies for long-term water resource management. The Department provides leadership, technical guidance and a resource management framework, based on important principles such as minimum standards, environmental protection, waste minimization. Provincial governments and local authorities are expected to address local and regional issues and to take appropriate responsibility for decisions within this management framework.

## 4.2 Relationship to other institutions and organizations

Within the Department, overall responsibility for water resource development and management has been segmented into several line function Directorates for increased efficiency. There is also some devolution of responsibility to regional offices of the Department who are responsible for implementing national policies in managing the water resources within their areas of jurisdiction.

The water resource management functions and responsibilities of the Central Government and the nine Provincial Governments are closely inter-linked and have been clearly defined. Provincial Governments share the responsibility for assuring service provision, specifically through the promotion of effective local government. Water Boards and Irrigation Boards represent the Department and also form a link between the Department (Central Government) and Local Government through their provision of bulk water supply services where there is an economic advantage to be gained from regional service provision. The overall relationships between the different levels of functional responsibility are summarized in **Figure 1**.

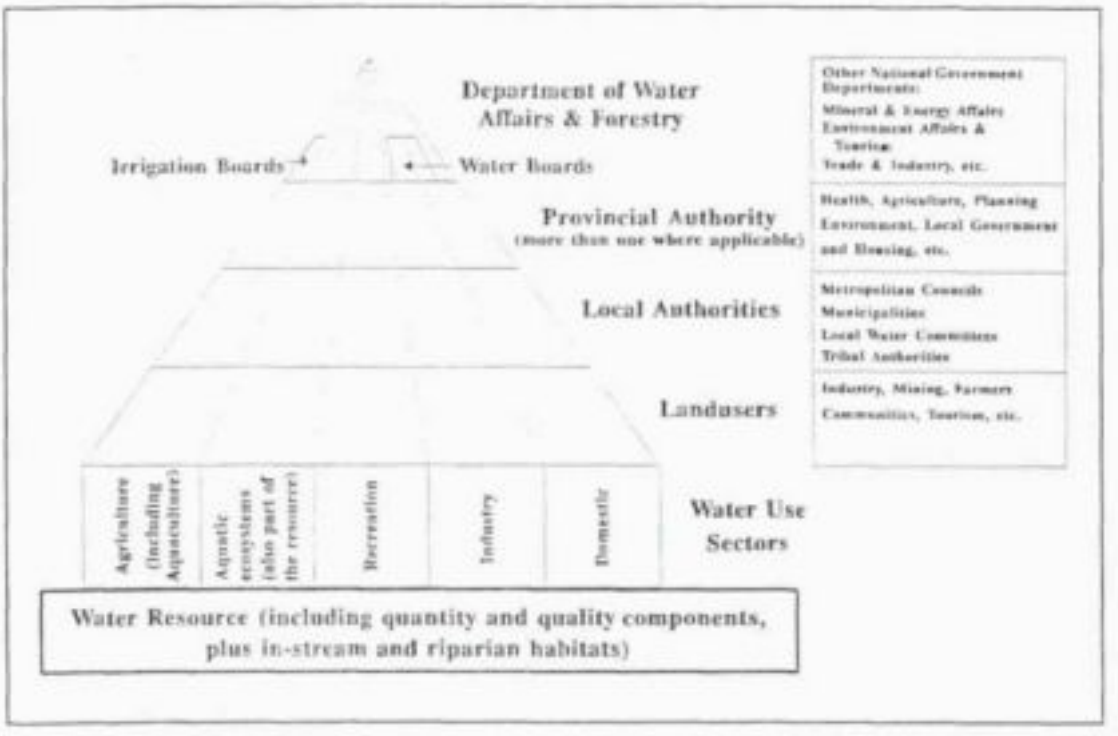


**Figure 1:** Diagrammatic representation of the inter-relationships between the different levels of stakeholders and functional responsibilities involved in water resource management and utilization in South Africa. (Adapted from a diagram provided by Mr JLJ van der Westhuizen of the Department of Water Affairs & Forestry).

Water Boards and Irrigation Boards act as agents on behalf of the Department of Water Affairs & Forestry. Their areas of operation often extend beyond provincial boundaries and they undertake important parts of the water resource service provision on behalf of the Department (DWAF, 1995).

Tribal authorities who enforce traditional laws relating to water resource use and allocation in certain designated areas, have largely been excluded from participation in water resource management to date. The empowerment and involvement of this group will in future form an important component of South Africa's overall water resource management strategy (DWAF, 1996a).

The importance of close collaboration and cooperation between the Department and Provincial Governments is clear, given their joint interest in the development of the capacity of local government to provide water supplies and sanitation services on an equitable and efficient basis. Provincial Water Liaison Committees have been established to ensure effective formal communication and liaison between the department and the Provincial governments. In addition, the Minister of Water Affairs & Forestry has been empowered to establish statutory Local Water Committees (LWCs). These LWCs will undertake the task of local water and sanitation provision until effective local government structures have been formed.

In addition to the Department of Water Affairs & Forestry, several other government departments control issues which impact directly and indirectly on water resource management. For example, the Department of Agriculture is responsible for agricultural activities and soil conservation, the Department of Water Affairs & Forestry is custodian of water quantity and water quality issues, and the Department of Environmental Affairs and Tourism controls conservation-related issues. Clearly, each of these areas of responsibility can and does influence the temporal and spatial availability and quality of water within a river system. The need to manage these issues co-operatively becomes further complicated where different government departments have delegated differing levels of management responsibility to provincial and local government levels.

## 4.3 Historical development of catchment management

During the 1980's, the Department of Water Affairs & Forestry (DWAF) adopted an integrated management approach to address various catchments in the former Eastern and Northern Transvaal provinces. The Department commissioned several detailed

investigations which attempted, with varying degrees of success, to assess the quantity and quality of available water resources, identify the needs of different water use sectors, predict likely future developments and develop holistic approaches and plans for water resource management in the catchments of concern.

Each successive catchment study built upon the experience gained in earlier investigations and identified a number of common needs or issues of concern. These included:

- the need to improve processes of public participation, including clear definition of the roles and responsibilities of all participants;
- the need to develop appropriate institutional structures which could facilitate communication, promote information sharing at all levels, assist in the decision making process, and allow the definition of clear responsibilities and accountabilities for implementation;
- the need to involve all water users in the planning and implementation phases of water resource management; and
- the need for the Department to take responsibility for leadership and the provision of technical guidance and a management framework for water resource management.

The theoretical aspects of these investigations provided a solid basis for understanding many of the technical, environmental and engineering-related complexities involved in managing water resources on a catchment basis. However, one of the major shortcomings of these early studies was the fact that they consisted largely of technical inventories and did not include public participation in the development and acceptance of water resource management plans with defined goals, objectives, strategies and time schedules.

As a result, the actual process of managing water resources on the ground did not meet people's expectations and centralized "command and control" approaches continued to operate without adequate stakeholder support. This led to widely-held public perceptions that the Department was unsuccessful in managing the country's water resources.

More recently, however, the situation in a few catchments and sub-catchments (e.g. the Wilderness Lakes area, upper Olifants River catchment, and the Sand, Vet, Jukskei and Mgeni catchments) has changed due to the incorporation of wider public participation in catchment forums and in the development of catchment management plans. This represents a major improvement in the public perception of the

Department's capabilities. In these recent examples, the public participation process has led to a widespread sense of "ownership" of the process amongst all participants, a better understanding of the complex issues that need to be dealt with, and greater appreciation of the needs of other stakeholders.

Perhaps the most visible problem area identified in the earlier catchment studies was that resource managers, engineers, scientists and the general public all had different levels of understanding of the precise meaning of ICM and lacked a shared vision and agreement as to how this could be achieved effectively. In turn, the problem was accentuated by a lack of appropriate institutional arrangements and the virtual absence of suitable mechanisms to facilitate interactions between water user groups and the Department's water resource managers. Conflicts still arose between water user groups competing for the same scarce resources and management remained relatively narrowly focused on meeting the demands of water supply to domestic, agricultural and industrial users.

Since the late 1980's, water resource managers have increasingly emphasized the urgency of meeting the growing demands of water users from a scarce resource. The problem was compounded by the fact that both the availability of the resource and its quality or fitness for designated uses had steadily diminished. They advocated that this could only be achieved through holistic approaches which balanced economic, social and environmental concerns and strove to assure sustainability of both the water resource and the use made of the resource. This triggered a number of investigations directed at resolving inter-sectoral conflicts around the use of water, and the development of public participation mechanisms to ensure the wider involvement of all participants in selecting appropriate management strategies.

## 5. THE CONCEPTUAL BASIS OF ICM

The conceptual basis of ICM relies on recognition that the different components of the hydrological cycle are intimately linked to one another, and each component is affected by changes in every other component. Therefore, they cannot be managed effectively as separate or disconnected units.

The core concepts embodied within ICM are often difficult to promote without an unambiguous terminology. The confusion has arisen principally because many terms have been used inconsistently, have been given extended meanings or have been misapplied. Care is therefore needed when ICM is applied.

## 5.1 The catchment as a basic management unit

A catchment area is the drainage basin of a river, and its boundaries are demarcated by the points of highest altitude in the surrounding landscape. It is adjoined by other catchments and its geographical area covers all of the land which drains into one river system, from its source to its estuary.

Much of the rainfall or precipitation falling on to a catchment is lost to the atmosphere by evapotranspiration; the remainder enters the surface as ground water or flows along stream and river channels as surface water. Within a catchment, surface and unconfined ground water flows are dominated by gravitational drainage from the catchment divide or watershed to the mouth of the river. Flows are usually unidirectional, through and over hillslopes to streams and along the channel system to the river mouth or estuary. The speed with which water moves through and over a catchment is dependent on the topography and geology of the catchment, whilst the characteristics of the geology, soils, vegetation and land use within the catchment contribute impurities to the water and alter its quality.

The physical, chemical and biological characteristics of the river system change progressively and cumulatively along its length as the water is altered by land use, runoff, water abstractions and effluent discharges. These processes of change link the different components into an integrated system which includes not only the water and biota in the river system, but also all of the human activities and natural processes in the catchment which affect the quantity and quality of the water. All of these features need to be taken into account when the water resource is managed.

The sustainable management of a catchment's water resource becomes extremely difficult if responsibility for this is fragmented by organizational, administrative and political boundaries. It is important to recognize the catchment as a single management unit and to streamline the structures and functions of bodies responsible for its management.

## 5.2 What is ICM ?

The term "Integrated Catchment Management" (ICM) represents a systems approach to the management of natural resources, in particular water resources, within the bounds of a geographical unit which is based on the catchment area of a single river system. This approach allows clear segmentation of river systems into logical or

functional management units (catchments and sub-catchments) which can then be linked together into an overall management plan for an entire river basin.

In its widest possible sense, ICM recognizes the need to integrate all environmental, economic and social issues within a river basin (or related to a river basin) into an overall management philosophy, process and plan. This is aimed at deriving the optimum possible mix of sustainable benefits for future generations and the communities in the area of concern, whilst protecting the natural resources which are used by these communities and minimizing possible adverse social, economic and environmental consequences. In its ideal form, this is a shift away from narrowly focused management of a single resource such as water or soil.

General acceptance and implementation of ICM is often hampered by differences in people's understanding as to exactly what is meant by the term ICM. This is largely due to the fact that ICM has three aspects, namely it is a philosophy, a process and a product. There is not always a clear consensus that these three characteristics are all part of ICM; indeed, many management approaches still attempt to focus solely on the more technical aspects of the process or product functions of ICM.

- ICM provides a **philosophy** which underpins sound natural resource management, and which is based on a consideration of whole natural systems, and a recognition that systems respond to disturbance or utilization as just that: systems, not as individual components in isolation from each other;
- ICM provides a **process** for engaging the community and government, in a "people-oriented" partnership which is designed to achieve better natural resource management at the local catchment level, and which takes account of the needs and aspirations of the whole community; and
- the ICM process results in a **product** or ICM strategy which can be implemented on the ground. This is a regional-scale strategy and management plan which incorporates environmental, social and economic considerations and is based on a set of development objectives which are identified jointly by the community and government. The identification of development objectives centres on identifying and acknowledging the environmental constraints of an area; these are the environmental or resource capacities that must be protected, otherwise all capacity to meet user needs may be lost. The management plan also provides a unifying central guide for implementation on the ground.

Whether ICM approaches are local or international in scope, all contain a common objective, namely: to ensure equitable and sustained use of the available natural resources through a shared development and management effort. This is aimed at working across political jurisdictions and involving in the decision making process all those constituencies which either place demands on the resources or cause impacts on the resources.

In practice, the ICM approach is most often used to provide a logical framework within which the water resources of a region or country can be managed. This is important in countries where different environmental systems and natural resource units have been artificially segmented and allocated to different political jurisdictions.

Catchment, or river basin-wide, approaches to the development and management of water resources have proven highly successful and are gaining greater prominence worldwide. This is due to their inherent effectiveness in budgeting and balancing the quantity and quality of the water resources available against the uses and demands made of them. This success has been responsible for the creation of management organizations on an international scale to manage the water resources of large river and lake systems shared by several countries.

Despite the fact that the concept of effective water resource management by means of ICM is relatively new in South Africa, many of the individual processes and approaches contained within the concept are widely understood and accepted. However, there has been a noticeable lack of success in our ability to integrate all these processes and functions into a coherent whole. Nevertheless, since the social and scientific basis of the ICM concept is inherently sound and the approach has been shown to work well in many other areas with similar types of problems to those experienced here, it is the only logical option to use in South Africa.

However, it is important to remember that the power of change-amplifying and change-reducing mechanisms within a catchment, and within nature in general, are such that human interventions need to be undertaken with a large measure of caution. We cannot always be confident that our interventions will produce the intended outcomes. This has direct implications for catchment management and has given rise to three important principles, namely:

- An *integrated or systems approach* is required to properly assess and link together the processes and actions which cause bio-physical and ecological change in catchment systems;

- An *adaptive management* approach is needed, which responds to changes in information regarding catchment conditions and knowledge of associated processes, and allows corresponding adjustments to management actions and strategies, according to the understanding gained by observing the effects of management; and
- Social organization for catchment management needs to be based on *an active partnership approach and joint strategic planning* so as to achieve outcomes which are acceptable to all participants and which will allow sustained use of the water resource.

## 5.3 Critical success factors for effective water resource management

Overseas experience has shown that effective and efficient water resource management based on ICM approaches can be characterized by four critical success factors or principles. These are described separately below.

### 5.3.1 An integrated approach to strategic planning and resource assessment

Typically, ICM must follow a systems approach to water resource management. This involves consideration of the whole natural system and all its linkages, including both natural and human systems and their inter-relationships. The management unit should encompass linkages between components and will usually consist of the whole catchment or another similar geographical unit such as a sub-catchment.

Policies, plans and actions must be linked together within a framework which maps out the strategically important development objectives and priorities for the management of the water resource and its catchment. At the same time, these activities must also ensure that the water resource is protected so that it can continue to sustain the uses made of the water. Important elements of this process are:

- *Objectives* for managing the suite of environmental values or beneficial uses of the water resource (e.g. protection of aquatic ecosystems, provision of safe supplies of water for domestic, industrial, recreational and agricultural use) must be drawn up and integrated into a coherent management plan;
- *Management options* which can directly or indirectly influence environmental outcomes within the system, and which may have complementary or synergistic benefits (e.g. wastewater treatment and wetland rehabilitation) must be designed and incorporated into a defined plan of action; and

- Consensus must be reached by all stakeholders regarding *co-ordinated action plans* for different aspects of water resource management by central, provincial and local government, industry, land user and community organizations.

An integrated or systems approach is required for appropriate assessment of the diverse, interacting components of catchment processes and resource management actions which impact on the water resource and the overall state of the catchment. The emphasis here should primarily be on technical aspects, though the economic and resource value implications of catchment conditions and management actions are also directly relevant. Key elements of the integrative process include:

- *Analysis* of aspects of the catchment system (e.g. water quality, streamflow and riparian conditions) which affect relevant values or uses of the water resource;
- *Assessment* of the prevailing environmental, economic and social values, together with the values arising from beneficial uses of the water resource and the related impacts of management actions; and
- *Monitoring* of environmental conditions and related socio-economic factors that are influenced by those organizations and groups responsible for implementing management actions and activities.

Following the assessment of specific values and impacts within a systems framework which helps to integrate these diverse issues, the overall merits of alternative combinations of technical activities and implementation actions should be evaluated. This integrated evaluation will assist in the identification of decision options which optimize or balance social, economic and environmental values with respect to:

- finding a sustainable balance at local and regional levels between resource use and resource conservation;
- reversing the adverse impacts of land uses on the status of the water resources and on other land and water uses, as well as preventing adverse impacts of proposed new land uses;
- achieving effective co-ordination and integration of water and other natural resource policies to focus on common goals and objectives at a catchment level;
- focusing planning and management actions and activities at a sensible regional and local scale which is strongly related to natural systems, and which can better accommodate local and regional community needs and desires, as well as national objectives;

- promoting the efficient use of public and private economic and other resources;
- ensuring an equitable distribution of costs and benefits amongst all stakeholders;
- defining the roles, responsibilities and accountabilities of each individual involved in implementation of the management plan; and
- ensuring the effectiveness of management actions in achieving desired outcomes.

### 5.3.2 Institutional arrangements for social and economic optimization

One of the most important factors in successful implementation of the ICM approach has been the development of institutional approaches that are appropriate to the needs of each situation. Different countries have created a wide variety of specific institutional structures to accommodate local resource or hydrological landscapes, demographic situations, specific management approaches and political situations. Whilst the broad principles remain the same, none of these institutional structures can easily be taken and imposed, without modification or customization to suit local circumstances, onto the situation in a different region or country. Nevertheless, the broad principles can be transferred and adapted successfully to a new situation.

From a systems perspective, there are a number of different levels of involvement of individuals, communities, institutions and government. Each level has its appropriate range of roles, responsibilities, functions and needs. For each of these levels to be able to operate efficiently and effectively, the levels immediately above and below it also need to operate effectively and within the scope of their respective roles and responsibilities.

A detailed evaluation of the types of institutional structures that will be required to ensure that ICM will work effectively and efficiently, in a South African context, are addressed in a separate study which is being undertaken by Mr Andrew Tanner of Ninham Shand.

### 5.3.3 An active partnership approach

Collaboration and the attainment of consensus amongst key stakeholder interests, either those affected by use of the water resource or those responsible for

management action, is essential in order to generate credibility, commitment and co-operation. This approach recognizes that all government agencies, as well as non-governmental organizations and individuals, have important roles in identifying common objectives and creating a shared vision. This helps to ensure a balanced approach in which the needs of the three components, namely: people, economic development and the environment are considered, together with any requirement for resource protection, when pursuing and achieving sustainable development at both regional and local scales.

In this process it is vitally important to ensure that appropriate processes, procedures and mechanisms are defined and accepted for mediation, reaching consensus and resolving conflicts. All of these issues need to be incorporated into the overall catchment management plan. It is also important to emphasize that this process should not be seen as a "threat" to existing decision makers. Instead, the incorporation of local objectives, local knowledge, increased local ownership and commitment to action should improve the effectiveness and success of water resource management.

### 5.3.4 Adaptive management processes

Overseas experience has shown that it is essential that the management process followed in ICM be flexible. This will allow continuous optimization of resource allocation (people, equipment and funding), whilst at the same time being effective enough to promote the overall goal of sustainable water resource use under continuously changing environmental, social and economic circumstances. The process evolves progressively so that individual and institutional learning is enhanced and can be incorporated into adaptations to structures, approaches and processes. Similarly, the catchment management plan must be flexible enough so that action strategies and programmes can be modified, when required, as the plan is implemented.

A flexible management framework is needed to guide staged implementation of action programmes, taking account of resource availability, developing knowledge, changing catchment conditions and on-going evaluations of effectiveness. The action strategies need to be adapted as experience of the effects of catchment management activities is accumulated, beginning with experimental or trial interventions where little knowledge of cause-effect relationships is available.

### 5.3.5 An effective catchment management plan

For management to be effective and successful, it must set out agreed policies and strategies, provide leadership to all participants, define roles and responsibilities, be able to communicate effectively with all participants, and be able to mobilize sufficient human, technical and financial resources to undertake the tasks at hand. In the context of water resource management, the management dimension requires a particularly broad-based appreciation of the need to attain a balance between protection of the water resource and meeting the varied needs of stakeholders.

The overall framework for water resource management is formed by national and provincial resource management policies which set out issues of national strategy and resource management principles. Within this framework, regional and local issues and concerns must be aligned consistently with national and provincial goals. Ideally, this requires that catchment management operates as part of a formal process of water resource management, which is supervised and guided by the Department of Water Affairs & Forestry. The Department would therefore be responsible for defining and approving the specific requirements for water resource management within each specific catchment or sub-catchment. This would normally take the form of Ministerial approval for a catchment management plan.

Whilst a formal catchment management plan is a prerequisite for effective water resource management on a catchment basis, the mere existence of formal documentation is insufficient. An effective catchment management plan must address the typical management aspects of: planning, co-ordination, implementation or operation, and monitoring, as well as control and auditing of the management process, plus feedback to stakeholders.

The typical components of a catchment management plan address the following management issues:

- *planning*:
  - who initiates and documents the process;
  - who funds any investigations which may be necessary;
  - who participates in the planning process and how are they selected for participation;
  - what institutional arrangements are required to facilitate interactions with stakeholders and ensure that the requirements of resource equity are met; and
  - who reviews and approves the plan.

- *implementation*
  - who is responsible for the necessary legislation in the different levels of national, provincial and local government;
  - who funds the implementation process;
  - who authorizes and directs the implementation process; and
  - what mechanisms are available to resolve potential conflicts amongst stakeholders.
- *operation*
  - what are the different lines of authority and responsibility;
  - who funds the different activities; and
  - who ensures that resources are applied effectively and efficiently.
- *auditing and control*
  - who undertakes the necessary monitoring;
  - what information is reported and to whom is it reported;
  - who evaluates the information and what are the criteria used for evaluation; and
  - who responds or reacts to the information, and how are they required to respond under given scenarios.
- *feedback to stakeholders*
  - who is responsible for communicating with stakeholders;
  - what types of information must be communicated; and
  - what form must this communication take, and how often should the information be communicated.

## 5.4 An appropriate management framework

To develop and manage water resources effectively, it is necessary that a balance be achieved between the legitimate competing demands placed on the resource. At the same time, interference with the natural hydrological cycle, and the disruption of ecological processes, should be minimized since these are critically important to the sustainability of the resource. Whilst this is relatively simple in concept, it is far more difficult to achieve this balance in practice. Indeed, a failing with many water resource management strategies worldwide is that, whilst they are able to adequately represent the correct aspirations for management of the resource, they are often unable to deliver the product on the ground to the satisfaction of the end-users. This is most often due to the fact that the end-users, or the people who are most affected by the management decisions, have not been adequately involved in the decision-making process.

Even when a single water resource system is located within a single political jurisdiction, the different uses made of the water often lead to conflicts amongst water users. In situations where water resources are scarce and under increasing pressure to be utilized, conflict is unlikely to be avoided. However, through appropriate processes of information sharing, stakeholder education and open negotiation, disputes and conflict situations can usually be resolved. Here, consensus can be achieved in negotiation situations through exploring alternative options for water use and allocation.

The concept of "national objectives" for water resource protection or maintenance of water resource quality should form the basis, or highest level of authority, in dispute cases. In addition, there would also need to be appropriate institutional systems involving the courts, as well as other dispute resolution techniques, to resolve those situations where consensus cannot be reached through negotiation. Clearly, conflict analysis and management are therefore key activities in water resource management.

The use of catchment management plans and strategies which have been developed by community-based or other publicly accepted participation processes will help to resolve potential conflicts through fostering a better understanding of the positions, aspirations, needs and vulnerabilities of each stakeholder. This process tends to alter the focus of negotiation and discussion away from the primary *goals* of the management plan, to one which is concerned with *how the goals will be decided and achieved*. Conflict can be reduced or resolved if the focus is placed rather on *how people decide* on the goals. World wide there is evidence that people do not support decisions in which they feel they have not been able to have some influence or participation.

Water resource management can be defined as the systematic use of a set of technical and non-technical measures and activities designed to ensure the effective and efficient management of water resources. The primary goal of water resource management must be to optimize the relationship between the capacity of the available resources to provide sustainable services, such as water of a given quantity and quality (which must be protected) because it is required to meet basic human needs, and utilization of the resource, including consumptive and non-consumptive uses and waste disposal.

The need to protect the water resource in perpetuity whilst at the same time ensuring sustained and effective utilization of the resource can be considered to be conflicting management functions. Whilst this is often true, sustained utilization of the water resource is only possible if the level of protection afforded to the resource is

adequate. This balance can only be achieved when there is good interactive dialogue between all parties so that their needs, capabilities and concerns are clearly understood at all stages of the process.

## 6. SUMMARY OF CURRENT APPROACHES TO ICM

Throughout the world, a variety of technical, economic and management approaches have been adopted in attempts implement ICM so as to manage water resources on a sustainable basis. Whilst many of these approaches have shown varying degrees of success, there have also been several notable failures. It is therefore important that South African water resource managers take careful cognisance of the overseas experience in their development of new ICM approaches for South Africa. Accordingly, the available information on ICM experiences to date has been reviewed to evaluate those principles, strategies and processes which would form an appropriate basis for implementing ICM in South Africa.

### 6.1 South African approaches

Over the past two decades, the widespread and growing concern over South Africa's scarce water resources has been accompanied by a growing awareness of the complexity of the processes and interactions required to manage these resources so that they can sustain the growing demands made on them. Since the early 1980's water resource managers within the Department of Water Affairs & Forestry have come to realize and accept that effective water resource management requires an integrated approach based on logical hydrological units. It was considered appropriate that these units should be whole river basins or catchments.

However, it was also clear that very little information was available which would allow the development of catchment-wide water resource management approaches based on ICM. This prompted the Department to initiate several major catchment studies which were designed to:

- obtain information on the physical, chemical and ecological characteristics of the water resources available within each catchment;
- identify and quantify the specific catchment processes and activities which affect the spatial and temporal distribution of these water resources;

- quantify the existing and future demand for water, by each water use sector, including specific requirements for water quantity, water quality and the timing of these requirements;
- identify those individuals, institutions and organizations which should be consulted or involved in decisions around water resource allocations; and
- define appropriate management strategies and actions which could help to alleviate the effects of frequent droughts, resolve conflicts associated with water allocations and inter-basin transfers, and comply with international agreements around shared water resources.

The Department then intended to develop a catchment management plan for each catchment which, when implemented, would help to ensure the equitable distribution of water resources between different water use sectors. It was anticipated that a suitable "catchment authority" would then be created to undertake the day-to-day management of water resources within each catchment. This "catchment authority" would represent each water use sector in the catchment and would be responsible for executing the management plan under Departmental supervision.

In theory, this new approach represented a radical change from previously exclusive "command and control" practices which were applied in a centralized manner. Here, the Department focused primarily on the national development of water resources, followed by the management of water allocations and the control of point sources of pollution.

The Department's new approach was very comprehensive in terms of the number and variety of issues that were investigated. Similarly, the Department clearly realized the need to integrate all of these issues into a single coherent assessment and management plan. However, this was seldom achieved in practice. Instead, the various issues were addressed individually and management actions tended to focus on the compilation of lists of problem areas and on the collection, transformation and presentation of data. Very little attention was paid to the processes linking and controlling interactions between different components, and the level of true stakeholder participation was relatively low. In addition, very little attention was given to the development of action plans to address the problem areas which were identified.

Overseas experience has shown that one of the major difficulties in being able to effectively implement an ICM approach in practice is usually a lack of appropriate experience and inadequate involvement of all stakeholders in a catchment. In the

absence of appropriate guidelines or handbooks, and lacking experience in participative catchment management, the Department's water resource managers have had to undergo a rapid learning experience whilst continuing with their more traditional water resource management activities. This usually resulted in limited acceptance of the Department's goals and strategies by those stakeholders who may have been excluded from the process.

In addition, the relatively narrow segmentation of functions and responsibilities between different Government departments, and the lack of effective inter-Departmental collaboration, had the result that many land use activities which affect water resources and water quality were outside the influence of the Department of Water Affairs & Forestry. This confined the Department's focus purely to that of water resource management. Since there was no co-ordinated administrative or management system which allowed the catchment processes and activities which affect water resources to be addressed, the process was often ineffective.

Within the Department, the lack of shared understanding of exactly what ICM really is, or could be, resulted in a rather *ad hoc* approach which focused on specific hydrological issues, water quality modelling on a small scale and assessments of the impacts of effluent discharges. For example, the introduction and implementation of systems analysis techniques enabled water supply and risk to be evaluated stochastically on a regional or whole catchment basis. Whilst this helped to alleviate many water supply problems, it largely ignored the critical issue of the flow and water quality requirements of aquatic ecosystems.

The Department's water resource managers were fully aware that the existing institutional structures and legal framework were inadequate to deal with the complexity of water resource management. Similarly, the Department accepted the need to ensure that the process would accommodate previously neglected environmental issues, and would be able to adapt to the changing political, social and economic needs of South African society. It is anticipated that the current review of South Africa's Water Law will address these critical issues and the new legislation will provide a more suitable and practical legal support for the necessary institutional frameworks.

The absence of suitable institutional structures and the presence of an inappropriate legal framework also prevented adequate involvement of the public in decisions around the wider socio-economic implications of development and resource management actions. In many cases, the public were informed on an *ad hoc* basis

of impending management actions rather than being involved in a participatory management system based on shared responsibility and joint decision-making.

This was made worse in those situations where the general public either did not understand the issues at stake or were unable to participate properly, either because they were uncertain as to their roles and responsibilities or because they lacked appropriate information. At the same time, continued rapid and uncontrolled urbanization and development, coupled with inadequate provision of water supply and sanitation systems, has led to over-exploitation of our water resources. Overall, therefore, the ICM approach to water resource management cannot be considered to have been successfully implemented on a large scale in South Africa.

However, in a few situations, (e.g. the Wilderness Lakes area, the upper Olifants River sub-catchment, and the Sand-Vet, Nkongolwana and Mgeni catchments), water resource managers have been able to ensure that most, if not all, the parties concerned have been widely involved in the decision-making process. In each of these situations, the participants have accepted that the ICM approach is at least partially successful and it is now in the process of formal implementation. Such successful applications could in future be used as a foundation for the design of improved institutional structures and communication processes elsewhere.

## 6.2 Australian approaches

### 6.2.1 Separation of commercial and non-commercial water sectors

The functions of water supply and sanitation provision are being separated from the non-commercial function of catchment and waterway management, unless it is more practical not to do so on a local basis. Water authorities and supply boards are being regionalized (for greater efficiency and economy of scale) and commercialised (as opposed to privatised). The supply agencies thus become bulk users of water and/or effluent dischargers, and are subject to the same licensing procedures as other catchment stakeholders or impacters.

Metropolitan water supply agencies will be allocated a bulk water entitlement, which they in turn allocate to domestic and industrial consumers. Rural water boards will further partition their bulk entitlement to agricultural and rural domestic users. Legally defensible water entitlements will be granted to the environment. Bulk water entitlements will be tradable, at real market-related prices.

### 6.2.2 Catchment and waterway management

Catchment and waterway management remains the responsibility of the Environmental Protection Agency (EPA) and relevant government departments, such as Water Resources, Agriculture, Environment. Management attention is focused primarily on identifying, controlling and remediating land use activities which have impacted, or are impacting, on water resources.

Impacts in catchments can broadly be grouped into:

- point sources;
- diffuse sources and the impacts of land use or land degradation; and
- degradation of the instream and riparian environment.

Point source discharges are subject to control by the EPA, who issue works approvals (permits). The criteria for discharge to the water environment are generally site-specific, though subject to certain minimum industry or State standards. Criteria would be based on receiving environment objectives for the local area in question. In many catchments, these objectives would have been set after negotiation amongst stakeholders, through a catchment board or committee.

Land use impacts and degradation of the instream environment might be related to industrial or urban development, which would be subject to control by the EPA or a government department. Where land use impacts arise from agricultural or forestry practices, then a much stronger emphasis is placed on community-based management and action.

### 6.2.3 Community involvement in land and water management

The most urgent and potentially damaging issues facing the rural Australian sector are salinization and nutrient enrichment of water resources. Salinization arises from two principal causes:

- dryland salinity, which is related to the clearing of deep-rooted forests for agriculture or commercial wood harvesting; and
- irrigation salinity, which occurs when irrigation leads to a rise in the water table, bringing very saline groundwater to the land surface.

Nutrient enrichment is a result of leaching of agricultural fertilisers, discharge of sewage effluents, runoff from agricultural land, and uncontrolled access to water

bodies by stock animals. In such cases, water resources management is very closely tied to land management. The problems can only be solved by changes in land use practices at a very local level.

The lead government agency, which may be a department responsible for water resources, environment or agriculture, usually takes the lead in identifying problems through monitoring. The lead agency then plays a critical role in initiating discussions with stakeholders in the catchment and establishing a catchment committee or board, which is representative of the interest in the catchment. The committee, under the guidance of the lead government agency, will usually begin by focusing on a priority problem, such as salinity or algal blooms. Again with guidance and technical support from a number of government agencies, the committee will develop long term objectives, a strategy and an action plan for dealing with the problem.

The initial focus on a priority problem creates cohesion in the group, and ensures that people get involved because they have a real interest in the outcome. As capacity is developed in the committee or group, they can then go on to address other issues in the catchment through the same process, and again with support from the government agencies.

The EPA and supporting government agencies provide the committees with a broader context for development of catchment plans: the objectives and plan for the catchment do need to fit within wider state and national interests. Once the objectives and plan have been developed, statutory support is provided by the EPA, who gazette the objectives, responsibilities and roles of the various agencies and stakeholders in a State Environment Protection Policy paper (SEPP). The SEPPs are catchment-specific, and subject to review every ten years or so. The EPA or a delegated agency is responsible for monitoring and assessing progress towards the achievement of objectives.

The catchment committees are formally constituted bodies, but have very little statutory power themselves: enforcement is still the role of EPA or a government department. The committees have more of a planning function. The lead government agencies provide a very strong "extension service", in their role of technical guidance and support. They may also provide funding for initial scientific/technical investigations, and for the running costs incurred by the committee (such as travel, secretariat).

The extent of the initial priority problem or issue may determine the extent of responsibility which is taken up by a catchment committee, and also the geographical boundaries of responsibility. These are fairly flexible. Sub-catchment committees can later be coordinated under a larger catchment committee or forum.

Once an action plan has been developed, it then remains for individual landowners to implement the relevant land use practices (such as replanting deep-rooted trees, installing drainage, irrigation management). Here the Australian approach is to rely on voluntary compliance, rather than centralized "command and control". It is considered that voluntary compliance, as a form of self-regulation, is more acceptable in Australian society, and also more cost-effective, since fewer resources are required to monitor and enforce compliance.

Self-regulation is admittedly not 100 % successful, but is widely encouraged through community groups such as Greening Australia and Landcare. National Landcare appears to be the key to achieving success in changing land use practices: farmers or groups can apply for grant funding or tax incentives to assist them in implementing on-farm management which complements the catchment plan. Excellent technical and educational support is also provided. (Urban Landcare is now in the early stages of development).

### 6.2.4 Lessons for South Africa

The fact that statutory power remains in the hands of a government agency may help to prevent misuse of that power to promote local interests above provincial or national interests. That, and the emphasis on extension and supporting services supplied by government agencies, may be a valuable lesson for South Africa, at least in so far as rural or undeveloped catchments are concerned.

If catchment authorities are granted statutory powers, then along with that power goes responsibility and accountability. To discharge responsibility adequately requires expertise, skill and judgement. Whether South Africa has, at the present time, sufficient expertise and skill at the local level, which can be utilised in catchment authorities, is very doubtful. The model of catchment committees with strong planning functions, supported by government agency personnel providing technical guidance, facilitation, statutory and regulatory support may be more resource- and cost-efficient at this stage of our development.

The implications of this model are that:

- the Regional offices of the Department and other relevant government departments would need to have the necessary expertise, not only in technical issues, but also in facilitation and extension services;
- collaboration and liaison between different government departments, both at national and provincial level, would need to be improved; and
- legislation promulgated by the various government departments should be complementary and focused on resource management.

## 6.3 North American (USA) Approaches

### 6.3.1 Introduction

This review is based on the results of an Internet search. The search was focused on the home pages of selected institutions which are involved in catchment management, in order to collect information on the structure, role and functions of such bodies. In additions, the USEPA National Library catalogue was searched for useful references, and these have been included in a bibliography as **Appendix 2**. The information obtained was fairly general in nature, and limited to a few key catchments. However, the references provided can be used as a guide for additional more detailed investigation and follow-up.

### 6.3.2 The watershed approach

*Description of the Watershed Approach*

The implementation of a so-called Watershed Approach in the USA is equivalent to the adoption of integrated catchment management in countries such as Australia and the United Kingdom. Presently, this approach is, as in many other countries, focused on protection and management of the quality of natural resources in a river basin. Catchment-based bodies have been set up to manage the major regulated rivers of the USA, and this is discussed in a separate section.

The Clean Water Act and Safe Drinking Water Act, which were passed more than 20 years ago in the USA, have led to significant progress in protecting and restoring the quality of water resources. These Acts were focused on the control of point source discharges from industry and from domestic sewage treatment works. As control of

pollution from such point sources has improved, the persistent problems of non-point sources, sewer overflows and habitat degradation have required more attention.

In order to deal effectively with non-point sources and habitat degradation, it was considered necessary to adopt a watershed-based planning and management approach. Therefore, for the last five years, government departments, agencies and local authorities have all adapted their policies to reflect a watershed-based planning. The watershed approach is being applied nationally, in all the activities of the related agencies and authorities, such as those involved in agriculture, forestry, conservation and development. The USEPA (Office of Water) plays a key role in implementing the watershed approach, providing technical guidance, financial support to community groups, co-ordination and partnerships between interested parties and government agencies, and regulatory support.

The watershed approach is made up of three key components:

- a geographic focus, where the watershed boundaries, including groundwater recharge areas, are used as the primary unit for planning any activities which are related to the utilisation and management of natural resources;
- the development and use of sound scientific data, tools and techniques to inform the planning and management process; and
- partnerships and stakeholder involvement in designing and implementing goals for the watershed.

The USEPA Office of Water (Wetlands, Oceans and Watersheds Program) can be contacted at any time for up-to-date information. Their home page address is:
**http://www.epa.gov/OW/**

*Implementation of the Watershed Approach*

A number of states are now implementing formal watershed planning approaches, and in particular this is being applied in the synchronisation of permitting on a watershed basis. For example, in Massachusetts, the state-wide Watershed Protection Approach was implemented in 1993. Under this policy, water quality monitoring and assessment, water abstraction permitting, non-point source control and point source permitting were all synchronised at the watershed scale. The regional USEPA office collaborated in this by realigning the schedules for permits, so that all permits in a watershed will expire and be reissued at the same time. The intention of this is to allow more options for assessing and implementing the most effective controls on

both point sources and non-point sources, depending on the impacts of these pollution sources on water bodies.

In the state of Georgia, legislative authority was granted in 1992 to the Georgia Department of Natural Resources Environmental Protection Division (GAEPD), to guide the state-wide development and implementation of the River Basin Management Planning Approach. This approach provides a planning framework for developing management strategies to "reduce pollution, enhance aquatic habitat, and provide dependable water supplies".

The state was divided into 14 major river basins, and a five-year cycle of planning and management was introduced. By late 1996, the first management plans should be drafted. Georgia's approach is similar to that followed in Australia, in requiring significant public involvement. A committee of stakeholders is appointed in each river basin, to assist with development of a management plan. The stakeholders represent interests such as landowners, agriculture, forestry, local government, concerned citizens and special interest groups. Staff of the GAEPD serve on the technical planning teams to provide co-ordination, guidance and continuity.

The management cycle has 12 steps, from setting up the stakeholder committee and basin team, resource assessment, setting of objectives, development of strategies, through to drafting of a management plan, review and implementation of the plan. It has been recognised that the River Basin Management Planning Approach will mature as all partners learn from the process. Issues which are not dealt with adequately in the first management cycle can be addressed in the next cycle.

In Utah, the Department of Environmental Quality is responsible for developing programmes to control or prevent pollution. Their Division of Water Quality has been identified as the lead agency for implementing the new Watershed Approach Framework. The emphasis here is on better co-ordination of existing management programs, and more direct involvement of citizens in protecting and managing watersheds.

As in Georgia, the state has been divided into watershed management units, and a five-year planning cycle has been established. Stakeholders will be involved in defining and implementing plans, and activities such as support of ongoing projects, issuing of permits and voluntary best management practices, will be co-ordinated within the strategy for a specific watershed.

A very useful information resource for accessing examples of watershed management plans, related to development of plans as well as implementation, is the California Watershed Projects Inventory. Watershed projects in California are mostly community and government agency partnerships for rehabilitation and management. The reports on the various watershed projects show how community-based advisory groups are established, to work together with government agencies to solve localised watershed problems.

Issues addressed include water quality, environmental quality, land use impacts and soil erosion. Various reports can be accessed through this web page, including:

- watershed management plans (small and large scale);
- conservation planning efforts (species and habitat);
- co-ordinated resource management planning;
- wetlands restoration and enhancement;
- riparian restoration and enhancement;
- native plant revegetation projects; and
- mining reclamation programmes and regulatory compliance.

The home page address of the Inventory is:
**http://ice.ucdavis.edu/California_Watershed_Projects_Inventory/**

### 6.3.3 Management of regulated rivers and shared river basins

Many of the larger rivers of the USA are shared between two or more States, and may be shared across international boundaries. In addition, many of the larger rivers are highly regulated, and have been so for much if this century, in some cases. The purposes for regulation include hydroelectric power generation, navigation, provision of irrigation water, and water storage facilities for urban supply.

Institutional models for basin management at this scale vary. In some cases, such as the Tennessee River, an independent commercialised authority, much like the South African water board, manages and operates the river for its primary business purpose. In the case of the Tennessee Valley Authority (TVA), whose primary purpose is to generate and supply hydropower, this authority may also have a water quality management and habitat management function assigned to it. The TVA must consult with stakeholders, in order to manage the river so as to best meet the needs of all users, within the constraints of the primary purpose of power generation.

In the Colorado Basin, the water is shared amongst several states of the USA, as well as Mexico. Compacts and treaties dating back to 1922 have been used to apportion the use of waters in the Colorado Basin. Management of water resources in the Colorado Basin is a constant challenge due to the demand for water which frequently exceeds the available supply, or the agreed portion, in this arid area.

Strategies for water resources management in the Colorado Basin are described in the Annual Operating Plan for Colorado River Reservoirs, and the report on the Colorado River Decision Support System, both of which are available on the web page belonging to the US Bureau of Reclamation, which is responsible for water and power management in the Lower Colorado. The address of this home page is:
**http://www.lc.usbr.gov/~g4000/index.html**

In a shared river basin such as the Colorado, the general institutional model resembles that used in the Murray-Darling Basin in Australia. A Basin Commission is set up which represents the interests of the states and water users to whom water has been legally apportioned. This Commission then makes decisions on river management, operation and water allocation, within the framework of state and national law, and any treaties or compacts which have been signed. The actual day-to-day management may be undertaken by a government agency, such as the US Army Corps of Engineers, the USGS, the US Bureau of Reclamation, or state government departments. Sometimes an executive office is established which can carry out delegated river management functions, such as the Ohio River Valley Water Sanitation Commission, which is an interstate water pollution control agency for the Ohio Basin.

The Great Lakes International Joint Commission (GLIJC) is a good example of an international authority which manages a very large shared drainage basin. The GLIJC was set up under the 1909 Boundary Waters Treaty, in order to manage the lakes and rivers of the basin for the benefit of citizens of the USA and Canada. Three Commissioners are appointed by the USA and three by Canada. Their role is to set broad policy guidance for basin management, and to provide impartial judgements in resolving any conflicts which might arise. A number of advisory and regulatory agencies, including a Great Lakes Regional Office of the GLIJC, have been set up to administer and implement management strategies.

Information on the GLIJC, and on treaties and agreements such as the Great Lakes Water Quality Agreement, can be found on the Great Lakes Information Network home page at: **http://www.great-lakes.net/**

### 6.3.4 USEPA information related to watershed management

The On-Line Library Catalogue of the National Library of the USEPA was searched for useful references relating to watershed management. The search parameters included policy on watershed management, examples of actual watershed management plans and reports, laws and agreements relating to management of shared watersheds, as well as strategies for watershed management (more technical in nature). The search was limited to documents published after 1980 (for law and agreements), and after 1985 (for watershed management). The results of the literature search are provided in **Appendix 2**.

All the documents listed in **Appendix 2** are available from the USEPA. Copies can be requested by electronic mail, addressed to: **water@epamail.epa.gov**

## 6.4 United Kingdom approaches

Recent developments and changes in the institutions involved in water resource management in the United Kingdom have resulted in the National Rivers Authority (NRA) and Her Majesty's Inspectorate of Pollution becoming part of the Environment Agency (EA). This now means that all the processes and functions of environmental protection, management and regulation can be matched to catchment boundaries and controlled largely by a single authority.

It is anticipated that this will lead to more effective protection of the environmental and ecological aspects of catchment processes, and to more efficient regulation of environmental impacts. However, much of the planning and decision-making is undertaken by the government agency on behalf of the communities involved in the area of concern; therefore, this is more of a "top-down" model.

The process is likely to be very effective as long as the regulatory agency has sufficient personnel with adequate expertise, and the appropriate technical and financial resources are available. Also, in contrast with the situation in South Africa, allocation of water is a problem only in certain areas of Britain, since the country, in the main, is not water-scarce. This feature, coupled with the considerable degree of trust shown towards regulatory authorities by the general public, has reduced the need for stakeholders to participate actively or have close involvement in the decision making process.

The development of approaches to ICM in the UK is still in the early stages, which may explain why public participation in actual decision making is relatively limited. A formal process of Catchment Management Planning has been adopted by the regulatory agency: the catchment management plan which is a result of this process, is intended to establish a long-term vision for individual river catchments; to balance conflicting uses and identify actions needed by government agencies and stakeholders; to promote effective and proactive planning to prevent future environmental damage and to provide lasting solutions to environmental problems. The focus is very much on protection of the general environment of the catchment, although long term water resources planning and development was also formerly a responsibility of the NRA.

The Catchment Management Planning process has several steps:

1. A multi-functional Catchment Management Planning Working Group is set up, consisting of NRA (or EA) members to give managerial and technical support to the planning process.
2. Current and potential catchment uses and activities are identified; liaison with other groups and organisations is informal, and limited to data collection and issue identification.
3. The Working Group identifies environmental objectives (water quantity, water quality, physical features) which are necessary for each of the catchment uses to be supported.
4. The current water quantity, quality and physical status of the catchment is reviewed, and compared to the objectives. Concerns and potential problem areas are identified, and management options to address these are put forward by the Working Group.
5. A Catchment Management Planning Consultation Report is produced, outlining the vision for the catchment, objectives, current status and options for management and/or rehabilitation. The consultation report is used as the basis for both internal and external consultation and discussion.
6. A Catchment Management Action Plan is drawn up which takes into account the issues and comments raised during the consultation process. The Action Plan outlines clearly the actions and timetable required to meet the objectives, and who is responsible for implementation. This responsibility will probably be shared by several agencies, stakeholder groups and organisations.

Examples of Action Plans which were made available by the then NRA reflect not only the fairly early stage of development of ICM in the UK, but also that the need for planning of new economic development is much less urgent than in South Africa. The Action Plans largely consist of lists of regulatory and auditing activities to be

undertaken by the NRA and other responsible agencies. While this kind of plan would be extremely useful in South Africa for regulating, managing and keeping track of environmental and water quality aspects in catchments, it does not adequately address the need for proactive planning of economic development which matches the constraints of the natural resource base.

The current UK approach has high requirements for competent administration, infrastructure, technical skills and funding at central and regional government levels. These features make it difficult to implement this system in South Africa simply on the basis of our limited skilled human resources. In addition, the South African constitution reflects the active desire of communities to have a more active and significant role in making decisions about critical natural resources such as water, than this approach allows at its current stage of development.

## 6.5 French approaches

All water-related issues in France are considered to be part of the responsibility of the Minister of Environment, and are dealt with under the auspices of the Department's Water Directorate. Water is considered to be an important natural resource and aquatic ecosystems are important and worthy of protection. The Ministry determines all water policy and supervises the implementation of these policies by local representatives. In each political and administrative district, local responsibilities have been delegated to the Prefect or administrative head of the district. In turn, the prefect appoints a Basin Co-ordinator for Water Administration to oversee the process. Currently, two sets of legislation (which were promulgated on 16 December 1964 and 3 January 1992) control all water-related activities in the country.

The French water legislation is based on five main principles:

- the unity of surface and underground water resources;
- water must be managed within the context of drainage basins;
- water management must be integrated to include all activities which influence the quantity and quality of the water;
- there must be financial solidarity between all categories of water users (people who abstract water as well as effluent dischargers); and
- the need to ensure close collaboration between all parties and agencies involved in, or associated with, water management.

The French approaches to water resource management have recognized the importance of focusing on the natural drainage basin of each river and its tributaries. Accordingly, the country has been divided into six major drainage basins, whose boundaries cross local and provincial political boundaries. Within each of the six drainage basins, a Drainage Basin Committee and a Drainage Basin Agency have been set up to deal with all issues related to water.

Each Drainage Basin Committee acts as a "mini parliament", and determines how best to address local and regional water problems in the river basin, within the context of national policies. Its decisions are then enacted by the appropriate Drainage Basin Agency. The Basin Committees often have over 100 members, composed of representatives drawn, in approximately equal proportions, from three main groups. These are:

- user groups (industry, land owners, effluent dischargers, etc.);
- representatives of the local departments, regions, cities and towns; and
- representatives of the French State, appointed by the Ministry.

The six Basin Agencies, (called Water Agencies since 1991), are public institutions which operate under the auspices of the Ministry of the Environment. Each Water Agency is an executive tool of the Committee and implements policies decided by the latter. Each Agency is controlled by a board of directors consisting of elected officials, water users, effluent dischargers, and State representatives appointed by each Basin Committee. They are financially autonomous, and thus able to address and support operations required to resolve water supply and water pollution problems.

Each Agency draws up a five-year plan for the development of water resources and for pollution control. Implementation of this plan is financed by taxes or levies collected from water users and effluent dischargers. These levies or taxes are in proportion to the quantity of water abstracted or the quantity and quality of effluent discharged, respectively.

The main objectives addressed by each Water Agency are the following:

- control of all forms of water pollution;
- the restoration of surface and groundwater quality where this may be required;
- preservation of aquatic ecosystems;
- the development, protection and distribution of the water resource to meet fully all uses as and when required, and to ensure drinking water supply;
- preservation of water flows and the prevention of flooding; and

- the provision of adequate water supplies for agriculture, fishing, leisure and all other legally permitted human activities.

The institutional features of the French approach seem to be relatively cumbersome when compared with other overseas approaches to water resource management. However, the basic concepts are similar to those of other countries and work well within their national context.

## 6.6 Other African approaches

### 6.6.1 Introduction

Elsewhere in Africa, considerable attention and rhetoric have been focused on the issue of water resource management and, in particular, integrated catchment management. Inevitably, much of the attention has been directed towards resolving the complex issues of large shared river basins (e.g. the Nile, Zambezi, Okavango, Kunene and Orange rivers) and inter-basin water transfers. Unfortunately, very limited success has been achieved to date in attempts to resolve these issues. The respective debates and negotiations have been particularly intense and often highly acrimonious in those regions where water resources are scarce or where civil war prevails (e.g. Sudan, Uganda and Ethiopia in the upper Nile River basin; Angola in the upper catchments of the Kunene and Okavango rivers).

Several international aid agencies have made concerted attempts to facilitate multi-national negotiations and agreements on shared water resources. Perhaps the best-known African examples are those of the Nile and the Zambezi rivers. Many of these international attempts have focused on the development of regional water balances and a variety of predictive modelling techniques have been used to examine different water allocation scenarios. However, due to the inherent political, economic and social instability of several of these basin countries, very little has been achieved beyond the development of conceptual plans. Therefore, it is unlikely that these attempts will succeed until each country is able to participate in the debate as an equal partner, and there are sufficient skilled personnel available plus the required technical and financial resources.

In some southern African countries, (e.g. Namibia and Zimbabwe), there is good appreciation that the ICM approach offers the most effective solution to water

resources management. However, the degree to which the principles of ICM are applied differs between them.

### 6.6.2 Namibia

In the case of Namibia, many water resource managers consider that there are too few perennial surface water resources to justify the application of this approach throughout the country. The only perennial rivers, (Kunene, Okavango, Zambezi and Orange), are located on the country's borders and are shared with other basin states, not all of whom share Namibia's problems of water scarcity. Each of these shared river basins are administered by Joint Permanent Technical Commissions, where each basin state is represented.

In the case of the Okavango River, for example, a tripartite organization called the Okavango River Basin Commission (OKACOM) has been formed by Namibia, Botswana and Angola. This organization aims to oversee water resource management within the entire river basin. Because this organization is still in the early stages of formalization, it has not yet undertaken any formal management activities. Elsewhere in Namibia, no formal catchment management authorities have yet been constituted, though water supply activities have begun to be commercialized through the formation of a parastatal organization called Namwater. This organization will function very similarly to a South African Water Board.

Nevertheless, the ICM approach has been used to good effect within Namibia, for example in the ephemeral westward-flowing rivers which drain through the Namib Desert to the Atlantic Ocean. Here, the ICM approach provides a valuable framework for defining the needs of users and selecting appropriate management options. In the case of the Central Namib State Water Scheme (CNSWS), demands on the groundwater resources from three different ephemeral river systems (the Kuiseb, Swakop and Omaruru rivers) can be carefully balanced to minimize environmental degradation.

### 6.6.3 Zimbabwe

In Zimbabwe, water resource management is a responsibility of the central government, specifically the Ministry of Lands and Water Resources, and includes both surface and groundwater resources. The responsible Minister has delegated

authority to regulate and supervise the exercise of water allocation rights and the control of water quality to a number of River Boards. The primary objectives of these Boards are to exploit and conserve the water resources of the(ir) specified area with the object of:

- securing their proper use and development;
- providing in both the short- and long-term, adequate water supplies on the most economic basis; and
- ensuring the efficient distribution of water supplies in order that the economic development of the area may be promoted, facilitated and expedited in the National interest.

Catchment Boards and River Boards are found in many areas of Zimbabwe but their areas of jurisdiction do not cover all of the country, all people holding water rights, all catchments or all commercial farmers. The legislation allows the formation of River Boards but does not make them compulsory. Therefore, it is only those people who have a critical interest in the day-to-day management of water who have formed boards in these areas - these are inevitably the larger commercial farmers who use over 80 % of the managed water in Zimbabwe. Given the important need to manage irrigation water on a day-to-day basis, the activities of River Boards can therefore be said to be acting on the basis of water use efficiency and the self-interest of the participating landowners and irrigators.

The enabling legislation in Zimbabwe refers only to River Boards, even though most established River Boards represent a section of river, stream or tributary which is only part of a catchment. Of the River Boards in operation, there is great variability in size, efficiency and effectiveness. In some parts of the country several River Boards have formally grouped themselves together to form a higher body, a Catchment Board, to manage a catchment or part of a catchment; this activity is allowed by the River Board regulations and legislation.

However, none of the areas of responsibility of these Catchment Boards actually covers an entire catchment. In addition, there are no formal mechanisms or processes which can be used to facilitate participation and negotiation amongst stakeholders. In some cases, River Boards could not be formed because of a lack of agreement amongst interested and concerned participants as to who should represent specific interest groups.

A Regional Water Authority (RWA) has been formed to assist with the development and management of water resources and agricultural potential in the south-eastern

region of Zimbabwe. However, despite owning and operating water supply dams, and possessing its own water rights, most commercial farmers operate independently of the RWA. In addition, the RWA is restricted in its ability to manage its own water in that virtually all of the water it manages is committed by long-term agreements to specific users.

The overall impression gained of water resource management in Zimbabwe is one of fragmented and divided responsibilities in which there is little or no co-ordination at regional or national level. Whilst some individual landowners may benefit from the actions River Boards, these do not function in a manner which is conducive to either efficient or effective water resource management. In conclusion, the Zimbabwe River Boards example is one which South Africa would do well to avoid.

## 7. CONCLUSIONS

Based on the information gained from local and overseas sources, several pertinent comments can be made regarding the level of commitment and types of arrangements that would be required to implement an ICM approach in South Africa. Clearly, whatever approaches appear to be applicable, the Department's objectives for adopting ICM will influence the type of ICM approach which is eventually implemented in South Africa. Two possible objectives are addressed below.

### 7.1 Objectives for ICM implementation

#### 7.1.1 Devolution of authority and responsibility

If the Department's objective is to devolve more of the day-to-day management function down to local level in order to relieve pressure on the available manpower resources at central government level, then it may be more appropriate to set up statutory catchment boards with the power to raise levies, issue permits for discharge and abstraction, and enforce permit conditions.

The advantages of this are that responsibility, accountability and authority are held at the catchment level, and this is in line with the philosophy of the present government. Real decision making can then take place at a catchment level, assuming the catchment boards are structured so that all stakeholders are represented.

However, the disadvantages of this model probably outweigh the advantages:

- the appropriate expertise, experience and judgement are not likely to be available within stakeholder communities at a catchment level, nor is it likely that South Africa could, in the short- to medium-term, find sufficient skilled people to be employed to carry out the executive and management functions of the boards.
- the activities and administration of the boards would probably have to be financed from the local tax base, possibly with additional support from central or provincial government. Sufficient funding may not always be available.
- given that many of South Africa's river catchments are shared across provincial boundaries, and that inter-basin transfers are common, there will be a good deal of administrative effort required in co-ordination. Also, the participation by local, provincial and national priorities will need to be balanced. This may be problematic if authority for water allocation is devolved to individual catchments or even individual province level.

### 7.1.2 Improved resource management

If the objective is to improve the long term management and protection of water resources, then the Australian or British models would probably serve as the best basis for implementing ICM in South Africa. However, it is important to remember that they are two fundamentally different models.

The British model has very high requirements for centralized control, administration, infrastructure, skills and funding at central and regional government levels. This would make it very difficult to implement in South Africa because of our limited skilled human resources. The South African constitution presents an additional problem in the way in which it reflects the desire of communities to have a more active and significant role in decision-making about natural resources.

An alternative approach to ICM which draws on the positive aspects of the Australian models seems to show the most promise for South Africa. The Australian approach relies on active community and stakeholder participation in natural resources management and decision making, within a framework of guidance and support from government agencies at state and federal level.

However, a perceived disadvantage of the Australian model may be that ICM is seen as a long-term process, where implementation is a gradual and slow process of

learning, negotiation, planning and action. In addition, the Australian model would need to be adapted to deal with the complex and sensitive water allocation decisions which have to be made in South Africa.

The advantages of the Australian models are that planning and actions are community-based. All stakeholders play an active role in management, from the institutional level down to the individual landholder level. Broad policies and objectives for water resources management can still be set at central government level, and these serve as a framework within which catchment communities can make their own decisions about how the resources are allocated and managed.

The Australian models require the following:

- a core of skilled personnel at central and regional government levels, to initiate, facilitate, assist and guide catchment community groups through the process of ICM;
- access to technical support through scientific and engineering strategies for assessing and dealing with resource management issues;
- greatly improved collaboration between the government departments and agencies involved in resource management. This may be facilitated through the adoption by all relevant government departments of an umbrella national policy towards ICM;
- long term commitment of funds and personnel to support each of the catchment community groups.
- policy support and guidance from central government level so that water resources management decisions are made on a consistent basis throughout the country.

Clearly, if ICM is to succeed in South Africa, there must be a far wider acceptance of the need to properly empower people so that they can participate in a transparent decision-making process. This will require a dramatic change in attitude and approach, both amongst the general public and from our water resource managers. At this crucially important time in the history of South Africa, we have the unique opportunity to facilitate this change as an integral part of the socio-economic reconstruction and development of our society. However, ICM will not succeed if the approach is not supported by suitable legal, institutional and administrative frameworks. Unfortunately, this will take both time and money to accomplish as we are still at an early stage in the development phase.

## 8. RECOMMENDATIONS FOR THE FUTURE

Ideally, South Africa should look at a gradual shift from a situation where ICM is regulated and controlled by central and regional government levels (as in Britain), but still with some stakeholder consultation, to the community-based self-regulatory approach towards which Australia seems to be moving. This would allow sufficient time for learning and the development of an appropriate skills base: the country could then expand ICM from the present relatively small core of skilled people at central and regional government level. This would also allow us to take the best learning from the different models used in other countries, and apply it in a logical and structured manner as we develop ICM towards its ideal.

On the ground, this could take the form of identifying priority catchments, and working initially with a catchment forum, or some similar participatory organisation. The forum could be gradually developed into a catchment committee, taking more responsibility and accountability as local capabilities are developed and enhanced. The next step could be the development and constitution of a catchment board or authority, whose legal, executive and fund-raising status would depend on the needs of the local situation.

Some specific recommendations can be made on the basis of overseas experience in ICM and our current state of knowledge. These are:

1. The Department should spend enough time on developing a sound policy basis for ICM in South Africa. The policy process needs to involve not only the Department as the regulatory and water management agency, but also representatives from other government departments and agencies whose responsibilities are related to water resources allocation and management, as well as other stakeholder groups.

2. The Department should consider the development of a national "umbrella" policy, to which all relevant government departments could subscribe. The intention of this would be to ensure commitment to ICM and collaboration from all the agencies at national, provincial and local level. Inter-department co-ordination on resource management issues at national, provincial and local level should be supported as a matter of policy.

3. The lead agencies involved in ICM should ensure long-term commitment to providing the right personnel to develop and implement national ICM policy

at the catchment level. This should be supported by parallel commitments to provide long-term funding to policy implementation. Perhaps the best location for personnel who are involved in setting up catchment community groups and guiding the planning process, would be at regional level within the Department of Water Affairs & Forestry.

4. The Department should minimise the introduction of detailed new legislation on ICM at this time, or at least until there is a wider shared vision of the way in which ICM should proceed in South Africa. In addition, the ICM philosophy is founded on flexibility and adaptability. Legislation and regulation should follow the ICM process, rather than attempt to lead it too strongly.

5. Ideally, the new Water Act should contain sufficient enabling legislation to allow an appropriate catchment management body (a forum, committee or board) to be set up within a catchment. This would allow lead agencies to:
   - facilitate the development of appropriate frameworks for catchment management plans;
   - allow the regulatory agency to enforce permit conditions and aspects of the management plan; and
   - set up appropriate consensus-seeking and conflict resolution mechanisms.

6. The revised Water Act should allow the Minister to issue regulations on a catchment-specific basis, regarding:
   - the geographical boundaries of a catchment;
   - resource management objectives for the catchment;
   - the nature of the process of developing a catchment management plan;
   - agency and stakeholder responsibilities for implementation;
   - authority, accountability and legal status of the catchment board or committee;
   - conflict resolution processes;
   - monitoring, auditing and reporting requirements and responsibilities; and
   - the time scale and process for review of regulations.

7. In order to ensure successful implementation of ICM approaches, there should be a clear long-term commitment from government to support ICM with financial and manpower resources.

8. Clear policy guidance will be required on the use in ICM of instruments such as: water quality guidelines, effluent emission standards and permits, environmental impact assessments.

## 9. REFERENCE MATERIALS USED

The individuals consulted and the published information examined during the execution of this investigation are listed below. The individuals are listed in alphabetical order whilst the published references are listed in alphabetical order and then in chronological order for subsequent articles by the primary author.

### 9.1 Personal communications and interviews

Dr V. Alavian, Vice-President: Rankin International Engineering Consultants, Knoxville, Tennessee, USA.

Professor A. Arthington, Director: Centre for Catchment and In-stream Research, Griffith University, Nathan Campus, Brisbane, Queensland, Australia.

Dr B.A. Banninck, Principal Scientist, Rijksinstituut voor Volksgezondheid en Milieuhygiene, Bilthoven, Holland; (Manager of the RIVM Nairobi Office).

Mr G. Bateman, NRA South Western Region, UK.

Dr G.A. Best, Principal Freshwater Scientist, Clyde River Purification Board, Glasgow, Scotland.

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# APPENDIX 1

## MANAGEMENT OF WATER RESOURCES IN AUSTRALIA

**Report to**

**Water Research Commission**

**and**

**Department of Water Affairs and Forestry**
**(Water Law Review: Institutional Arrangements Task Team)**

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CONTENTS

# MANAGEMENT OF WATER RESOURCES IN AUSTRALIA

## 1. INTRODUCTION

### 1.1 Background to the Australian Study

Australia is a country which, over the last two hundred years, has built an economic foundation on the development and commercial utilisation of natural resources, primarily land, forests and water, before beginning to strengthen their manufacturing and resource beneficiation industries. Much of Australia is water-scarce, with great variability in the distribution of water. The generally semi-arid climate is similar to that of southern Africa. Hence we can expect that Australia has faced, or is presently facing, many of the same issues as South Africa does, in relation to the development, utilisation and management of natural resources.

A study visit was undertaken in 1994 to identify key issues in natural resources management in Australia, with the intention of finding out how similar these issues were to those facing South Africa, and what learning could be gained from comparing the approaches used in the two countries. The Australian situation was assessed within a framework which covered, broadly:

- *issues* - the most significant current issues being dealt with in Australia, in the context of natural resources management;
- *policy* - current and developing policies for addressing these significant issues;
- *legislation* - key legislation which facilitates (or constrains) the sound management of natural resources;
- *institutional arrangements* - the roles, responsibilities and interactions between the agencies, authorities and government departments involved in natural resources management, including the interactions between the Federal and various State governments;
- *implementation* - how the policy and legislation is translated into practical action plans, and how these actions are being undertaken. This includes the development of scientific and technical support systems, but also, and most importantly, addresses the role of communities and individuals in implementation of national, state and regional policy and legislation. The study included an investigation of community-based programs such as Landcare, Salt Action and Waterwatch; the establishment of catchment co-ordinating committees for addressing land and water management issues; the role of lead government agencies in initiating and supporting community-based programs.

Melbourne, in the state of Victoria, was used as the geographical base for the study. This was principally because, among the Australian states and territories, Victoria has the longest history of policy and legal support for the protection and management of natural resources. Their Environment Protection Act of 1970[1] gave the basis for the establishment of the Victoria Environmental Protection Authority (VEPA), and for co-operation between the relevant government departments in integrated management of natural resources. Experience gained in implementation has allowed the policy, legislation and institutional functions to be reviewed and optimised over the years. The Water Studies Centre of Monash University provided an ideal base from which to work, due to the close proximity to most state government central offices, and the availability of library facilities.

The Australian states each tend to follow slightly different approaches to management of natural resources. Although recent agreements[2] have led to closer collaboration between the Commonwealth Government in Canberra and the states, each state still retains a considerable degree of autonomy in decision making. From Melbourne, visits were made to Queensland, Western Australia and Canberra to investigate the policy, legislation, institutional and practical aspects of resource management.

The scope of the study included the management of agricultural land, forests and water resources. All of these three are closely linked in Australia, since the most significant issues related to water resources management arise primarily from the impacts of forestry or agricultural practices, although industrial and domestic effluents and urban developments are also of concern.

For the purposes of this report, we have focused on water resources management, specifically the development and implementation of integrated catchment management approaches. In many of the examples discussed, forestry and agriculture have been used to illustrate the development and application of systems for the optimal integrated management of land and water on a catchment basis. As far as possible, the policy, legislation, institutional structures and community-based programs which make up these management systems are identified and critically reviewed.

## 1.2 Study Methodology

The study method was based on personal interviews with:

- people in each government department dealing with land, water and forestry resources;
- people in VEPA and the Commonwealth EPA (CEPA);

- key people in water authorities, including Melbourne Water, the Murray-Darling Basin Commission and the Water Authority of Western Australia;
- people involved in the initiation and implementation of community programs, specifically Landcare and Waterwatch;
- scientists and researchers involved in development of supporting technical information and scientific understanding, including the Land and Water Resources Research and Development Corporation (LWRRDC) and various Co-operative Research Centres;
- community representatives involved in the activities of catchment management committees.

Discussions with these interviewees were based on the study framework of identifying the key issues, policy, legislation, institutional functions and implementation related to natural resources management. In each case, these interviewees were asked for referrals to other key people, and were also requested to provide documentation or references to documentation which would support the study.

It is a tribute to all of these Australians that no request for an interview was ever refused, and that everyone interviewed gave of their time generously and often on more than one occasion, since it was sometimes necessary to follow up on certain issues; that everyone interviewed was willing to openly discuss the issues from their perspective, and how their roles and responsibilities contributed to the management of natural resources; and that a large amount of documentation was provided freely, which has formed an important information resource for this study. Dr Jane Doolan and Ms Patricia Geraghty of the Department of Conservation and Natural Resources in Victoria, and Dr Phil Price of LWRRDC deserve special mention and thanks.

## 1.3 Structure of this Report

Current reforms in the Australian water sector are progressing towards an eventual separation of the commercial functions of water supply and sewerage services, and the non-commercial function of waterway management. Therefore this report is presented in three main sections:

- firstly, a brief discussion of current reforms related to water supply functions, and the changing role of water supply agencies. This is relevant to waterway and catchment management in so far as commercialised water supply agencies will now be more clearly identified with other land users and bulk users of water, through the implementation of new legislation regarding tradable water entitlements.

- Secondly, a discussion of integrated catchment and waterway management, which will remain the responsibility of state agencies or those to whom authority is delegated by the state government.
- Thirdly, sections outlining some lessons from the Australian experience of ICM, which may be useful for South Africa, and some points for discussion as part of the Water Law Review process.

Because of the comprehensive nature of the study, and also because there are so many related aspects of land and water management, this report is intended to serve more as a broad overview. Rather than incorporating all the detail here, the report should provide guidance for further investigation of specific aspects. In the general discussion of catchment and waterway management, the framework of issues, policy, legislation, institutions and implementation will be followed.

The reader in search of more detailed information will be referred to the relevant documents, or to people in Australia who can assist with queries. Almost all of the documents cited in this report are available, and will be archived at the main library of the Department of Water Affairs & Forestry in Pretoria. One of the supporting products of the study is a keyword-searchable database of these documents, with reference information and brief summary notes on the content of each.

## 2. THE COMMERCIAL WATER SECTOR

The Australian water industry has assets of $80 billion but in commercial terms relative to land values, the return on these assets is very poor. In order to promote economic development, the real cost of water to agricultural, industrial and domestic consumers has often been subsidised[3]. This has led to the situation where water, although recognised as being a scarce and valuable resource, has not always been treated as such in a financial sense.

The current trend in Australia is towards commercialisation of water supply functions, with the objectives of providing a more efficient and effective service, but also of achieving some degree of cost recovery in a real-market situation[4,5]. The reform of the water industry in Victoria is discussed here as an example.

The promulgation of the 1989 Water Act in Victoria signalled an attitudinal change of the State Government towards integrated resource management based on modern economic, social and environmental principles. The Act represents a marked shift from the view that water is a plentiful resource for all to take for granted, to the

prevailing reality that water is a scarce resource which requires wise and efficient management.[6,3]

Superimposed on new and existing legislation is the Victorian Government's desire to corporatise the institutions which manage water resources, and make them more autonomous and financially accountable. The underlying philosophy of the State Government is to open up the water sector to market forces, particularly competition.[3]

Victoriaš water supply sector can be divided into three primary sub-sectors, and each of these are discussed separately:

- the Melbourne metropolitan area;
- outer Melbourne and peri-urban areas;
- rural areas.

## 2.1 Water Supply in the Melbourne Metropolitan Area

The sole responsibility for bulk harvesting and supply of drinking water, removal of sewerage, urban drainage, trade disposal, and parks waterways and catchment management for the Melbourne metropolitan area lay until recently with Melbourne Water. Melbourne Water is a "State Government Owned" company, which operates under the Water Act 1989, the Melbourne and Metropolitan Board of Works Act 1958, Melbourne Water Corporation Act 1992, Catchment and Land Protection Act 1994[7] and the State Owned Enterprises Act. Proposed reforms to Melbourne Water include[3]:

- separating core commercial activities of water, sewerage and drainage services for which returns can be expected, from non-commercial activities such as management of parks and waterways;
- issuing Melbourne Water with an operating licence which will legally require it to deliver its core functions of water, sewerage and drainage services, and require these services to meet standards and be price-regulated;
- restructuring the accounting system to introduce three main catchment based water distribution businesses within Melbourne Water i.e. competition generated by internal comparisons;
- contracting out services like water and sewerage maintenance, survey and mapping, cafeteria, geotechnical and insurance to private industry;
- allowing a private company to build, own and operate the Yan Yean drinking water treatment plant which then sells treated water i.e. Melbourne Water

buys treated water rather than pays to treat the water itself. This allows Melbourne Water to focus on its core business of supplying water;

- implementing a user-pays pricing structure for consumers so that the more one uses, the more one pays;
- privatisation of assets, although Melbourne Water will continue to be Government owned (for now).

The planning handbook *Water Victoria: The Next 100 Years*[8], proposed three possible scenarios for taking Victoria into the next century in relation to water resource management.

The scenario which incurs the least cost to the environment, and to the government and consumer, is to make water a tradable commodity. There is also the option of treating low quality water or sewerage to provide potable water in the future. Water is presently allocated by the State Government, but this system has not always operated efficiently, and has been conducive to mismanagement of both land and water[4]. The National approach to water reform is set up water markets within which water entitlements can be bought and sold, and in which the environment has a legal entitlement. This approach will eventually underpin how the water sector, including Melbourne Water[10], operates in the future. A separate discussion on tradable water entitlements, and the development of policy and legislation in this respect, can be found in section 2.1.4 below.

## 2.2 Water Supply to Outer Melbourne

The same services which Melbourne Water was supplying to the Melbourne area were provided by over 100 different water authorities to the outer Melbourne or peri-urban area. The underlying thrust of the reform for this sector is to make water services more catchment oriented rather than local region oriented.

All of the legislation which applies to Melbourne Water and the Melbourne area also applies to this sector. The main mechanism for facilitating the reforms is to amalgamate the authorities, reducing the number from 83 to 17 regional water supply authorities,[6] (catchment-based as far as is practical). Benefits should flow on from economies of scale and more co-ordinated management. Essentially the same principles of separating core business from non-commercial functions apply to this sector also, and it is expected that the new Catchment and Land Protection legislation[7] will provide for management of the land and water resources.

## 2.3 Water Supply in Rural Areas

The Rural Water Corporation, which is now a statutory authority or a Government managed institution, has responsibility for supplying irrigation, agricultural, stock and rural domestic water to the rural areas of Victoria. The Corporation had relied on cross-subsidies to finance the provision of water supply to rural areas, but substantial reform is intended to improve efficiency in this sector also. The Rural Water Corporation now operates under the Water (Rural Water Corporation) Act 1992. The proposed reforms[6] include:

- having a small central corporation providing strategic direction and fiscal guidance while driving the change process;
- having five regional organisations, based on physical water systems, each with a Regional Management Board, which will provide the full range of wholesale and retail water services;
- having technical and business support services provided by service companies open to market competition;
- making up the shortfall in revenue by restructuring, debt forgiveness in exchange for Government owned equity, revenue from new sources, increased charges and a government subsidy over an adjustment period;
- setting up semi-independent service companies;

Activities such as water quality monitoring, floodplain management and licensing of works are no longer the responsibility of the Rural Water Corporation, but will be the responsibilities of VEPA, Department of Conservation and Natural Resources and the proposed Catchment Boards.

## 2.4 Tradable Water Entitlements and Water Accounting

Under the Water Act 1989, the State Government or "Crown" has the ultimate legal control and right over all surface and groundwater in Victoria. The Crown allocates water to water authorities such as Melbourne Water and the Rural Water Corporation, who then partition and allocate water to consumers.

In Victoria, a task force examined ways to convert existing water rights to "bulk entitlements". There are attenuated and non-attenuated entitlements to water. Non-attenuated (NA) entitlements derive from a percentage of the source i.e. dam or reservoir, whereas attenuated (A) entitlements derive from volumetric abstractions from a water network, mostly at the point of delivery. A water authority which operates in a headwater or catchment would have NA bulk entitlements, whereas an

authority downstream who must take water from a stream or river would operate under an A entitlement for example, by using a licence system. The details of such a system can be found in additional references.[9,11,12,13]

It is expected that this approach will cost less in both environmental and economic terms because future growth and development will be sustained through reallocation of existing stores of water and not by building more dams and diversions. It is, however, important that water rights be precisely specified and that the total entitlements allocated do not add up to more than 100 % of available water.

The principal objectives of implementing Bulk Water Entitlements are:

- to provide authorities with a clearly defined property right to water;
- to provide authorities with flexibility to manage within their entitlements;
- to provide a basis for sharing limited water resources;
- to facilitate water trading between user groups;
- to allow specific entitlements for environmental purposes.

In order for the system to be successful, Bulk Water Entitlements must be:

- explicit in defining where or from which source the water will be abstracted;
- exclusive to the authority to which the water has been granted;
- tradable in part or in total to other authorities;
- enforceable by law through proper monitoring and policing.

To support the system of entitlements, a form of water accounting is likely to be necessary. The water accounting system presently used in the Murray-Darling Basin, where several states are granted water entitlements from a shared water resource, is described in greater detail in additional documentation.[14]

Under the system of tradable entitlements, legal entitlements can be made to the aquatic environment. In some cases, these entitlements may need to be bought back from users by the State, and reallocated to the environment. In cases of new water developments, the entitlement to the environment would be allocated on the basis of representations made by environmental managers (such as the relevant government departments, the VEPA, National Parks or Catchment Boards).

## 3. CATCHMENT AND WATERWAY MANAGEMENT

Approaches to integrated catchment management differ from State to State in Australia, but are generally all in early stages of development, and show different

degrees of implementation and formalisation, as well as differing levels of success in meeting objectives. A comprehensive review of integrated catchment management processes in Australia was carried out by the Australian Research Centre for Water in Society[15] in 1993, and several recommendations were made in that report which would be relevant for the South African situation.

This section covers descriptions of different approaches to integrated catchment management in Australia, focusing primarily on the management of land use impacts on water resources. There is a strong emphasis on the role of private landholders in integrated catchment management in Australia, but the principles described here can be applied to the management of publicly held land, and of land uses which generate point source effluent discharges (such as industry and urban development).

The section begins with an overview of the key catchment issues of concern in Australia, and then the different State approaches are dealt with in separate sub-sections. The role of National Landcare in integrated catchment management is covered in a separate section.

## 3.1 Key Issues in Land and Water Management

The key issues of concern which have led to the need for integrated management of water resources and the land areas which impact on them are similar to issues of concern in South Africa. The issues are listed below. In some cases, more detail is given in the following sub-sections:

- dryland salinity
- irrigation-induced salinity
- nutrient enrichment
- soil erosion and sediment discharge into surface waters
- degradation of riparian and instream habitat
- river regulation for irrigation and supply purposes
- discharge of point source effluents to surface waters (industrial and domestic effluents).

### 3.1.1 Salinity

Many areas of Australia are underlain by extremely saline groundwater reservoirs. Salinisation, or the accumulation of salts in water and soil, occurs naturally over time. When it results from natural geological processes such as weathering, it is

referred to as primary salinisation. Land and water salinisation due to human activities is known as secondary salinisation. A further distinction can be made between the types of secondary salinisation. Dryland salinity is a result of water table rise due to accelerated recharge form non irrigated land as opposed to irrigation salinity where the water table rises due to accelerated recharge from irrigated land. Even though the results are the same, distinguishing between the two types of salinity is useful in as much as it distinguishes between two different types of land use and thus different management options. Dryland salinity may also include non-water table related "dry scald" where top soil is lost, exposing a naturally saline sub-soil.

It is now well established that the unprecedented clearing of deep-rooted native vegetation and replacement with shallow rooted perennial grasses and annual crops is the principal cause of secondary dryland salinity in Australia. Overgrazing and the changed frequency and timing of fire also contribute to dryland salinity. In addition to the degradation of the land is the concomitant degradation of surface water by salts being washed off the land and by salinisation of groundwater discharge into streams. There is also the problem of downstream siltation and flooding.

Even though the consequences of land clearing have been obvious in Australia since the early 1900's, land continues to be cleared and legislation has been required, in order to control the rate of land degradation. The states now have mixes of tenure, land use, and land management arrangements.[16,17,18,19,20,21] These include various forms of clearing controls, tax incentives and deductions, state and federal grants for projects, and public awareness and education about the benefits of native vegetation. State-wide controls regulating the broadscale clearing of native vegetation for agriculture have recently been introduced in South Australia and Victoria.

There is a considerable amount of legislation controlling vegetation clearing, housed in various State and Federal departments, which does make matters complicated. However, there are no legislative impediments which would deter landowners from planting deep-rooted trees if they so desired, and such activities are supported through programmes such as Landcare and Greening Australia. The co-ordination of such activities should be done on a catchment basis, and hence salinity management has often formed the initial catalyst for broader integrated catchment management processes to begin.

The Land and Water Resources Research and Development Corporation (LWRRDC) provides the national leadership and co-ordinating role for research and funding of salinity management throughout Australia.

### 3.1.2 Nutrient enrichment

Nutrient enrichment of surface waters is a significant concern in Australia. Recent massive algal blooms in the Murray-Darling and in many other rivers and reservoirs have led to the adoption of strategies for nutrient load reduction. Although point source discharges contribute to the problem, it is considered that enhanced control of non-point sources on a catchment basis should lead to improvements in water quality. The Federal Government has published recommendations for nutrient management, which include recommendations on the roles of government agencies and landholders.[22]

In Victoria, the recently passed Catchment and Land Protection Act 1994[7] provides the legislative framework to support the implementation of improved catchment management plans. One aspect of improved catchment management is the Victorian Nutrient Management Strategy[23] which is designed to provide the policy and planning framework necessary to address eutrophication.

Programmes for controlling nutrient pollution might include a mixture of regulatory (i.e. licensing releases into a stream and planning approvals), market based approaches (i.e. tradable effluent permits) and educational initiatives (i.e. Landcare, Waterwatch). Examples of catchment plans focused on nutrient management include stormwater management in the Murray-Darling Basin[24], nutrient management in the Peel-Harvey system[25], reservoir management plans for Candowie and Lance Creek[26].

Mechanisms for control of diffuse nutrient pollution would be applied in a co-ordinated manner through the several responsible government agencies, within the context of an agreed catchment management plan, and include:

- managing fertiliser application;
- maintaining vegetation cover to reduce soil and nutrient runoff;
- preventing stock access to a water body;
- better management of riparian zones;
- regulating irrigation drainage;
- using wastewater for irrigation; and
- retaining effluent from intensive animal industries on land.

Measures for reducing nutrient pollution from point sources include:

- removing or reducing phosphorus in detergents;
- treatment of domestic sewerage;

- retaining effluent in holding basins and wetlands which assimilate some of the nutrients, and allow particulate matter to settle out;
- diverting effluent to land i.e. to plantations;
- not allowing septic tanks to discharge into rivers and streams; and
- providing gross pollutant traps in storm drains before the stormwater reaches waterways.

### 3.1.3 Degradation of riparian and instream habitat

The degradation of riparian and instream habitat leads to damage to ecosystem health, which in turn can cause water quality problems in surface water resources. Typical concerns related to riparian and instream degradation are:

- removal of vegetation by stock, agriculture, recreation, human development and erosion;
- weeds and vermin infestation, i.e. blackberries and willows;
- increased salinity in rivers adversely affecting existing riparian vegetation and revegetation;
- vandalism of fences;
- loss of ecological niches; and
- loss of landscape, cultural and recreation values.

In Victoria, the river frontages are administered and managed by DCNR who license river frontages to private landowners for grazing and agriculture. However, Management Committees can be set up to take the managerial responsibility. Some landowners own river frontage but rarely the bed and banks of a river. One approach being tested in Victoria is to delegate responsibility of management to a local river management authority which retains river frontage revenue and uses it for frontage management programs[27].

Suggested management options include:

- regulation of weir operation, where possible, to mimic natural flow conditions. This could involve prolonging the rates of rise and fall by staging operations to offset the rapid changes typical of the regulated river;
- control of the effects of grazing on riparian vegetation through fencing off of certain areas;
- license fees which reflect the true value of river frontages;
- reduction of license fees to encourage the landowner to undertake river frontage rehabilitation works; and
- planning controls.

### 3.1.4 Point source discharges

Point source discharges are licensed and regulated by a government agency, usually the State EPA. In Victoria, the VEPA, under the Environment Protection Act 1970[1], issues a "works approval" (equivalent to a discharge permit) for an industry, which covers emissions to the water, air or land environments[28].

Discharge standards are set in the context of the receiving water environment objectives for a particular river or river reach. These objectives would have been decided by the catchment committee or board, with guidance from the VEPA and other government agencies.

There is a strong emphasis by both Federal and State EPA on encouraging cleaner production and waste minimisation, through the use of economic incentives and awareness programmes.[29,30,31,32]

## 3.2 Approaches to Integrated Catchment Management

### 3.2.1 Broad policy support for integrated catchment management

Integrated management of land and water is supported by several other national and State policies in Australia. Umbrella policies which give a context and impetus to integrated catchment management include:

- the National Conservation Strategy. Examples of Victoria's initiatives under this policy are available[33,34,35];
- the National Strategy for Ecologically Sustainable Development[36], and the associated recommendations for sectoral development[37];
- the National Soil Conservation Program[38];
- policies of the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ);
- policies and guidelines of the Australian and New Zealand Environment and Conservation Council (ANZECC).

Frameworks for implementation of umbrella policy, on a national basis, include:

- the National Water Quality Management Strategy[39], which provides policy guidance for drawing up water quality management plans, setting water quality objectives, controlling the impacts of diffuse and point sources, and initiating integrated catchment management[40,41,42,43];

- the national Decade of Landcare Plan[44] and National Landcare programmes[45] (discussed in more detail in a separate sub-section).

### 3.2.2 Integrated catchment management in Victoria

Integrated catchment management in Victoria is probably further advanced, in terms of planning and action, than in the other states. Salinity management has formed the focus for development of integrated catchment management strategies in Victoria.

Integrated catchment management in the broader context has developed from this single-issue basis to address much wider aspects of land and water management. This natural evolution from a single-issue focus to a more integrated process has allowed the development of learning, skills, capability and the willingness to take responsibility for land and water management, both in government agencies and amongst members of the community.

Initially, technical approaches to salinity management and the control of land and water degradation through salinisation were imposed from the "top-down" by government, but this was not successful[15], and hence Victoria has moved to an approach which emphasises active local community involvement in drawing up land and water management plans.

Legislation to support integrated catchment management has developed in response to perceived needs, as experience was gained in the planning and implementation process. The recent Catchment and Land Protection Act[7] represents the first significant step towards a legislative framework for integrated catchment management in Victoria. The Act will allow the integration of other policies, on issues such as salinity, nutrients and soil conservation. It is intended to support:

- the establishment of institutional arrangements which allow local planning and action;
- a process of community-based planning and review to identify priorities, co-ordinate activities and allow the assessment of progress;
- the application of incentives to promote sustainable land and water use.

A State Catchment and Land Protection Council has been established, to act as an advisory body to the government on the management of natural resources, to ensure co-ordination between community and government agencies, and the new Catchment and Land Protection Boards, and to provide guidance and specialist advice. These Boards will include representatives of major resource users and landholders, local

government and people with knowledge and experience in resource management issues. The Boards will be allocated financial support by government, to fulfil administrative and executive functions.

The primary activity of such a Catchment Board would be to ensure co-ordination between the various groups involved in land and water management, and to carry out a planning function. Catchment boundaries are not specifically defined in the Act, but will be proclaimed by the Minister for Natural Resources. The boundaries will be catchment-based, but will also depend on common issues and community structures.

The lead government agencies (DCNR, Department of Agriculture and Rural Water Corporation) take responsibility for initiating and implementing integrated catchment management. Members from one or more of these agencies assist in the identification of problems, through monitoring, and in the facilitation and establishment of community-based groups. These groups then play a major role in developing catchment management plans focused on the priority issues (such as salinity or nutrients). The plans would include objectives, options for control and programmes of action, and would be developed within the context of state-wide objectives for land and water management. It is interesting to note that despite almost constant restructuring of the civil service in Victoria, the facilitation and support function in integrated catchment management remains strong. This is possibly due to the good collaboration between personnel of various agencies.

A participatory modelling approach which has been tested with considerable success is Adaptive Environmental Assessment and Management (AEAM)[46,56]. This approach, for problem identification, prioritisation and development of management action plans, shows promise for application in South Africa.

The involvement of the VEPA in planning and advising catchment community groups ensures that local interests do not conflict with regional or state interests, and the VEPA provides the regulatory and statutory authority necessary for implementation of the management plans[47,48]. Once the plan and the objectives are approved, the VEPA issues a State Environment Protection Policy (SEPP), essentially a gazette designating the catchment area and different reaches, listing beneficial uses and environmental values, describing the water and environment quality objectives for a catchment, and the responsibilities of various agencies and groups[49,50]. Permits or approvals for development are then issued by the VEPA on the basis of these objectives. A SEPP is reviewed periodically, with the same level of stakeholder

involvement in assessing progress, reviewing objectives, and developing a new management plan if necessary.

Implementation of the catchment management plan is supported financially by the government, through the use of grant funding or economic incentives such as tax relief. Individual landholders or community groups can apply for funding from National Landcare to undertake rehabilitation or land management activities.

The generally successful development of ICM approaches in Victoria seems to have been achieved by allowing natural progress from single priority issues to broader management, by focusing on community-based planning processes, and by avoiding the premature imposition of potentially restrictive legislative frameworks. However, the role of the lead government agencies in facilitating (rather than driving) the ICM process is absolutely critical, as is the provision of adequate manpower and financial support for the process.

### 3.2.3 Integrated catchment management in New South Wales

The information on integrated catchment management in New South Wales is based on an Australian review[15].

New South Wales passed a Catchment Management Act in 1989, which gave formal structure and a statutory basis for ICM. The lead government agency in this respect is the Department of Conservation and Land Management. Administration of the Act is the responsibility of the Minister of Land and Water Conservation. The objectives of the Act are to ensure the co-ordination of policies, programmes and initiatives related to resource management, and to further good working relationships between government and communities.

Currently, there are three main institutional levels:

- Local action groups (usually Landcare groups) which address common issues of concern related to land and water resources;
- Regional Catchment Management Committees which co-ordinate integrated catchment management policies and programmes at a regional or river basin level. These bodies prepare regional strategies, co-ordinate funding for management and rehabilitation activities, and also serve as a forum for co-ordination of agency roles. Membership is voluntary, the majority of representation is from catchment stakeholders. If considered necessary, Catchment Management Trusts can be established by the Minister. These

bodies can then levy rates within a "catchment contribution area"; they must submit corporate plans, strategies and programmes to government for approval.

- The State Catchment Management Co-ordinating Committee provides central co-ordination. The committee includes representatives from the community, from Catchment Management Committees, industry, environmental groups, local government and state government agencies. It is responsible to the Minister of Land and Water Conservation on rural issues, and to the Minister of the Environment on urban issues.

Some problems have been identified with the implementation of integrated catchment management in New South Wales. In particular, it is considered that there is insufficient technical support and guidance at a local level: agency staff are over-stretched and cannot give sufficient attention to the community groups. Funding becomes a problem when too many Catchment Management Committees request statutory Trust status. The general feeling is that if the State wishes to devolve the responsibility for environmental management to a regional or local level, then adequate manpower and financial resources must be provided.

### 3.2.4 Integrated catchment management in Queensland

An integrated catchment management implementation programme began in Queensland in 1990, as part of the Natural Resources Management Programme. At the time, one of the issues of concern was the potential impact of pollutants derived from agricultural practices on the Great Barrier Reef ecosystem. No new legislation was introduced at that time, since it was considered that existing legislation gave sufficient basis for integrated catchment management. Most of the state functions related to integrated catchment management and Landcare are within the Department of Primary Industries.

The approach to integrated catchment management is based on common understanding of issues between stakeholders, on acceptance of individual responsibility for land and water management, and on voluntary changes in land and water use practices.

Five pilot studies were established, of which the Johnstone River was one. These studies have provided valuable learning for future implementation of integrated catchment management on a larger scale in Queensland. The Johnstone River is discussed here as an example (Merrin, personal communication).

A Catchment Co-ordinating Committee was established, representing major stakeholder groups and government agencies. A Catchment Co-ordinator was appointed by the Department of Primary Industries, who provide financial and administrative support for the Catchment Office. One of the most important responsibilities of the Co-ordinator is to oversee a comprehensive resource assessment of the catchment. The Catchment Office also acts as a link between the public, the Committee and government agencies, and develops educational and promotional material related to integrated catchment management.

The Co-ordinating Committee held public meetings and workshops with groups and agencies in the catchment, to identify the issues of concern in the catchment. These issues included water quality, management of the river system and estuarine and coastal areas, loss of habitat in the catchment, and the maintenance of agricultural viability.

The Committee provided a forum for debate on these issues, prioritisation of the issues, and the development of integrated catchment management strategies. Since there was no single clear issue of concern on which to focus initially, the identification and prioritisation of key issues was a difficult and lengthy process (Merrin, personal communication). Technical Advisory Groups were appointed, who produced discussion papers on specific issues. These were used in the development of a strategic plan for catchment management. The strategic plan identifies what actions and programmes are to be implemented, who is responsible, and the time frame for implementation.

The Committee and the Co-ordinator have worked with existing regional and local agencies, to facilitate their involvement in planning and implementation. One important objective was to draw up a memorandum of understanding between the Catchment Committee and resource management agencies, to clarify and assign responsibilities for implementation of management plans in the future. Without formal legislative support, implementation relies on the goodwill of all parties involved. Problems have occurred in gaining support from state or central government for catchment plans, due to the lack of close involvement of these agencies in the planning process.

The involvement of local government is considered to be a key factor in successful integrated catchment management in Queensland, since this can provide a local focus, and co-ordination with local strategic and economic development plans.

At a state level in Queensland, a Catchment Management Co-ordinating Committee co-ordinates and provides advice and support for Catchment Management Committees. The State Committee also reviews proposed catchment plans.

### 3.2.5 Integrated catchment management in Western Australia

In Western Australia, integrated catchment management is also still in the process of evolution. The major concerns related to land and water management included the extensive clearing of native bush for agriculture, eutrophication of surface water bodies, salinisation of land and water, soil erosion and degradation[51]. Existing legislation allowed for the establishment of Land Conservation Districts, in which concerned landholders could, having identified the boundaries, request the Minister of Agriculture to appoint a Land Conservation Committee. However, this was not sufficient to prevent continuing degradation of natural resources.

In 1989, the state government issued a policy on integrated catchment management which stated that integrated catchment management should:

- include co-ordinated planning, use and management of water, land, vegetation and other natural resources on a river or groundwater catchment basis;
- involve landowners and local communities at all stages from identification of issues to planning and implementation;
- provide a co-ordinated government approach to complex resource management issues.

No new legislation was introduced to formalise integrated catchment management, since it was considered that existing legislation amongst the various government agencies was sufficient, and that improved co-ordination would be more effective. Integrated catchment management processes and structures have developed through learning and trial. Mitchell and Hollick[51] give a detailed review of the problems and successes associated with the development of integrated catchment management in Western Australia.

At a local level, Community Catchment Groups are being established, on a priority catchment basis, and these are the main mechanism for stakeholder involvement. Representation includes major stakeholder groups, local government and supporting government agencies. The Blackwood Community Catchment Group is a good example[52,53]. The lead government agency, in this case the Office of Catchment Management, facilitates and guides the group through the process of identifying and prioritising issues, and developing a management plan[54], which includes objectives

and a programme of action. In the case of the Blackwood catchment, funding has been granted by National Landcare to support the establishment of a secretariat and the appointment of a full-time catchment co-ordinator. Initially there was a lack of clarity and agreement on whether groups such as this would be only advisory bodies or whether they would be involved in making management decisions.

At state level, an inter-departmental committee, the Integrated Catchment Management Co-ordinating Group, deals with inter-agency implications, co-ordination of policies and collaboration. Representation is entirely from government agencies, and the Group is responsible to the Minister for the Environment. Responsibilities include:

- guidelines for financing of multi-agency initiatives;
- recommendations on government funding for integrated catchment management;
- review of legislation and institutional arrangements for implementation of integrated catchment management;
- consideration of appropriate power-sharing amongst stakeholders;
- research needs;
- development of performance indicators at state and catchment levels.

The Office of Catchment Management supports the Group's activities, taking a proactive role in the facilitation and implementation of integrated catchment management.

It has taken some time to arrive at a wider understanding of the process and products of integrated catchment management in Western Australia, but there is general agreement that the critical elements of the process are[51]:

- setting the boundaries; delineating catchment areas, including groundwater;
- identifying the environmental limits of different parts of the catchment environment, in particular very sensitive components;
- working closely with the local catchment community to see what objectives they have for development, and comparing these with environmental limits, and also the aspirations of the state-wide community, where appropriate;
- developing strategies to meet the objectives, primarily at the local level;
- encouraging community self-monitoring to measure changes and progress;
- involving the wider community, both in setting objectives and as a resource for labour, money and expertise; and
- auditing progress at the local and state level.

Although some notable successes have been achieved, such as planning for management of the Peel-Harvey system[25,55], the Blackwood catchment, and the Perth coastal region[56,57], the lack of legislation sometimes led to difficulties in clearly delineating the responsibility and authority of various government departments. Much of the success has been due to the intensive, long-term involvement of personnel of the lead government agencies in facilitating and establishing catchment groups, and the value of this contribution must not be under-estimated.

Recent recommendations for further implementation of integrated catchment management in Western Australia[51] are that integrated catchment management must be given credibility as a state policy through explicit political, administrative and financial commitment. The state government should publicly endorse integrated catchment management, issue a revised policy, and instruct chief executive officers of state departments and agencies to include integrated catchment management as a key component in their corporate plans and programmes.

It was also recommended that a three-year programme be established, with committed funding, to provide direction and specific objectives for advancement of integrated catchment management on a state-wide basis. The Integrated Catchment Management Co-ordinating Group should include representation from non-government groups. The role, power and authority of Community Catchment Groups in planning and decision-making must be clarified.

### 3.2.6 Integrated catchment management in the Murray-Darling Basin

The Murray-Darling Basin covers 1.06 million km$^2$, and a significant proportion of Australiaš agricultural production is located within this area. The Murray-Darling river system runs through four different states: New South Wales, Victoria, South Australia and Queensland. Significant areas of the Basin are degraded as a result of land practices, water abstraction and discharges.[64] Typical problems include soil erosion, land and water salinisation, soil acidification and eutrophication of surface waters. In order to manage the natural resources of the Basin, a co-ordinated approach from the various state governments and national government is required. Similar problems arise in South Africa, where many river basins are shared across political or administrative boundaries, and the development of integrated management of the Murray-Darling Basin holds some lessons for this country.

New South Wales, Victoria and South Australia signed a water sharing agreement in 1914, and this has stood largely unchanged for the better part of the century.

However, the need to manage land and water quality led to the signing of the Murray-Darling Basin Agreement in 1988.[14] The objective of this agreement, between three states and the federal government, was to facilitate joint management of the Basin and its natural resources. This promotes the integration of policies and programs at political and bureaucratic levels, rather than simply at local or regional levels[65].

The management structure of the Murray-Darling Basin consists of:

- at the highest level, a Ministerial Council, who set broad policy on those issues requiring common action by member states. Council members are Ministers from the signatory governments, representing the land, water and environment departments. The charter of the Murray-Darling Basin Ministerial Council is to "promote and coordinate effective planning and management for the equitable, efficient and sustainable use of the land, water and environmental resources of the Murray-Darling Basin".
- The executive functions of management are carried out by the Murray-Darling Basin Commission, who see themselves as being accountable for the state of the natural resources in the Basin (Blackmore, personal communication). The Commission is made up of two representatives from each government, usually the heads of the departments which are responsible for land, water and environmental management.
- The Office of the Commission, situated in Canberra, provides technical support, undertakes operation of works, planning, investigations and technical programmes. The Office, which consists of about 40 people, is funded jointly by the signatory governments.
- A Community Advisory Committee represents regional, special and community interests. The role of this Committee is to advise the Ministerial Council on policy directions and regional issues.

Water sharing among the Basin states is now facilitated through a system of continuous water accounting. This provides the necessary water security for each state, but allows flexibility in the way in which they use their water allocations.

The salinity and drainage strategy[66] has been developed to manage the serious problems of land and water salinisation on a basin scale. Each member state is allocated tradable salt credits. Within their salt load allocation, each state may then develop strategies which best balance the needs of river protection with the needs for land management and drainage.

Most land in the Murray-Darling Basin is held by private owners, and hence implementation of any catchment management plan relies heavily on community commitment, involvement, knowledge and resources.[67] As part of the community participation program, Communities of Common Concern (CCCs) have been set up around the Basin (about 750 Landcare groups exist so far). These CCCs address issues of local concern, according to local priorities, within the framework of the management objectives for the Basin as a whole.

The size, function and responsibility of the CCCS is flexible, in order to deal with the different local issues. The role of the CCCs is to identify issues and problems, to develop plans for solving problems or managing land and water on a local basis, and to implement these plans. Government support for the CCCs is in the form of education, policy and legislative frameworks, research, funding, monitoring and review of plans.

## 3.3 The Role of National Landcare in Catchment Management at Community Level

National Landcare in Australia plays an important role in co-ordinated planning and in the implementation of plans for land and water management. The Landcare movement encourages the establishment of strong partnerships between government agencies and communities, and the development of Landcare has useful lessons which could be applicable for ICM in South Africa.

In the face of long-standing problems of land degradation, such as salinisation and soil erosion, small community Landcare groups were formed on a voluntary basis, under the guidance of conservation-oriented agencies, in the early 1980s. However, the extent of serious land degradation, and the substantial losses in agricultural production as a result of land degradation, as well as the consequent damage to natural resources, led to a joint submission to the Federal Government in 1989 by the National Farmers' Federation and the Australian Conservation Foundation[63], for the establishment of a national land management program.

This submission outlined a plan for setting up Landcare groups on a national basis, with co-ordination and support from national and state governments. The principles of the submission included:

- that partnerships for land management and rehabilitation should be formed, on a no-blame basis, rather moving forward from that time with a national approach;

- that it was necessary to have political support from all parties, and long term commitment to a partnership between government, landowners, communities and also aboriginal people living on tribal lands;
- that a regulatory approach would be discouraged in favour of a long term but voluntary approach to solving problems of land degradation.

The program of action for establishing National Landcare included several steps:

1. The setting up of local Landcare groups, on a priority basis. These should be integrated with existing community groups, and should be representative of all land users (including representation from users or managers of public lands). Although the groups should be encouraged to become self-funding as soon as possible, government support initially should include funding for secretariat and co-ordination functions, administration and communication. An amount of A$2500 per year, for each group, was proposed to assist the groups in their initial stages.
2. The development of property plans, for management of private land in a way that would be consistent with catchment or regional plans.
3. Technical support structures for information dissemination and training, direct government funding of projects and training programs.
4. Tax rebates for the cost of works established as part of approved land management plans.
5. Incentives for conservation farming practices.
6. Administrative support from the state in developing and approving plans.
7. National assessment of priority land degradation areas.
8. Development of legislation to support land management, as appropriate.
9. Education and awareness programs aimed at both rural and metropolitan residents.

National Landcare developed from being focused primarily on agricultural land, to encompassing broader principles of management of natural resources. This arose naturally because of the link between land and water processes within catchments: land practices were often dependent on the state of water resources, yet land practices also influenced the state of water resources. Several other related programs were amalgamated under the National Landcare umbrella, which encouraged the "whole systems" approach to natural resources management. These programs included the National Soil Conservation Program, the Federal Water Resources Assistance Program, Save the Bush, One Billion Trees and the Murray-Darling Basin Natural Resources Management Strategy.[59]

The principal components of National Landcare are:

- Community Landcare groups. These are local groups, representative of land users, who are responsible for planning, promoting and implementing land and water rehabilitation programs. In the larger context, the role of the groups is also to generate commitment to sustainable natural resource use at a local level. Approximately 20% of farmers are now involved in Landcare groups or group activities.
- The State component. State governments are responsible for strategy development, for integration of Landcare strategies with economic development planning, for funding and action.
- The National component. National government is responsible for monitoring, evaluation and review of Landcare activities; for policy development, investigation and trials, communication and awareness, and dissemination of information.
- A National Landcare Facilitator, whose role is to encourage collaboration between the states in monitoring and evaluation, to develop strategies to improve the effectiveness of Landcare groups, to ensure liaison, communication and awareness, and to develop proposals for future directions in Landcare.[62]
- The National Decade of Landcare Plan[61], the objective of which is to manage natural resources so as to improve their productivity and to enhance their ability to support economic development.
- City Landcare, which aims to broaden awareness of land use and catchment management amongst urban dwellers. Objectives include improvement of the environment in urban areas, and establishment of links between urban and rural Landcare groups.[58]
- Links to many other community programs such as Waterwatch[60], and research programs such as the river health initiatives.

Landcare is intended to provide incentives and a framework at local level for understanding problems, identifying and acquiring the information and skills to develop practical, locally-suited solutions to problems of natural resources management. The philosophy and ideas on which Landcare has been based could be very valuable for implementation of ICM at a community level.

One of the primary reasons for the phenomenal success and growth of Landcare in Australia has been that Landcare is not politically oriented in any way. There is widespread support for the principles and activities of Landcare across all political groups, and within all government departments (Farley, personal communication). The Federal government has provided commitment and financial support, and has

undertaken to review all policies and programs so that they are consistent with Landcare objectives, and so that economic development meets the requirements for protection and management of the natural resource base.

A recommendation has been made[62] that in the future, a resource economics approach should be applied, to investigate the costs and benefits of implementing natural resources management or rehabilitation plans, against the costs of degradation of the natural resource base. This would form the basis for determining an appropriate level of national and state expenditure on programs such as Landcare.

## 4. SUMMARY OF AUSTRALIA'S EXPERIENCE

### 4.1 Separation of Commercial and Non-Commercial Water Sectors

The functions of water supply and sanitation provision are being separated from the non-commercial function of catchment and waterway management, unless it is more practical not to do so on a local basis. Water authorities and supply boards are being regionalised (for greater efficiency and economy of scale) and commercialised (as opposed to privatised). The supply agencies thus become a bulk users of water and/or dischargers, subject to the same licensing procedures as other catchment stakeholders or impacters. Metropolitan water supply agencies will be allocated a bulk water entitlement, which they in turn allocate to domestic and industrial consumers. Rural water boards will further partition their bulk entitlement to agricultural and rural domestic users. Legally defensible water entitlements will be granted to the environment. Bulk water entitlements will be tradable, at real market-related prices.

Catchment and waterway management remains the responsibility of the EPA and relevant government departments, such as Water Resources, Agriculture, Environment.

### 4.2 Catchment and Waterway Management

Impacts in catchments can broadly be grouped into:

- point sources;
- diffuse sources and the impacts of land use or land degradation; and
- degradation of the instream and riparian environment.

The most urgent and potentially damaging issues facing the rural Australian sector are salinisation and nutrient enrichment of water resources. Salinisation arises from two principal causes:

- dryland salinity, which is related to the clearing of deep-rooted forests for agriculture or commercial wood harvesting;
- irrigation salinity, which occurs when irrigation leads to a rise in the water table, bringing very saline groundwater to the land surface.

Nutrient enrichment is a result of leaching of agricultural fertilisers, discharge of sewage effluents, runoff from agricultural land, and uncontrolled access to water bodies by stock animals. In such cases, water resources management is very closely tied to land management. The problems can only be solved by changes in land use practices at a very local level.

Point source discharges are subject to control by the EPA, who issue works approvals (permits). The criteria for discharge to the water environment are generally site-specific, though subject to certain minimum industry or State standards. Criteria would be based on receiving environment objectives for the local area in question. In many catchments, these objectives would have been set after negotiation amongst stakeholders, through a catchment board or committee.

Land use impacts and degradation of the instream environment might be related to industrial or urban development, which would be subject to control by the EPA or a government department. Where land use impacts arise from agricultural or forestry practices, then a much stronger emphasis is placed on community-based management and action.

A lead government agency, which may be a department responsible for water resources, environment or agriculture, usually takes the initiative in identifying problems through monitoring. The lead agency then plays a critical role in initiating discussions with stakeholders in the catchment and establishing a catchment committee or board, which is representative of the interest in the catchment.

The committee, under the guidance of the lead government agency, will usually begin by focusing on a priority problem, such as salinity or algal blooms. Again with guidance and technical support from a number of government agencies, the committee will develop long term objectives, a strategy and an action plan for dealing with the problem. The initial focus on a priority problem creates cohesion in the group, and ensures that people get involved because they have a real interest in the outcome. As

capacity is developed in the committee or group, they can then go on to address other issues in the catchment through the same process, and again with support from the government agencies.

The EPA and supporting government agencies provide the committees with a broader context for development of catchment plans: the objectives and plan for the catchment do need to fit within wider state and national interests. Once the objectives and plan have been developed, statutory support is provided by the EPA, who gazette the objectives, responsibilities and roles of the various agencies and stakeholders in a State Environment Protection Policy paper (SEPP). The SEPPs are catchment-specific, and subject to review every ten years or so. The EPA or a delegated agency is responsible for monitoring and assessing progress towards the achievement of objectives.

The catchment committees are formally constituted bodies, but have very little statutory power themselves: enforcement is still the role of EPA or a government department. The committees have more of a planning function. The lead government agencies provide a very strong "extension service", in their role of technical guidance and support. They may also provide funding for initial scientific/technical investigations, and for the running costs incurred by the committee (such as travel and secretariat).

The extent of the initial priority problem or issue may determine the extent of responsibility which is taken up by a catchment committee, and also the geographical boundaries of responsibility. These are fairly flexible. Sub-catchment committees can later be co-ordinated under a larger catchment committee or forum.

Once an action plan has been developed, it then remains for individual landowners to implement the relevant land use practices (such as replanting deep-rooted trees, installing drainage, irrigation management). Here the Australian approach is to rely on voluntary compliance, rather than "command and control". It is considered that voluntary compliance, as a form of self-regulation, is more acceptable in Australian society, and also more cost-effective, since fewer resources are required to monitor and enforce compliance.

Self-regulation is admittedly not 100 % successful, but is widely encouraged through community groups such as Greening Australia and Landcare. National Landcare appears to be the key to achieving success in changing land use practices: farmers or groups can apply for grant funding or tax incentives to assist them in implementing on-farm management which complements the catchment plan. Excellent technical and

educational support is also provided. (Urban Landcare is now in the early stages of development).

## 5. IMPLICATIONS FOR INTEGRATED CATCHMENT MANAGEMENT IN SOUTH AFRICA, BASED ON AUSTRALIAN EXPERIENCE

### 5.1 General Principles

Some general principles related to integrated catchment management can be distilled from the Australian experience[15]. The most important is that land and water degradation, and the subsequent impacts on land and water users, usually transcend property boundaries. This means that co-ordinated planning and action is required at all levels, from national government to the individual. The most important principles are:

- Institutional arrangements, the structure and role of catchment committees must be flexible, allowing for varying social structures and issues.
- The government's role in integrated catchment management in Australia tends to remain within the co-ordination of skills and skills transfer, provision of technical advice and support, and provision of funding for local groups or individuals.
- Technical and scientific experts must recognise landholders and stakeholders as competent partners in resource management.
- Successful implementation of ICM depends on sound long term relationships, goodwill and trust amongst the people and agencies involved. Restructuring of government agencies and promulgation of legislation will never be sufficient to ensure success. Long term continuity and commitment from lead agencies is also essential.
- Adequate financial and human resources must be provided on a long-term basis, or else integrated catchment management cannot be implemented successfully.
- The catchment community should be defined by a common interest or a clear environmental variable such as soil type. For land use action, catchment communities can be defined in social terms rather than necessarily in geographic or hydrological terms.
- Expectations and goals must be defined in realistic short to medium terms, but integrated catchment management must be recognised as a long term process, requiring continuity of support from government agencies.

Mitchell and Hollick set out suggested building blocks for integrated catchment management, and it is worth quoting them here in full[51].

"The building blocks for integrated catchment management should be:

1. A systems approach, in which attention is directed toward both human and natural systems, their component parts, and the inter-relationships among those parts. To be consistent with this approach, the management unit should be the one that highlights linkages. This will often, but not automatically, lead to the catchment or river basin being the appropriate planning and management unit.
2. An integrated approach rather than a comprehensive approach, in which attention is directed to key issues and variables identified through consultation with stakeholders and to the linkages among key issues and variables. In contrast, in the comprehensive approach, attention is given to all issues and variables.
3. A stakeholder approach, in which it is recognised that citizens and non-government groups should be able to participate in decisions about what ought to be, what can be, and what will be for an area.
4. A partnership approach, in which it is recognised that state agencies, local government organisations and individuals each have a role. This requires a search for common objectives, decisions at the outset about the relative roles and powers of state agencies, local governments and citizens, and identification of mechanisms that will be used to make decisions when conflicts arise.
5. A balanced approach, in which attention is directed to weighing concern about enhancing economic development, protecting the integrity of natural systems, and satisfying social norms and values."

## 5.2 Implications for Integrated Catchment Management in South Africa

The general model for integrated catchment management as practised in Australia rests heavily on the acceptance of individual or group responsibility by communities, with as little "top-down" governance as possible. This model works for the management of impacts of land use, for both private and public land. Integrated catchment management in Australia relies on not decoupling land resources management from water resources management. This would be difficult to implement fully in South Africa while so many inter-agency and inter-department boundaries exist, at national and provincial levels, and while there is considerable fragmentation of responsibility for natural resources management. The lack of consistent national and regional policy in South Africa also adds to the problem.

The Australian model would be applicable for water quality management on a catchment basis in South Africa, but may well fail when there is a need to resolve issues of water allocation, whether these are directly linked to water quality issues or not. Water allocation is a politically sensitive issue, at various levels, and it may be that a catchment management system based on partnership and consensus-seeking will not be adequate for water allocation decisions in South Africa at this time. The responsibility, accountability and authority for water allocation, in the context of implementation of integrated catchment management, need to be carefully considered.

The trend in Australia is to separate water supply functions from catchment and waterway management functions. Water supply agencies are seen as bulk users of water. The future role of water boards and irrigation boards in integrated catchment management in South Africa must be clarified. Conflict of interest is likely if commercialised or corporatised water supply agencies, as primary resource users, are also entrusted with responsibilities related to the development, allocation and management of resources. They can, however, provide certain technical functions such as operation of works, monitoring of resources and demand, education, communication and awareness programmes.

The fact that, in Australia, statutory and regulatory power remains primarily in the hands of a government agency may help to prevent misuse of that power to promote local interests above provincial or national interests. That, and the emphasis on extension and supporting services supplied by government agencies, may be a valuable lesson for South Africa, at least in so far as rural catchments are concerned.

If catchment authorities are granted statutory powers, then along with that power goes responsibility and accountability. To discharge responsibility adequately requires expertise, skill and judgement. Whether South Africa has, at the present time, sufficient expertise and skill at the local level, which can be utilised in catchment authorities, is very doubtful. The model of catchment committees with strong planning functions, supported by government agency personnel providing technical guidance, facilitation, statutory and regulatory functions may be more resource- and cost-efficient at this stage of our development.

The Australian model for catchment community groups is dependent on a high level of skill in the lead government agencies, especially in facilitation, co-ordination, negotiation and provision of technical advice. These skills would need to be available in the regional office of DWAF and related government departments. Capability would be required at national level to co-ordinate integrated catchment management policy and approaches, to provide support, funding, skills transfer and training.

An issue which has not been resolved in Australia will also need to be addressed in South Africa, and that is the constitutional right of an individual landholder to manage his land freely, versus protection of the public good.

## 5.3 Discussion Points for Development of Legislation Options

The following are intended to serve as points of departure for discussion on adoption of an integrated catchment management model which is similar to that used in Australia:

1. The introduction of new legislation, new agency structures or prescriptive institutional arrangements should be minimised at this stage, since we are still in the early stages of a learning process, and because the integrated catchment management philosophy is founded on flexibility and adaptability. Legislation and regulation should follow the integrated catchment management process, rather than attempt to lead it too strongly.

2. The revised Water Act should allow the Minister to issue regulations on a catchment-specific basis, regarding
   - the geographical boundaries of a catchment,
   - resource management objectives for the catchment,
   - the nature of the process of developing a catchment management plan,
   - agency and stakeholder responsibilities for implementation,
   - authority, accountability and legal status of the catchment board or committee,
   - conflict resolution processes,
   - monitoring, auditing and reporting requirements and responsibilities, and
   - the time scale and process for review of regulations.

3. An umbrella national policy on integrated catchment management should be considered, which is supported by all appropriate government departments, and which is incorporated in the planning functions of all departments and agencies at national and regional level. Inter-department co-ordination on resource management issues at national, provincial and local level should be supported as a matter of policy.

4. In order to ensure successful implementation of integrated catchment management approaches, there should be a clear long-term commitment from

government to support integrated catchment management with financial and manpower resources.

5. Clear policy guidance will be required on the use in integrated catchment management of instruments such as water quality guidelines, emission standards, environmental impact assessments.

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# APPENDIX 2

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**Water Research Commission**

**and**

**Department of Water Affairs and Forestry**
**(Water Law Review: Institutional Arrangements Task Team)**

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Publisher: Water Division, Watershed Section, U.S. Environmental Protection Agency, Region 10.
Year Published: 1992
Report Number: EPA 910/9-91-035

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Main Title: Comprehensive planning for lake watersheds.
Personal Author: Lea, Fergus
Publisher: Maine Department of Environmental Protection : Androscoggin Valley Council of Governments.
Year Published: 1990

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Main Title: Watershed protection a project focus.
Publisher: U.S. EPA, Office of Wetlands, Oceans, and Watersheds.
Year Published: 1995
Report Number: EPA 841-R-95-003

Accession Number: 225916
Main Title: Watershed protection a statewide approach.
Publisher: U.S. EPA, Office of Wetlands, Oceans, and Watersheds.
Year Published: 1995
Report Number: EPA 841-R-95-004

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Main Title: Why watersheds?
Publisher: U.S. Environmental Protection Agency, Office of Water.
Year Published: 1996
Report Number: EPA800-F-96-001

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Main Title: Watershed protection approach 1993/94 activity report.
Publisher: U.S. Environmental Protection Agency, Office of Water.
Year Published: 1994
Report Number: EPA840-S-94-001

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Main Title: Statewide watershed management course.
Publisher: U.S. Environmental Protection Agency.
Year Published: 1994
Report Number: EPA 833-R-96-006

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Main Title: Texas Rural Water Quality Network Project : challenge of the colonias, small community wastewater management in the Lower Rio Grande Valley.
Corporate Author: Texas. Dept. of Agriculture.; National Demonstration Water Project (U.S.)
Publisher: Texas Dept. of Agriculture : National Demonstration Water Project.
Year Published: 1986

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Main Title: Water resources for the future : Michigan's action plan.
Corporate Author: Great Lakes and Water Resources Planning Commission.
Publisher: The Commission
Year Published: 1987

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Main Title: Water resources for the future : executive summary.
Corporate Author: Great Lakes and Water Resources Planning Commission.
Publisher: The Commission
Year Published: 1987

Accession Number: 79893
Main Title: Water resources for the future Michigan's draft action plan.
Corporate Author: Great Lakes and Water Resources Planning Commission.
Publisher: The Commission
Year Published: 1987

Accession Number: 87341
Main Title: Analysis of Regional Lake Water Quality Patterns: Implications for Lake Resource Management in Minnesota.
Personal Author: Heiskary, S.A.; Wilson, C.B.; Larsen, D.P.
Corporate Author: Corvallis Environmental Research Lab., OR.; Minnesota Pollution Control Agency, Roseville., Division of Water Quality.
Year Published: 1987
Call Number: PB87-188157
Report Number: EPA/600/D-87/010

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Main Title: Statement of policy and by-laws 1988-1989.
Corporate Author: Interstate Conference on Water Policy.
Publisher: Interstate Conference on Water Policy
Year Published: 1989

Accession Number: 130465
Main Title: Water values and markets emerging management tools : a special report.
Publisher: Freshwater Foundation / Freshwater Society
Year Published: 1986

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Main Title: Water resources for the future Michigan's action plan.
Publisher: Great Lakes and Water Resources Planning Commission
Year Published: 1987

Accession Number: 159522
Main Title: Progress in the National Estuary Program: Report to Congress.
Corporate Author: Environmental Protection Agency, Washington, DC., Office of Marine and Estuarine Protection.
Year Published: 1990
Call Number: PB91-168385
Report Number: EPA/503/9-90/005

Accession Number: 166731
Main Title: Water resources in Pennsylvania availability, quality, and management.
Publisher: Pennsylvania Academy of Science
Year Published: 1990

Accession Number: 173590
Main Title: EPA/State management conference agreement
Corporate Author: Galveston Bay National Estuary Program.
Publisher: s.n.
Year Published: 1989

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Main Title: U.S.-Canada transboundary resource issues
Year Published: 1986

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Main Title: Protecting the Nation's Wetlands, Oceans, and Watersheds: An Overview of Programs and Activities.
Corporate Author: U.S. EPA, Washington, DC., Office of Wetlands, Oceans and Watersheds.
Year Published: 1992
Call Number: PB93-105609
Report Number: EPA/840/S-92/001

Accession Number: 184201
Main Title: Coordinating water resources in the federal system the groundwater-surface water connection.
Personal Author: Blomquist, William A.
Publisher: U.S. Advisory Commission on Intergovernmental Relations
Year Published: 1991
Report Number: A-118

Accession Number: 184240
Main Title: Water resources people and issues interview with
Gilbert F. White.
Personal Author: White, Gilbert F.
Publisher: Office of History, U.S. Army Corps of Engineers
Year Published: 1992

Accession Number: 185804
Main Title: Tribal water utility management
Publisher: United States Environmental Protection Agency, Office of Water
Year Published: 1993
Report Number: EPA 812-B-93-005

Accession Number: 187830
Main Title: Regional Nonpoint Source Program Summary.
Personal Author: Edwards, R.; Partee, G.; Fleming, F.
Corporate Author: Environmental Protection Agency, Chicago, IL., Water Div.
Year Published: 1992
Call Number: PB93-169134
Report Number: EPA/910/9-91/035

Accession Number: 192911
Main Title: National Estuary Program Guidance. Comprehensive Conservation and Management Plans: Content and Approval Requirements.
Corporate Author: Environmental Protection Agency, Washington, DC., Office of Water.
Publisher: Oct 92
Year Published: 1992
Call Number: PB93-217172
Report Number: EPA/842/B-92/002

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Main Title: Institutional arrangements for areawide water resources management planning in the Washington DC region under the Federal Water Pollution Control Act amendments of 1972
Personal Author: Lieber, Harvey.
Corporate Author: University of the District of Columbia. Water Resources Research Center.
Publisher: Water Resources Research Center, University of the District of Columbia

Year Published: 1980

Accession Number: ?
Main Title: Groundwater quality protection policies for the Rocky Mountain Region and the nation : transcript of a conference.
Corporate Author: Environmental and Energy Study Institute.; Colorado Water Resources Research Institute.
Publisher: Colorado Water Resources Reseach Institute, Colorado State University.
Year Published: 1986

Accession Number: 221359
Main Title: EPA Nonpoint Source Strategy.
Corporate Author: Environmental Protection Agency, Washington, DC., Office of Water.
Publisher: Feb 85
Year Published: 1985
Call Number: PB95-194379

Accession Number: 164018
Main Title: General Proceedings and Action Agendas from the U.S. Environmental Protection Agency's National Leadership Conference on Building Public-Private Partnerships. Held in Washington, DC. on October 26, 1988.
Corporate Author: Environmental Protection Agency, Washington, DC., Resource Management Div.
Year Published: 1989
Call Number: PB91-219584

Accession Number: 185795
Main Title: Public participation and remedial action plans an overview of approaches, activities and issues arising form RAP coordinator's forums.
Publisher: International Joint Commission, Great Lakes Regional Office,
Year Published: 1990

Accession Number: 216050
Main Title: Working for Clean Water: An Information Program for Advisory Groups. Public Participation. Citizen Handbook.
Corporate Author: Pennsylvania State Univ. Capitol Campus, Middletown.;Environmental Protection Agency, Washington, DC. Office of Water.
Year Published: 1995
Call Number: PB95-157244

Accession Number: 221207
Main Title: Working for Clean Water: An Information Program for Advisory Groups. 1. Citizen Handbooks.
Personal Author: Stoltzfus, L.C.
Corporate Author: Ohio State Univ., Columbus. SMEAC Information Reference Center.; Environmental Protection Agency, Washington, DC. Office of Water.
Year Published: 1995
Call Number: PB95-156048

Accession Number: 221208
Main Title: Working for Clean Water: An Information Program for Advisory Groups. Role of Advisory Groups. Citizen Handbook.
Corporate Author: Pennsylvania State Univ. Capitol Campus, Middletown. Inst. of State and Regional Affairs.;Environmental Protection Agency, Washington, DC. Office of Water.
Year Published: 1995
Call Number: PB95-156055

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| Accession Number: | 221214 |
| Main Title: | Working for Clean Water: An Information Program for Advisory Groups. Public Participation. Instructor Guide. |
| Personal Author: | Buskirk, E.D.; Auker, D. |
| Corporate Author: | Pennsylvania State Univ. Capitol Campus, Middletown. Inst. of State and Regional Affairs.; Environmental Protection Agency, Washington, DC. Office of Water. |
| Year Published: | 1995 |
| Call Number: | PB95-156113 |

## Section 2 : Examples of Watershed Management Plans

Accession Number: 82553
Main Title: Western branch river subbasin low flow management framework plan /
Personal Author: Heicher, David W.
Publisher: Susquehanna River Basin Commission,
Year Published: 1989

Accession Number: 129348
Main Title: Waimea-Paauilo watershed, Hawaii County, Hawaii watershed plan and environmental assessment.
Publisher: U.S. Dept. of Agriculture, Soil Conservation Service
Year Published: 1989

Accession Number: 131335
Main Title: Salinity control on BLM-administered public lands in the Colorado River Basin a report to Congress.
Corporate Author: United States Bureau of Land Management.
Publisher: The Bureau
Year Published: 1987

Accession Number: 133622
Main Title: Water resources Corps of Engineers' drought management of Savannah River projects; report to the honorable Butler Derrick, House of Representatives.
Corporate Author: United States. General Accounting Office.
Publisher: The Office
Year Published: 1989

Accession Number: 150714
Main Title: Clean Lakes Program Phase 2 Project. Report for Lake Le-Aqua-Na Stephenson County, Illinois.
Corporate Author: Illinois State Environmental Protection Agency, Springfield. Div. of Water Pollution Control.
Year Published: 1990
Call Number: PB91-123323
Report Number: IEPA/WPC/90-296

Accession Number: 159207
Main Title: Buffalo-Trempealeau River water quality management plan
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: The Department
Year Published: 1991

Accession Number: 161742
Main Title: Manitowoc River Basin water quality management plan a five-year plan to enhance and protect our water resources.
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: Dept. of Natural Resources
Year Published: 1991

Accession Number: 163426
Main Title: Lower Chippewa River Basin water quality management plan
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: The Department
Year Published: 1989

Accession Number: 167946
Main Title: Watershed Nitrogen Management: Upper Potomac River Basin Case Study.
Personal Author: Groffman, P.M.; Jaworski, N.A.
Corporate Author: Environmental Research Lab., Narragansett, RI.; Rhode Island Univ., Narragansett.; Chesapeake Research Consortium, Inc., Baltimore, MD.
Year Published: 1990
Call Number: PB92-108083
Report Number: EPA/600/D-91/233; ERLN-1255

Accession Number: 169043
Main Title: Upper Susquehanna subbasin low flow management framework plan.
Personal Author: Heicher, David W.
Publisher: Susquehanna River Basin Commission,
Year Published: 1991

Accession Number: 190360
Main Title: Massachusetts Bays program progress 1990.
Publisher: Massachusetts Bays Program
Year Published: 1990

Accession Number: 192641
Main Title: Regulatory Effectiveness Study for the Armand Bayou Coastal Preserve.
Personal Author: Mitchell, G.; Windsor, D.
Corporate Author: Galveston Bay National Estuary Program,, Austin, TX.; Jesse H. Jones Graduate School of Administration, Houston, TX.; Environmental Protection Agency, Washington, DC.
Year Published: 1991
Call Number: PB93-205680
Report Number: GBNEP-13

Accession Number: 192642
Main Title: Regulatory Effectiveness Study for the Christmas Bay Coastal Preserve.
Personal Author: Mitchell, G.; Windsor, D.
Corporate Author: Galveston Bay National Estuary Program,, Austin, TX.; Jesse H. Jones Graduate School of Administration, Houston, TX.; Environmental Protection Agency, Washington, DC.
Year Published: 1991
Call Number: PB93-205698
Report Number: GBNEP-14

Accession Number: 196490
Main Title: Chesapeake Bay Executive Council Directive: Fish Passage Goals.
Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
Year Published: 1993
Call Number: PB94-110152

Accession Number: 199070
Main Title: Water quality standards for salinity, Colorado River system final report.
Publisher: The Forum
Year Published: 1993

Accession Number: 204860
Main Title: Watershed Planning in the Albemarle-Pamlico Estuarine System. Report 1. Annual Average Nutrient Budgets.
Personal Author: Dodd, R.C.; McMahon, G.; Stichter, S.
Corporate Author: Research Triangle Inst., Research Triangle Park, NC. Center for Environmental Analysis; Geological Survey, Raleigh, NC.;North Carolina Dept. of Environment,

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| | Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.; Environmental Protection Agency, Washington, DC. |
| Year Published: | 1992 |
| Call Number: | PB94-173366 |
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| Accession Number: | 204972 |
| Main Title: | Comprehensive Environmental Management Plan for the Currituck Sound Drainage Basin: Background Investigations. |
| Personal Author: | Rideout, R.R. ; |
| Corporate Author: | North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study; North Carolina State Univ. at Raleigh. Dept. of Forestry.; Environmental Protection Agency, Washington, DC. |
| Year Published: | 1990 |
| Call Number: | PB94-181625 |
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| Main Title: | North Carolina's Estuaries: A Pilot Study for Managing Multiple Use in the State's Public Trust Waters. |
| Personal Author: | Clark, W.F.; Edgerton, C.R. |
| Corporate Author: | North Carolina State Univ. at Raleigh. Sea Grant Coll. Program.;North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study. |
| Year Published: | 1990 |
| Call Number: | PB94-183530 |
| Report Number: | APES-90-10 |
| Accession Number: | 205731 |
| Main Title: | Ground-water management plan |
| Corporate Author: | Susquehanna River Basin Commission. |
| Publisher: | Susquehanna River Basin Commission |
| Year Published: | 1993 |
| Accession Number: | 206322 |
| Main Title: | Restoration of the Anacostia River the report to Congress. |
| Publisher: | Printed by the U.S. Environmental Protection Agency for the Chesapeake Bay Program |
| Year Published: | 1992 |
| Report Number: | CBP/TRS 79/92 |
| Accession Number: | 210640 |
| Main Title: | 1994 Columbia River Basin Fish and Wildlife Program overview. |
| Publisher: | Northwest Power Planning Council |
| Year Published: | 1994 |
| Accession Number: | 210679 |
| Main Title: | Evaluation of watershed quality in the Minnesota River basin |
| Personal Author: | Arthur, John W. |
| Publisher: | Environmental Research Laboratory - Duluth, Office of Research and Development, U.S. Environmental Protection Agency |
| Year Published: | 1994 |
| Report Number: | EPA/600/R-94/143 |
| Accession Number: | 210902 |
| Main Title: | Seeking an integrated approach to watershed management in the South Platte Basin October 27-28, 1993, University Park Holiday Inn, Fort Collins, Colorado. |

Publisher: Colorado Water Resources Research Institute, Colorado State University
Year Published: 1993

Accession Number: 210903
Main Title: Defining ecological and sociological integrity for the South Platte River Basin
Publisher: Colorado Water Resources Research Institute
Year Published: 1993

Accession Number: 211513
Main Title: Water availability, use, and estimated future water demand in the upper Duck River basin, middle Tennessee
Personal Author: Hutson, Susan S.
Publisher: U.S. Dept. of the Interior, U.S. Geological Survey
Year Published: 1993

Accession Number: 211831
Main Title: Environmental Management Program for the Hampton Roads Virginia Portion of the Albemarle-Pamlico Estuarine Watershed.
Corporate Author: Hampton Roads Planning District Commission, VA.; North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.; Environmental Protection Agency, Research Triangle Park, NC.; National Estuary Program.
Year Published: 1993
Call Number: PB95-106811
Report Number: A/P-92-19; APES-92-19

Accession Number: 211837
Main Title: Watershed Planning in the Albemarle-Pamlico Estuarine System. Report 6 - Use of Information Systems for Developing Subbasin Profiles.
Personal Author: Dodd, R.C.; Cunningham, P.A.; Curry, R.J.; Stichter, S.J.
Corporate Author: Research Triangle Inst., Research Triangle Park, NC.; North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.; Environmental Protection Agency, Research Triangle Park, NC.; National Estuary Program.
Year Published: 1993
Call Number: PB95-109484
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Accession Number: 213251
Main Title: Opportunities for action an evolving plan for the future of the Lake Champlain Basin : pollution prevention, control & restoration plan : draft.
Publisher: Lake Champlain Basin Program
Year Published: 1994

Accession Number: 215900
Main Title: River and Watershed Planning: The San Luis Rey River Case Study.
Personal Author: Micheli, E.
Corporate Author: California Univ., Berkeley.; Corvallis Environmental Research Lab., OR.
Year Published: 1994
Call Number: PB95-155826
Report Number: EPA/600/R-94/213

Accession Number: 219586
Main Title: Integrated watershed management in the South Platte Basin status and practical implementation : October 26-27, 1994, Ramkota Inn, Greeley, Colorado.
Publisher: Colorado Water Resources Research Institute, Colorado State University,
Year Published: 1994

Accession Number: 223377
Main Title: Report on the Potomac River Watershed Visions Project.
Corporate Author: Potomac River Watershed Visions Project.
Publisher: Interstate Commission on the Potomac River Basin
Year Published: 1994

Accession Number: 226393
Main Title: Monitoring Program to Assess Environmental Changes in Tampa Bay, Florida.
Personal Author: Squires, A.; Janicki, A.; Heimbuch, D.; Wade, D.; Wilson, H.
Corporate Author: Coastal Environmental, Inc., St. Petersburg, FL.; Tampa Bay National Estuary Program, St. Petersburg, FL.
Year Published: 1994
Call Number: PB95-260907
Report Number: TBNEP-T-92-02; TBNEP-02-93

Accession Number: 229515
Main Title: Controlling salinity in the Colorado River Basin
Publisher: s.n.
Year Published: 1989

Accession Number: 233384
Main Title: National Water-Quality Assessment Program the upper Tennessee River Basin.
Personal Author: Hampson, Paul S.
Publisher: U.S. Dept. of the Interior, U.S. Geological Survey
Year Published: 1995

Accession Number: 233441
Main Title: Merrimack Project a cooperative effort of the United States Environmental Protection Agency, the Commonwealth of Massachusetts, the state of New Hampshire.
Publisher: U.S. Environmental Protection Agency, Office of Water
Year Published: 1995
Report Number: EPA 820-R-95-004

Accession Number: 75346
Main Title: Voluntary basinwide water management : South Platte River Basin, Colorado
Personal Author: Caulfield, Henry P.
Corporate Author: Colorado Water Resources Research Institute.
Publisher: The Institute
Year Published: 1987

Accession Number: 122579
Main Title: Initial remedial action plan for the Rouge River basin.
Corporate Author: Southeast Michigan Council of Governments.
Year Published: 1987

Accession Number: 122788
Main Title: Remedial action plan for the Rouge River Basin draft.
Corporate Author: Southeast Michigan Council of Governments.
Publisher: The Council
Year Published: 1988

Accession Number: 159253
Main Title: Upper Wisconsin River northern sub-basin water quality management plan prepared by the Wisconsin Dept. of Natural Resources.
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: The Department
Year Published: 1991

Accession Number: 161742
Main Title: Manitowoc River Basin water quality management plan a five-year plan to enhance and protect our water resources.
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: Dept. of Natural Resources
Year Published: 1991

Accession Number: 163426
Main Title: Lower Chippewa River Basin water quality management plan.
Corporate Author: Wisconsin. Dept. of Natural Resources.
Publisher: The Department
Year Published: 1989

Accession Number: 167857
Main Title: Chester river basin water quality management plan.
Publisher: Dept. of Health and Mental Hygiene
Year Published: 1987

Accession Number: 167946
Main Title: Watershed Nitrogen Management: Upper Potomac River Basin Case Study.
Personal Author: Groffman, P.M.; Jaworski, N.A.
Corporate Author: Environmental Research Lab., Narragansett, RI.; Rhode Island Univ., Narragansett.; Chesapeake Research Consortium, Inc., Baltimore, MD.
Year Published: 1990
Call Number: PB92-108083
Report Number: EPA/600/D-91/233; ERLN-1255

Accession Number: 168603
Main Title: Water resources Corps' management of ongoing drought in the Missouri River Basin : report to Congressional requesters.
Corporate Author: United States. General Accounting Office.
Publisher: The Office
Year Published: 1992
Report Number: GAO/RCED-92-4 B-241794

Accession Number: 192727
Main Title: Clark-Fork-Pend Oreille Basin Water Quality Study: A Summary of Findings and a Management Plan.
Corporate Author: Environmental Protection Agency, Seattle, WA. Region X.
Year Published: 1993
Call Number: PB93-208148
Report Number: EPA/910/R-93/006

Accession Number: 222969
Main Title: Water quality information on salinity control projects in the Colorado River Basin : statement of James Duffus, III, Director, Natural Resources Management Issues, Resources, Community, and Economic Development Division, before the Subcommittee on Water and Power Resources, Committee on Resources, House of Representatives.
Personal Author: Duffus, James.
Publisher: The Office
Year Published: 1995

Accession Number: 120001
Main Title: Cape Cod Aquifer Management Project (CCAMP).
Personal Author: Zoto, G.A.; Gallagher, T.

Corporate Author: Environmental Protection Agency, Boston, MA. Region I.; Geological Survey, Boston, MA. Water Resources Div.; Massachusetts Dept. of Environmental Quality Engineering, Boston.; Cape Cod Planning and Economic Development Commission, Barnstable, MA.
Year Published: 1988
Call Number: PB89-106298
Report Number: EPA/901/3-88/006

Accession Number: 121377
Main Title: Cape Cod Aquifer Management Project (CCAMP) : Institutional Recommendations.
Corporate Author: Massachusetts Dept. of Environmental Quality Engineering, Boston.; Environmental Protection Agency, Boston, MA. Region I.; Geological Survey, Boston, MA. Water Resources Div.; Cape Cod Planning and Economic Development Commission, Barnstable, MA.
Year Published: 1988
Call Number: PB89-140024

Accession Number: 121660
Main Title: Cape Cod Aquifer Management Project (CAMP). Executive Summary.
Corporate Author: Environmental Protection Agency, Boston, MA. Region I.; Geological Survey, Boston, MA. Water Resources Div.; Massachusetts Dept. of Environmental Quality Engineering, Boston.; Cape Cod Planning and Economic Development Commission, Barnstable, MA.
Year Published: 1988
Call Number: PB89-155782
Report Number: EPA/901/3-88/003

Accession Number: 132588
Main Title: Chesapeake Bay Annual Workplan, 1989.
Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
Year Published: 1989
Call Number: PB89-237788

Accession Number: 133639
Main Title: Federal land management Chandler Lake land exchange not in the government's best interest : report to the Chairman, Subcommittee on Water and Power Resources, Committee on Interior and Insular Affairs, House of Representatives.
Corporate Author: United States. General Accounting Office.
Publisher: The Office
Year Published: 1989
Report Number: GAO/RCED-90-5 B-229232

Accession Number: 139968
Main Title: Lake Union and Ship Canal water quality management program background report.
Corporate Author: Land Use & Transportation Project (Seattle, Wash.)
Publisher: The Project
Year Published: 1986

Accession Number: 153368
Main Title: Water resources management plan for Fresno-Clovis urban & northeast Fresno County
Publisher: The County
Year Published: 1986

Accession Number: 153972
Main Title: Revised workplan for the proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta estuary.

Corporate Author: California. State Water Resources Control Board.
Publisher: The Board
Year Published: 1989

Accession Number: 160995
Main Title: Water resources Corps' management of 1990 flooding in the Arkansas, Red, and White River basins : briefing report to the Honorable David Pryor, U.S. Senate.
Corporate Author: United States. General Accounting Office.
Publisher: General Accounting Office
Year Published: 1991
Report Number: GAO/RCED-91-172BR B-243956

Accession Number: 182194
Main Title: Water resources Corps of Engineers management of 1986 flooding in northeastern Oklahoma : briefing report to the Chairman, Subcommittee on Environment, Energy, and Natural Resources, Committee on Government Operations, House of Representatives.
Corporate Author: United States. General Accounting Office.
Publisher: The Office
Year Published: 1987

Accession Number: 188318
Main Title: Framework for Characterization. (Revised Final Report March 1992).
Personal Author: Ramsay, M.; Boynton, W.; Clark, P.
Corporate Author: Tampa Bay Regional Planning Council, St. Petersburg, FL.;Tampa Bay National Estuary Program, St. Petersburg, FL.
Year Published: 1992
Call Number: PB93-191237
Report Number: T-91-01; TBNEP-01-92

Accession Number: ?
Main Title: Economic Characterization of the Albemarle-Pamlico Comprehensive Conservation andManagement Plan.
Personal Author: Chazal, J.; Peck, L.G.; Cox, V.; Smutko, L.S.
Corporate Author: Resource Analytics Inc., Raleigh, NC.;North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.;Environmental Protection Agency, Research Triangle Park, NC. NationalEstuary Program.
Year Published: 1993
Call Number: PB95-104055
Report Number: APES-93-16

Accession Number: 211818
Main Title: Public Attitudes Toward Water Quality and Management Alternatives in the Albemarle-Pamlico Estuarine System. Phase 2 Report.
Personal Author: Hoban, T.; Clifford, W.
Corporate Author: North Carolina State Univ. at Raleigh. Dept. of Sociology.; North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.; Environmental Protection Agency, Research Triangle Park, NC. National Estuary Program.
Year Published: 1992
Call Number: PB95-105425
Report Number: NCSU-89-6; APES-PR-92-13; APES-92-13

Accession Number: 212128
Main Title: Chesapeake Bay Basinwide Toxics Reduction Strategy Reevaluation Report. Executive Summary.

Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
Year Published: 1994
Call Number: PB95-136453

Accession Number: 212359
Main Title: Long Island Sound Study: Summary of the Comprehensive Conservation and Management Plan, July 1994.
Corporate Author: Environmental Protection Agency, Washington, DC. Office of Wetlands, Oceans and Watersheds.; New York State Dept. of Environmental Conservation, Albany. Div. of Marine Resources; Connecticut Dept. of Environmental Protection, Hartford.
Year Published: 1994
Call Number: PB95-137865
Report Number: EPA/842/S-94/001

Accession Number: 230612
Main Title: Chesapeake Bay Habitat Restoration: A Framework for Action.
Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
Year Published: 1995
Call Number: PB96-144274
Report Number: CBP/TRS-140/95; EPA/903/R-95/015

Accession Number: 3686
Main Title: Ohio River Basin comprehensive survey - main report and development program formulation. Communication from the Chairman, United States Water Resources Council, transmitting the Council's report on a comprehensive program for water and related land use in the Ohio River Basin, pursuant to Public law 89-80.
Corporate Author: U.S. Water Resources Council.; U.S. Congress. House. Committee on Interior and Insular Affairs.
Publisher: U.S. Govt. Print. Office
Year Published: 1971

Accession Number: 95701
Main Title: River Basin Management Post-Audit and Analysis.
Personal Author: Wilkinson, John M.
Corporate Author: Little (Authur D.) Inc., Cambridge, Mass.
Year Published: 1900
Call Number: PB-222 941
Report Number: DI-14-31-0001-3719; OWRR-C-3353(3719); 13715,; C-3353(3719)(1)

Accession Number: 64881
Main Title: Policy for water allocation in the Lake Tahoe Basin.
Corporate Author: California. State Water Resources Control Board.
Publisher: The Board
Year Published: 1984

Accession Number: 211831
Main Title: Environmental Management Program for the Hampton Roads Virginia Portion of the Albemarle-Pamlico Estuarine Watershed.
Corporate Author: Hampton Roads Planning District Commission, VA.; North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.; Environmental Protection Agency, Research Triangle Park, NC. National Estuary Program.
Year Published: 1993
Call Number: PB95-106811
Report Number: A/P-92-19; APES-92-19

## Section 3 : Strategies for Watershed Management

Accession Number: 182945
Main Title: Otter Creek Watershed Conservation Tillage Demonstration Project (October 1987).
Personal Author: Smith, M.; Pielsticker, K.F.
Corporate Author: Monroe County Soil and Water Conservation District, MI.:Environmental Protection Agency, Chicago, IL. Great Lakes National Program Office.
Year Published: 1987
Call Number: PB93-128114
Report Number: GLNPO-08/91; EPA/905/9-91/007

Accession Number: 183950
Main Title: Compendium of watershed-scale models for TMDL development.
Publisher: U.S. Environmental Protection Agency
Year Published: 1992
Report Number: EPA 841-R-92-002 Contract no. 68-C9-0013

Accession Number: 183953
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Year Published: 1992
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Personal Author: Satterlund, Donald R.
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Year Published: 1992

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Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
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Main Title: Lake and Reservoir Restoration Guidance Manual: Second Edition.
Personal Author: Olem, H. ; Flock, G.
Corporate Author: North American Lake Management Society, Merrifield, VA.; Environmental Protection Agency, Washington, DC. Nonpoint Sources Branch.
Year Published: 1990
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Main Title: Stormwater program guidance manual for the Puget Sound Basin.
Corporate Author: Washington (State). Dept. of Ecology.
Publisher: The Department
Year Published: 1992

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Main Title: Standard methodology for conducting watershed analysis under chapter 222-22 WAC.
Corporate Author: Washington (State). Forest Practices Board.
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Main Title: Clean water in your watershed a citizen guide to watershed protection.
Personal Author: Alexander, Susan V.
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Main Title: Watershed Planning in the Albemarle-Pamlico Estuarine System. Report 3. Toxics Analysis.
Personal Author: Cunningham, P.A.; Williams, R.E.; Chessin, R.L.; McCarthy, J.M.; Curry, R.J.
Corporate Author: Research Triangle Inst., Research Triangle Park, NC.; North Carolina Dept. of Environment, Health, and Natural Resources, Raleigh. Albemarle-Pamlico Estuarine Study.
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Personal Author: Shoemaker, L.L.; Lahlou, M.; Thoms, S.; Xue, R.; Wright, J.
Corporate Author: Tetra Tech, Inc., Fairfax, VA.; Environmental Protection Agency, Washington, DC. Office of Wetlands, Oceans and Watersheds.
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Personal Author: Eckles, S.D.; Barnard, T.; Dawson, F.; Goodger, T.; Kimidy, K.
Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
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Personal Author: Hudson, H.L.; Soulliere, K.F.
Corporate Author: Northeastern Illinois Planning Commission, Chicago.; Illinois State Environmental Protection Agency, Springfield. Div. of Water Pollution Control.; Environmental Protection Agency, Washington, DC.
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Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
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Personal Author: Adler, K.J.; Smolen, M.D.
Corporate Author: Environmental Protection Agency, Washington, DC. Office of the Assistant Administrator for Water; North Carolina State Univ. at Raleigh.
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Corporate Author: Industrial Economics, Inc., Cambridge, MA.; Environmental Protection Agency, Washington, DC. Office of the Assistant Administrator for Water.
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Main Title: Saving Bays and Estuaries: A Primer for Establishing and Managing Estuary Programs. Appendices G, H, and I.
Corporate Author: Environmental Protection Agency, Washington, DC. Office of the Assistant Administrator for Water.
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Main Title: Office of Water administrative systems compendium information resources management : tools for making water program decisions.
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Main Title: Organizing lake users a practical guide.
Personal Author: Flock, Gretchen H.

Publisher: Terrene Institute
Year Published: 1991

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Main Title: Watershed Handbook. A Management Technique for Choosing Among Point and Nonpoint Control Strategies.
Personal Author: Monteith, T.J.; Sullivan, R.A.C.; Heidtke, T.M.; Sonzogni, W.C.
Corporate Author: Great Lakes Basin Commission, Ann Arbor, MI.; National Oceanic and Atmospheric Administration, Ann Arbor, MI. Great Lakes Environmental Research Lab.
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Main Title: Review of a framework for improving surface water monitoring support for decision-making.
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Main Title: Chesapeake Bay Toxics Reduction Strategy Stakeholder Roundtables: Pennsylvania, Maryland and the District of Columbia Summaries.
Personal Author: Flanigan, F.; Barth, C.A.; Dunn, C.
Corporate Author: Alliance for the Chesapeake Bay, Baltimore, MD.; Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
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Corporate Author: Chesapeake Executive Council.
Publisher: Chesapeake Executive Council,
Year Published: 1987

Accession Number: 82492
Main Title: 1987 Chesapeake Bay agreement draft proposals.
Publisher: United States Environmental Protection Agency.
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Main Title: Potomac River basin compact. April 1970.
Corporate Author: Potomac River Basin Advisory Committee.
Publisher: Potomac River Basin Advisory Committee
Year Published: 1970

Accession Number: 7463
Main Title: Susquehanna River Basin compact.
Corporate Author: Interstate Advisory Committee on the Susquehanna River Basin.; New York (State)
Publisher: Interstate Advisory Committee on the Susquehanna River Basin
Year Published: 1967

Accession Number: 19722
Main Title: Water and the West : the Colorado River Compact and the politics of water in the American West
Personal Author: Hundley, Norris.
Corporate Author: Colorado River Commission. Colorado River Compact. 1975.
Publisher: University of California Press
Year Published: 1975

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Main Title: Chesapeake Bay Research Coordination Act : hearing before the Subcommittee on Governmental Efficiency and the District of Columbia of the Committee on Governmental Affairs, United States Senate, Ninety-sixth Congress, second session, on S. 1316 and H.R. 4417, July 31, 1980.
Corporate Author: United States. Congress. Senate. Committee on Governmental Affairs. Subcommittee on Governmental Efficiency and the District of Columbia.
Publisher: U.S. G.P.O.
Year Published: 1980

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Main Title: Water Resources Policy Act of 1981 : hearing before the Subcommittee on Conservation, Credit, and Rural Development of the Committee on Agriculture, House of Representatives, Ninety-seventh Congress, first session, on H.R. 3432, June 16, 1981.
Corporate Author: United States. Congress. House. Committee on Agriculture. Subcommittee on Conservation, Credit, and Rural Development.
Publisher: U.S. G.P.O.
Year Published: 1981

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Main Title: State laws mandating water conservation
Personal Author: Sawyer, Stephen W.; Eney, Allen B.

Corporate Author: United States. Office of Water Policy.; University of Maryland, College Park. Water Resources Research Center.
Publisher: Maryland Water Resources Research Center, University of Maryland,
Year Published: 1983

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Main Title: Growth of water-resources law under the American federal system
Personal Author: Laurent, Francis W.
Corporate Author: University of Wisconsin--Madison. Water Resources Center.
Publisher: Water Resources Center, University of Wisconsin,
Year Published: 1977

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Main Title: Legal Aspects of Water Use and Control in South Carolina. Part A. Legal Considerations Relating to a New Water Resources Law for South Carolina.
Personal Author: Randall, J. Charles H.
Corporate Author: Clemson Univ., S. C. Water Resources Research Inst.
Year Published: 1900
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Main Title: Symposium on Water Law and Its Relationship to the Economic Development of Montana's Water Resources.
Personal Author: Holj, Helmer
Corporate Author: Montana State Univ., Bozeman. Water Resources Research Center.
Year Published: 1900
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Personal Author: Sherida, Richard G.
Corporate Author: Montana State Univ., Bozeman. Water Resources Research Center.
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Main Title: Water Resources Laws for Virginia.
Personal Author: Walke, William R.; Co, William E.
Corporate Author: Virginia Polytechnic Inst., Blacksburg. Water Resources Research Center.
Year Published: 1900
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Main Title: Interstate Ground-Water Aquifers of the State of Washington, Physical and Legal Problems. A Preliminary Assessment. Part A. The Physical Situation. Part B. Legal Aspects.
Personal Author: Agne, Allen F.; Busc, Russel W.
Corporate Author: Washington State Water Research Center, Pullman.
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Report Number: DI-14-31-0001-3048; OWRR-A-038-WASH; 06608; A-038-WASH(1)

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Main Title: Columbia River Interstate Compact, Politics of Negotiation.
Personal Author: Doerkse, Harvey R.
Corporate Author: Washington State Water Research Center, Pullman.
Year Published: 1900
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Main Title: Economic, Political, and Legal Aspects of Colorado Water Law.
Personal Author: Radosevic, G. E.; Nob, K. C.; Mee, R. L.; Flac, J. E.
Corporate Author: Colorado State Univ., Fort Collins. Environmental Resources Center.
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Main Title: Bibliography on Legal and Regulatory Aspects of Water Pollution Control and Abatement. I. Abstracts. II. Center of Competence for Eastern U.S. Water Laws.
Corporate Author: Florida Univ., Gainesville. Coll. of Law.
Year Published: 1900
Call Number: PB-222 228-SET

Accession Number: 130315
Main Title: Compilation of selected water resources and water pollution control laws Federal Water Pollution Control Act ; sections 9 to 20 of the Act of March 3, 1899 ; selected provisions of the Water Resources Development Act of 1986.
Corporate Author: United States.
Publisher: U.S. G.P.O.
Year Published: 1989
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Main Title: Law of water rights and resources
Personal Author: Tarlock, A. Dan
Publisher: C. Boardman
Year Published: 1988

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Main Title: Water resources legislation and administration in selected Caribbean countries
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Main Title: Water law in historical perspective
Personal Author: Teclaff, Ludwik A.
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Main Title: Down by the river the impact of federal water projects and policies on biological diversity.
Personal Author: Hunt, Constance Elizabeth.
Publisher: Island Press
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Main Title: Colorado water laws a compilation of statutes, regulations, compacts and selected cases.
Personal Author: Radosevich, George
Publisher: County Information Service, Agricultural and Natural Resource Economics & Colorado Water Resources Research Institute, Colorado State University,
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Main Title: Law of international water resources some general conventions, declarations, and resolutions adopted by governments, international legal institutions, and international organizations, on the management of international water resources.
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Personal Author: Bell, D. Craig.
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Main Title: Water resources Delaware River Basin Commission's management of certain water activities : report to the Honorable Peter H. Kostmayer, House of Representatives.
Personal Author: Kostmayer, Peter H.
Corporate Author: United States. General Accounting Office.
Publisher: The Office
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Main Title: Proceedings of the California Watershed Management Conference, November 18-20, 1986, West Sacramento, California
Personal Author: Callaham, Robert Z.; DeVries, Johannes J.
Corporate Author: University of California, Berkeley. Wildland Resources Center.
Publisher: Wildland Resources Center, Division of Agriculture and Natural Resources, University of California
Year Published: 1987

Accession Number: 76344
Main Title: Recharge as augmentation in the South Platte River Basin
Personal Author: Warner, James W.; Sunada, D.; Hartwell, Anne.
Corporate Author: Colorado Water Resources Research Institute.
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Year Published: 1986

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Main Title: State of the Chesapeake Bay ... biennial monitoring report
Corporate Author: United States. Environmental Protection Agency. Chesapeake Bay Program. Monitoring Subcommittee.
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Year Published: 1989

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Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
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Main Title: New Alsea watershed study.
Publisher: National Council of the Paper Industry for Air and Stream Improvement
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Main Title: California watersheds at the urban interface proceedings of the Third Biennial Watershed Conference, Ontario Hilton, Ontario, California, October 30-31, 1990.
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Main Title: Evaluation of the Watershed Protection and Flood Prevention Program
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Main Title: Turning the tide saving the Chesapeake Bay.
Personal Author: Horton, Tom
Publisher: Island Press
Year Published: 1991

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Main Title: Republic of Haiti agroforestry and watershed management project Artibonite river pre-feasibility study.
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Main Title: Watershed management balancing sustainability and environmental change.
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Personal Author: Swanson, F.J.; Neilson, R.P.; Grant, G.E.
Corporate Author: Pacific Northwest Forest and Range Experiment Station, Corvallis, OR. Forestry Sciences Lab.; Corvallis Environmental Research Lab., OR.
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Main Title: Urban and regional conflict resolution in water related issues proceedings of the symposium sponsored by the Irrigation and Drainage Division of the American Society of Civil Engineers in conjunction with the ASCE Convention, Orlando, Florida, October 21-22, 1991.
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Personal Author: Ahmad, Masood.
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Main Title: Protecting drinking water quality at the source proceedings of a conference, Sacramento, California, April 3-4, 1991.
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Main Title: President Clinton's Clean Water Initiative: Analysis of Benefits and Costs.
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Report Number: EPA/800/R-94/002

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Main Title: Geographic targeting selected state examples.
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Main Title: Overcoming obstacles proceedings of the Fourth Biennial Watershed Management Conference, Embassy Suites Hotel, South Lake Tahoe, California, November 18-20, 1992.
Publisher: Centers for Water and Wildland Resources, University of California
Year Published: 1994

Accession Number: 202426
Main Title: Runoff report.
Publisher: National NonPoint Source Federation.
Year Published: 1993

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Main Title: WATERSHED '93: A National Conference on Watershed Management. Held in Alexandria, Virginia on March 21-24, 1993.
Corporate Author: Environmental Protection Agency, Washington, DC. Office of Wetlands, Oceans and Watersheds.
Year Published: 1993
Call Number: PB94-181609
Report Number: EPA/840/R-94/002

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Main Title: Annotated bibliography of publications on watershed management and ecological studies at Coweeta Hydrologic Laboratory, 1934-1994.
Personal Author: Stickney, Patricia L.
Publisher: U.S.Department of Agriculture, Forest Service, Southeastern Forest Experiment Station
Year Published: 1994

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Main Title: Watershed restoration sourcebook collected papers presented at the Conference "Restoring Our Home River - Water Quality and Habitat in the Anacostia" held November 6th and 7th, 1991, in College Park, Md.
Publisher: The Council
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Main Title: Investing in natural capital the ecological economics approach to sustainability.
Publisher: Island Press
Year Published: 1994

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Main Title: Southern Regional review of state nonpoint source control programs and best management practices for forest management operations.
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Main Title: Proceedings of a Workshop on Risk Assessment, Communication and Management in the Great Lakes Basin February 1-2, 1993, St. Catherines, Ontario.
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Year Published: 1993

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Main Title: Integrated economic hydrologic model for groundwater basin management.
Personal Author: Faisal, Islam M.
Publisher: Colorado Water Resources Research Institute, Colorado State University,
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Main Title: Mill Creek an unnatural history of an urban stream.
Personal Author: Hedeen, Stanley E.
Publisher: Rivers Unlimited Mill Creek Restoration Project : Blue Heron Press
Year Published: 1994

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Main Title: State of the Chesapeake Bay, 1995.
Personal Author: Magnien, R.; Boward, D.; Bieber, S.
Corporate Author: Environmental Protection Agency, Annapolis, MD. Chesapeake Bay Program.
Year Published: 1995
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Corporate Author: Environmental Protection Agency, Washington, DC. Office of Wetlands, Oceans and Watersheds.
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Main Title: Proceedings of the 1990 Clark Fork River Symposium, April 20, 1990, University of Montana, Missoula, Montana.
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Main Title: Agriculture and the environment information on and characteristics of selected watershed projects : report to the Committee on Agriculture, Nutrition, and Forestry, U.S. Senate.
Corporate Author: United States. General Accounting Office.
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Publisher: Centers for Water and Wildland Resources, Water Resources Center, University of California
Year Published: 1995

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Publisher: Lewis Publishers
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Main Title: Mobilizing the Watershed Community: Linking Land, Water, and People.
Corporate Author: Illinois State Environmental Protection Agency, Springfield. Bureau of Water.
Year Published: 1995
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Main Title: Nisqually watershed Glacier to Delta : a river's legacy.
Personal Author: Gordon, David G.
Publisher: Mountaineers
Year Published: 1995

Accession Number: 237108
Main Title: Seminar publication National Conference on Urban Runoff Management : enhancing urban watershed management at the local, county, and state levels.
Publisher: U.S. Environmental Protection Agency
Year Published: 1995
Report Number: EPA/625/R-95/003

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Main Title: Ecology, diversity, and sustainability of the Middle Rio Grande Basin
Publisher: U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station
Year Published: 1995

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Main Title: Down by the river the impact of federal water projects and policies on biological diversity.
Personal Author: Hunt, Constance Elizabeth.
Publisher: Island Press
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Main Title: Social and environmental objectives in water resources planning and management.
Personal Author: Viessman, Warren.; Schilling, Kyle E.
Corporate Author: Engineering Foundation (U.S.); American Society of Civil Engineers. Water Resources Planning and Management Division. Committee on Social and Environmental Objectives.
Publisher: American Society of Civil Engineers
Year Published: 1986

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Main Title: Symposium on the Natural Resources of the Mobile Bay Estuary.
Personal Author: Lowery, T.A.
Corporate Author: Mississippi-Alabama Sea Grant Consortium, Ocean Springs, MS.;Alabama Dept. of Economic and Community Affairs, Montgomery.;Environmental Protection Agency, Washington, DC.;Corps of Engineers, Washington, DC.;Fish and Wildlife Service, Washington, DC.
Year Published: 1987
Call Number: PB88-137559
Report Number: MASGP-87-007

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Main Title: Watering the garden state water, land and community in Victoria, 1834-1988.
Personal Author: Powell, J.M.
Publisher: Allen & Unwin
Year Published: 1989

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Main Title: Proceedings of the Symposium on International and Transboundary Water Resources Issues.
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Year Published: 1990

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Main Title: Financial risk analysis of infrastructure debt the case of water and power investments.
Personal Author: Jones, Clive Vaughan.
Publisher: Quorum Books
Year Published: 1991

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Main Title: Water resources management in search of an environmental ethic.
Personal Author: Feldman, David Lewis
Publisher: Johns Hopkins University Press
Year Published: 1991

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Main Title: Water resources management in Latin America and the Caribbean.
Personal Author: Lee, Terence R.
Publisher: Westview Press
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Main Title: Country experiences with water resources management economic, institutional, technological, and environmental issues.
Publisher: World Bank
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Main Title: Challenges in the binational management of water resources in the Rio Grande / Rio Bravo.
Personal Author: Eaton, David J.
Publisher: Lyndon B. Johnson School of Public Affairs, University of Texas at Austin
Year Published: 1992

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Main Title: Water Transfers in the West: Efficiency, Equity, and the Environment.
Corporate Author: National Research Council, Washington, DC. Committee on Western Water Management.; Southern California Metropolitan Water District, La Verne.; East Bay Municipal Utility District, Oakland, CA.; Bureau of Reclamation, Washington, DC.; Environmental Protection Agency, Washington, DC.
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Call Number: PB94-122397
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Main Title: Water resources management.
Publisher: World Bank
Year Published: 1993

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Main Title: EPA Great Waters Program: An Introduction to the Issues and the Ecosystems.
Corporate Author: Environmental Protection Agency, Research Triangle Park, NC. Office of Air Quality Planning and Standards.
Year Published: 1994
Call Number: PB94-195997
Report Number: EPA/453/B-94/030

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Main Title: Water resources management in Asia
Personal Author: Frederiksen, Harald D.
Publisher: World Bank
Year Published: 1993

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Main Title: Principles and practices for dealing with water resources issues.
Personal Author: Frederiksen, Harald D.
Publisher: World Bank
Year Published: 1994

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Main Title: Financing Strong State Water Programs in New Ways. Proceedings of a National Workshop. Held in Denver, Colorado, March 20-21, 1989.

Corporate Author: National Academy of Public Administration, Washington, DC.; Environmental Protection Agency, Washington, DC. Office of Water.; Association of State and Interstate Water Pollution Control Administrators, Washington, DC.; Association of State Drinking Water Administrators, Arlington, VA.; Government Finance Officers Association, Washington, DC. Government Finance Research Center.
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Main Title: Discussion Paper on Alternative Financing Mechanisms for State Water Programs.
Corporate Author: Environmental Protection Agency, Washington, DC., Office of Water.
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