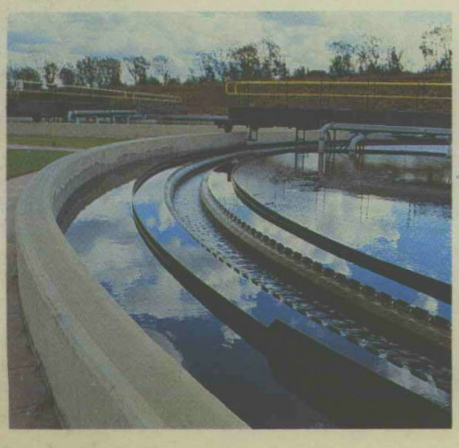
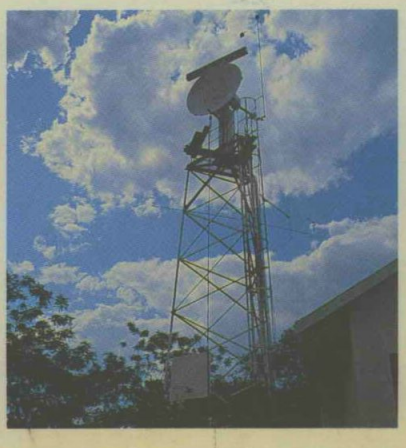
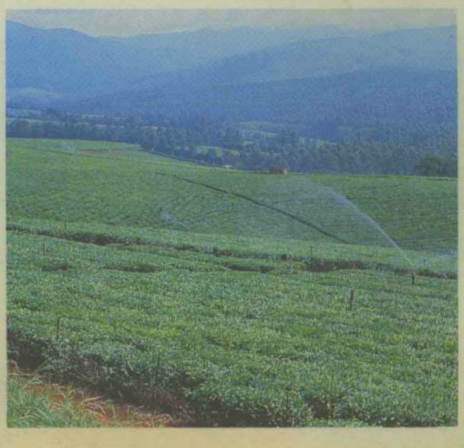
WATER RESEARCH COMMISSION

ANNUAL REPORT 1984







WATER RESEARCH COMMISSION ANNUAL REPORT

84

1 JANUARY

TO 31 DECEMBER

Water Research Commission
P O Box 824
PRETORIA
0001

Telegraphic Address:
WATERKOM
Telex: 32-0464
ISBN 0 908356 31 5

Hierdie verslag is ook in Afrikaans beskikbaar

The objectives of the Water Research Commission

In terms of section 2(3) of the Water Research Act 1971, (Act No. 34 of 1971) the objectives of the Commission are "to coordinate, to promote, to encourage or to cause to be undertaken, as determined by the Minister specifically or in broad outline, research in respect of

(a) the occurrence, preservation, conservation, utilization, control, supply, distribution, purification, pollution or reclamation of water supplies and water;

(b) the use of water for
  (i) agricultural purposes;
  (ii) industrial purposes; or
  (iii) urban purposes".

Section 3(1) of the above-mentioned Act describes the functions of the Commission and stipulates *inter alia* that the Commission shall "accumulate, assimilate and disseminate knowledge in regard to the results of such research and the application thereof, and promote development work for the purpose of such application."

Contents

Water Research Commission
P O Box 824
PRETORIA
0001
16 April 1985

Dear Mr Wentzel

We take pleasure in submitting to you, herewith, the report of the Water Research Commission. This report covers the period 1 January 1984 to 31 December 1984.

The balance sheet and statement of revenue and expenditure for the financial year 1 January 1984 to 31 December 1984, as certified by the Auditor General, are furnished in Chapter 16 of this report.

Yours respectfully

J P Kriel
CHAIRMAN

J G du Plessis
VICE CHAIRMAN

The Honourable J J G Wentzel, MP
Minister of Agricultural Economics and of Water Affairs
P O Box 3
CAPE TOWN
8000

MEMBERS OF THE WATER RESEARCH COMMISSION AS ON 31 DECEMBER 1984

DR MR HENZEN
Chairman:
Chief Executive Officer

MR JG DU PLESSIS
Vice Chairman
Director General:
Department of Water Affairs

DR JP KRIEL
Former Secretary for Water Affairs and
now consultant: Special water studies for the Department of Water Affairs

DR N STUTTERHEIM
Chairman:Council of the University of the Witwatersrand
Chairman: Telephone Manufacturers of South Africa

PROF DJ SCHOEMAN
Dean: Faculty of Engineering
University of Pretoria

DR CF GARBERS
President:
Council for Scientific and Industrial Research

DR DW IMMELMAN
Director General:
Department of Agricultural Economics and Marketing

MR JG BRAND
City Engineer of Cape Town
(Co-opted member)

1 Introduction

The extent and intensity of the crippling drought in South Africa has once again emphasized the indispensable role that water plays with respect to survival and progress and has also resulted in a greater awareness of water among consumers. When the drought is broken and water becomes more readily available, it is important that this awareness and appreciation of water continues so that every water consumer in the Republic demonstrates a responsibility towards the judicious utilisation of water. This responsibility is important because of the fact that calculations, as already generally known, indicate that with present consumption patterns, South Africa will fully utilise its available water sources early in the next century.

The drought resulted in the introduction of drastic water economy measures in certain areas of the country. In this regard a gratifying aspect has come to the fore, *viz.* that in many instances production can be maintained in spite of reduced water consumption. It is possible that in many industries water economy has been regarded for the first time as a specific management objective.

Maximum yield per water unit can only be achieved by using improved management strategies and the application of advanced technology which has been established through research and development.

In view of the expected water shortage, continued attention should be given to the necessary long-term planning, correct water management, and sustained water research. The latter is essential since present knowledge is insufficient for the optimal utilization of existing water sources and the establishment of new water sources in order to supply adequate water of satisfactory quality for essential use in the future. In this regard, two aspects need to be emphasized again.

In the first place the important role of water research can to a large extent be nullified if the research results are not used and applied judiciously. It is, therefore, of utmost importance that in the allocation of research funds technology transfer be actively promoted. In the second place it should also be remembered that water research demands a multidisciplinary approach and provision should be made for research over a wide spectrum.

The Commission supports research in the national interest and the above-mentioned two aspects, viz. technology transfer and the multidisciplinary approach, are inherently part of its research planning and programmes. Technology transfer is acchieved mainly through the incorporation of the partnership principle in research agreements. It is also promoted via, inter alia, the publication of relevant documents, arranging meetings (demonstrations, simposia, workshops) and personal communication.

With respect to the multidisciplinary approach to research, the Commission, firstly, has at its disposal a staff which represents a variety of disciplines and which is responsible for the coordination of activities in the various fields of interest and the initiation and management of research programmes and projects. Secondly, the Commission covers the wide spectrum by closely collaborating with government and statutory organisations, local authorities, the industrial sector (especially via their national associations) and the agricultural sector and also makes use of local and overseas consultants.

The Commission contracts various organisations to carry out research work and in the process creates centres of expertise which are then utilised in the national interest.

UTILISATION OF RESEARCH ORGANISATIONS

Of the 81 research projects supported by the Commission during 1984, 65 were undertaken in terms of dual contracts, (i.e., between the Commission and one party only), 13 in terms of tripartite and 3 in terms of quadripartite contracts. In addition to these, sub-contracts were also involved as well as various industries on whose sites research was undertaken and who, as "partners" made important inputs by way of facilities, manpower, etc. Table 1 has been compiled to illustrate the involvement of the various research sectors in the execution of research.

TABLE 1
INVOLVEMENT OF RESEARCH SECTORS IN THE EXECUTION OF THE 81 RESEARCH PROJECTS IN 1984

Research sector	Number of times involved
Universities	43
CSIR	15
Consulting engineers	14
Other statutory organisations and industries	13
Municipalities	8
Government departments	7
	100

FINANCIAL SUPPORT FOR RESEARCH AREAS

During the year under review as in the past, the Commission supported water research within the framework of its task areas and according to specific priorities. Table 2 sets out the financial allocations to various areas in terms of research agreements. These amounts do not include consulting fees and block grants.

It is important to realise that a reduction in the relative financial expenditure does not necessarily imply that a lower priority has been accorded to a specific area - it could mean that research results are now successfully being applied, resulting in a reduced demand for further research.

In the different chapters information is given on the Commission's research activities in the various fields and on the 81 projects which were financed during the year. Of these 81 projects, 13 were completed and 21 new projects commenced.

RESEARCH PROJECTS WHICH WERE COMPLETED DURING 1984

The final reports of each of the 13 completed projects were accepted by the Commission. These reports were distributed to interested organisations and persons and, where applicable, guidelines were or are being compiled in order to further promote the application of results. Based on the research, several papers were also presented at conferences and reports and articles were published (in this regard see also Appendix: Publications in 1984).

The following projects were completed during the year:

- Hydrological investigation of rural catchments in Natal with specific reference to flood events. (Contract with the University of Natal - Department of Agricultural Engineering).
- Hydrological research in Zululand. (Contract with the University of Zululand - Department of Geography).
- Research on drought occurrences. (Contract with the University of Stellenbosch, Department of Civil Engineering).
- Evaluation of the impact of phosphate limitation on the trophic status of South African impoundments. (Contract with the Department of Environment Affairs - Hydrological Research Institute, and with the University of the Orange Free State - Institute for Environmental Sciences).
- Sewage sludge dewatering and the treatment of sludge liquors. (Contract with the City Council of Port Elizabeth).
- Autothermic aerobic digestion of sludge. (Contract with the City Council of Johannesburg).

TABLE 2
EXPENDITURE ON RESEARCH AREAS IN R X10³*

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	TOTAL
1. Surface hydrology	—	1 (0,5%)	40 (6%)	221 (14%)	352 (11%)	214 (7,5%)	216 (7%)	274 (10%)	337 (12,5%)	404 (13%)	234 (5,5%)	337 (5,5%)	686 (9,5%)	3 316 (9%)
2. Ground water	—	—	—	252 (16%)	458 (14%)	448 (15,5%)	586 (18,5%)	345 (13%)	238 (9%)	202 (6%)	96 (2%)	102 (2%)	442 (6%)	3 169 (8,5%)
3. Hydrometeorology	—	—	2 (0,5%)	10 (0,5%)	63 (2%)	141 (5%)	229 (7%)	277 (10,5%)	254 (9,5%)	297 (9%)	1 223 (30%)	2 285 (38%)	1 931 (27,5%)	6 712 (18%)
4. Irrigation	—	—	—	29 (2%)	68 (2%)	86 (3%)	119 (4%)	167 (6%)	175 (6,5%)	250 (10%)	486 (12%)	578 (10%)	798 (11,5%)	2 756 (7%)
5. Mineralisation	—	—	—	—	—	—	—	—	—	—	106 (2,5%)	749 (12,5%)	231 (3,5%)	1 086 (3%)
6. Eutrophication	—	—	60 (9%)	72 (5%)	143 (4,5%)	180 (6%)	169 (5%)	69 (2,5%)	54 (2%)	—	59 (1,5%)	89 (1,5%)	137 (2%)	1 032 (3%)
7. Municipal wastewater and sewage sludge	—	24 (6,5%)	116 (17,5%)	125 (8%)	126 (4%)	131 (4,5%)	690 (22%)	262 (10%)	257 (9,5%)	365 (11,5%)	318 (8%)	264 (4%)	430 (6%)	3 108 (8%)
8. Industrial effluents	—	7 (2%)	38 (5,5%)	69 (4,5%)	136 (4%)	204 (7%)	243 (7,5%)	297 (11%)	411 (15%)	495 (15,5%)	487 (12%)	626 (10,5%)	1 276 (18%)	4 289 (11,5%)
9. Water purification and -reuse	20 (80%)	238 (67%)	293 (44,5%)	569 (37%)	1 662 (51,5%)	1 279 (44%)	689 (22%)	754 (28%)	581 (22%)	643 (20%)	650 (16%)	256 (4%)	303 (4,5%)	7 937 (21%)
10. Desalination	5 (20%)	71 (20%)	104 (16%)	179 (11,5%)	174 (5,5%)	152 (5,5%)	199 (6%)	180 (7%)	163 (6%)	188 (6%)	187 (4,5%)	361 (6%)	333 (5%)	2 296 (6%)
11. Water economy in urban areas	—	—	—	16 (1%)	38 (1%)	54 (2%)	22 (1%)	27 (1%)	110 (4%)	136 (4%)	158 (4%)	139 (2%)	235 (3%)	935 (2,5%)
12. Water economy at power stations	—	14 (4%)	7 (1%)	8 (0,5%)	6 (0,5%)	—	—	20 (1%)	109 (4%)	177 (5%)	87 (2%)	228 (4%)	255 (3,5%)	911 (2,5%)
TOTAL	25	355	660	1 550	3 226	2 889	3 162	2 672	2 689	3 157	4 091	6 014	7 057	37 547

*Expenditure in terms of contracts for the execution of research projects.
(Figures in brackets indicate the percentages for a specific year)

- Research into the characterisation of sludge. (Contract with the CSIR - National Institute for Water Research).
- Research on water economy measures for water distribution systems in urban areas. (Contract with the South African Bureau of Standards and the CSIR - National Building Research Institute).
- Research to investigate leak detection in water supply distribution systems. (Contract with the CSIR - National Building Research Institute).
- Research on the auto-analysis of sulphate and alkalinity in water. (Contract with the University of Pretoria - Department of Chemistry).
- Research on the desalination of mine water. (Contract with the Chamber of Mines).
- Evaluation of electrodialysis reversal for the desalination of effluents and brackish water. (Contract with ESCOM).
- Research on and development of membrane support systems for reverse osmosis and ultrafiltration. (Contract with the University of Stellenbosch - Institute for Polymer Science, and the CSIR - National Institute for Water Research).

RESEARCH PROJECTS WHICH COMMENCED DURING 1984

After negotiations between the Commission's staff and the other party (or parties) have been finalised in connection with a proposed new project and the necessary clearance meetings have taken place, the relevant documents (motivation, background information and contract) are tabled at a Commission meeting. Should the Commission approve the proposed contract, it is then referred to the Minister

for final approval. The contract agreements are then signed by the parties and then the research can commence.

The 21 new projects which commenced during the year, are the following:

- Research on applied hydrological process and modelling studies for the determination of water and sediment yield. (Contract with the University of Natal - Department of Agricultural Engineering).
- Research on design stormflow and peak discharge rates for small catchments in Southern Africa. (Contract with the University of Natal - Department of Agricultural Engineering)
- Hydrological research in catchments in North-Eastern Natal. (Contract with the University of Zululand - Hydrological Research Unit).
- Research into the development of a national data bank for ground-water data. (Contract with the University of the Orange Free State - Institute for Groundwater Studies).
- An investigation into rainfall recharge to ground water. (Contract with a firm of consulting engineers, Steffen, Robertson and Kirsten).
- Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat. (Contract with the University of the Orange Free State - Department of Agrometeorology).
- Research on the quantification and limitation of water losses associated with centre pivot irrigation systems. (Contract with the University of the Orange Free State - Department of Agronomy).
- Research on the practical scheduling of irrigation in the Northern Transvaal. (Contract with the University of the North - Department of Crop Production).
- Research on the use of the soil-root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil-plant-atmosphere systems. (Contract with the University of the Orange Free State - Department of Soil Science).
- Research on the inhibition of algal growth by water hyacinth. (Contract with the University of Natal - Department of Botany).
- Research on biological foam in the activated sludge process. (Contract with the University of Pretoria - Division of Water Utilization Engineering, Department of Chemical Engineering).
- Research on biological excess phosphate removal. (Contract with the University of Cape Town - Department of Civil Engineering).
- Research on the evaluation and optimisation of full-scale chemical phosphate removal in biological sewage treatment processes. (Contract with the City Council of Boksburg and a firm of consulting engineers,Scott and De Waal).
- Research on marine disposal of wastewaters: a guide for the marine disposal of wastewaters. (Contract with the CSIR - National Research Institute for Oceanology).
- A national industrial water and wastewater survey. (Contract with a firm of consulting engineers, Binnie and Partners).
- Research into the development of wastewater pretreatment techniques : cross-flow microfiltration. (Contract with the University of Natal - Pollution Research Group, Department of Chemical Engineering).
- Research into water loss analysis on municipal water distribution systems. (Contract with Castle Brass Holdings (Pty) Ltd and the Johannnesburg City Council).
- Research on thermal feedback caused by dry cooling at power generating stations. (Contract with ESCOM and the CSIR - National Physical Research Laboratory).
- Research on the development of polymers for the formation of dynamic membranes. (Contract with the University of Stellenbosch - Institute for Polymer Science).
- Research on membrane development and fabrication for reverse osmosis and ultrafiltration. (Contract with the University of Stellenbosch - Institute for Polymer Science.)
- The technical performance evaluation of a full-scale industrial wastewater treatment plant: Textile dyehouse effluent treatment by hyperfiltration and evaporation. (Contract with Kluk Textile Industries (Pty) Ltd T/A MYM Textiles and the University of Natal.)

2 Research on surface hydrology

Surface hydrology deals with water occurring on and near to the land surface and includes streamflow, impounded water, catchment processes and soil moisture. It also deals with the supply and demand interactions between the water utilization cycle on the one hand and the hydrological cycle on the other hand. Research on surface hydrology is, therefore, important and can contribute significantly to alleviate constraints in the Republic's water economy and to assure an adequate water supply.

It is estimated for South Africa as a whole that on average only about 9% (54 000 x $10^6 m^3/a$) of the mean annual rainfall that reaches the land surface, flows into streams and rivers. The remaining approximately 90% is either stored in the soil for use by plants and crops through transpiration, evaporates directly back to the atmosphere or recharges the ground water. Using present technology, only about 60% of the runoff can be made available for beneficial use. The reason for this relates to a combination of problems concerning the natural high variability of the hydrological regime, the distribution of water over South Africa, high evaporation rates from impoundments and sedimentation. If, however, the percentage of water which could be made available for beneficial use could be increased by even say 5% from the present 60% to 65%, it would mean an extra 2 700 x $10^6 m^3/a$ on average.

In general the Commission's surface hydrology research is aimed at providing improved methods for the development and utilization of the natural water sources; providing information and methods for raising the efficiency of the current use of developed supplies; and seeking ways of creating new sources of water.

Fundamental to all water resources research and planning activities is a knowledge of the actual present availability of water and its utilization. The present estimates are subject to error and one of the highest priorities in surface hydrology is the collection and processing of reliable data with reference to the hydrological cycle. In this respect, renewed emphasis was placed on improving the hydrological data base of the Department of Water Affairs and negotiations in this regard have reached an advanced stage.

CURRENT RESEARCH PROJECTS

The Commission is currently sponsoring nine research projects on surface hydrology and they cover the following interrelated areas, *viz.*

- regional studies where the primary aim is to determine the temporal and spatial distribution of surface water resources;

- the development, improvement and evaluation of analytical, empirical, numerical and statistical techniques as aids to surface water resource assessment, planning and management (including high and low flow occurrences); and

- process studies that are designed to improve the abovementioned methods, in particular the numerical simulation methods, thus ultimately facilitating the prediction of the effects of changes in catchment management on water resources in urban and rural environments.

With the knowledge gained from the above research, it is hoped that it will be possible to improve strategies for water resources development and management to allow the so necessary synchronisation of water supply and demand to be effected.

During the year two research projects were completed, while three new projects commenced.

COMPLETION OF PROJECTS

Hydrological investigation of rural catchments in Natal with specific reference to flood events

This project was successfully completed by the Department of Agricultural Engineering, University of Natal. The primary objective was to develop, adapt and test hydrological simulation models for use in ungauged situations in Southern Africa with emphasis being placed on isolated flood events which dominate the flow of small ephemeral streams. The internationally used Soil Conservation Service (SCS) Model for simulation of natural or design flood events, has been modified, improved and successfully applied. A new model, the ACRU (Agricultural Catchments Research Unit) Model, was also developed for the simulation of streamflow volume, supplementary irrigation requirements and crop yields per unit of water based on daily time steps. In addition to these, South African soils were classified into units of similar hydrological response for use in hydrological models.

Hydrological research in Zululand

This project was successfully completed by the Hydrological Research Unit of the Department of Geography, University of Zululand. The aims of the project were to develop parametric models for the simulation of infiltration rates; the application of these models in the simulation of runoff by means of physiographically based models; and the development of data for use in different models with special reference to antecedent base flow and moisture conditions.

The project concentrated on two different models for stormflow simulation, *viz.* the SCS technique and the R-Index model. The above aims were met and significant improvements were made to these models with regard to the components of antecedent moisture and base flow conditions.

A report on the influence of infiltration on stormflow in the Ntuze River catchment confirms the concept of "quick flows", occurring through the top layers of the soil, being a major contributor to stormflow in this catchment. This has far reaching implications for conceptual model structures where this type of runoff producing mechanism needs to be incorporated.

NEW RESEARCH PROJECTS ON SURFACE HYDROLOGY

Hydrological research in catchments in North-Eastern Natal

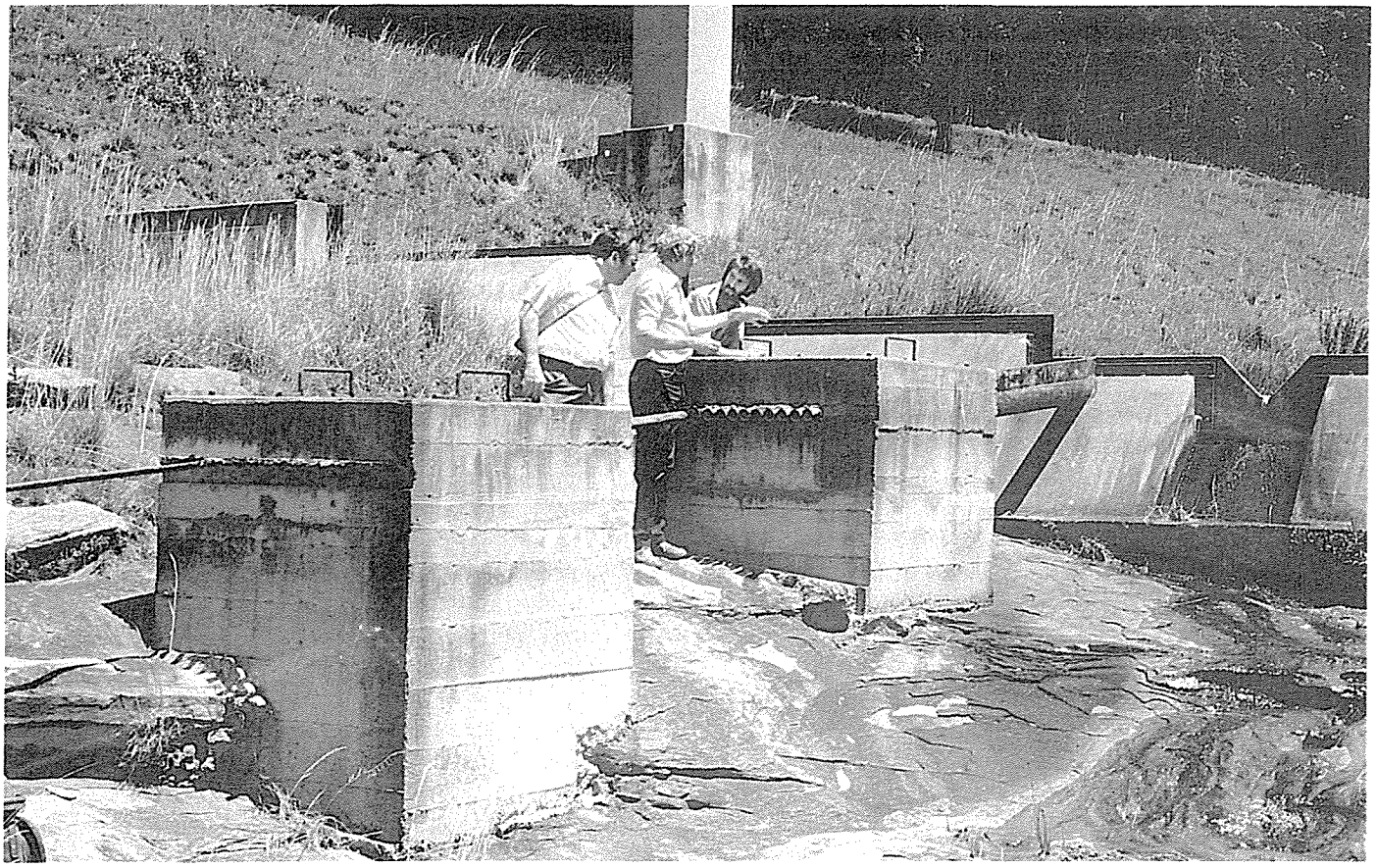
A contract was negotiated with the University of Zululand in terms of which their Hydrological Research Unit will undertake research into the water quality of selected streams in the Ntuze catchments. At the same time the hydrological data collection and processing programme will continue.

Applied hydrological process and modelling studies for the determination of water and sediment yield

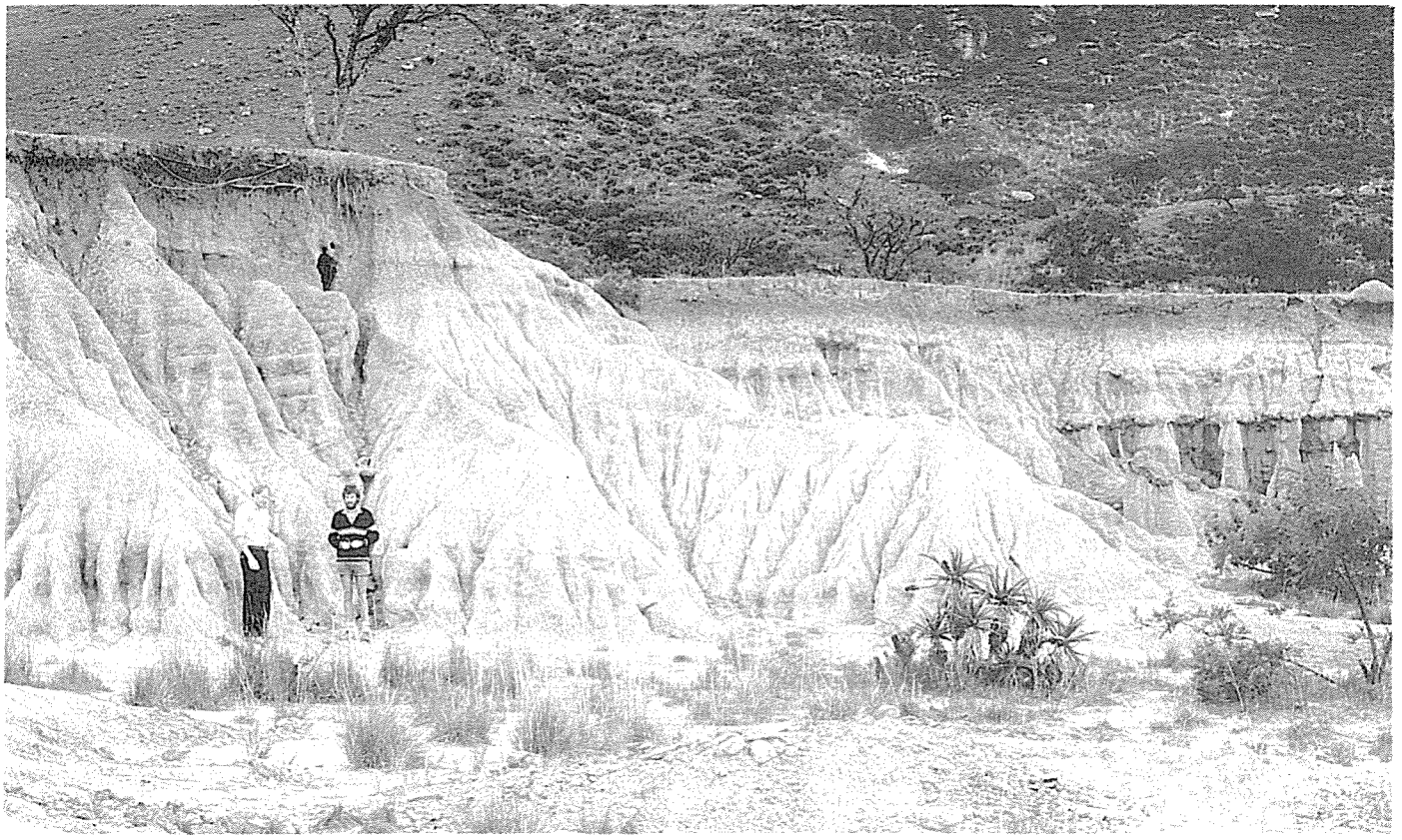
A contract was entered into with the University of Natal in terms of which their Department of Agricultural Engineering will develop, test and adapt hydrological models to yield output for decision makers in the form of runoff, sediment yield, soil moisture and water utilization by different major crop types. These models must reflect and be able to account for the uniqueness of South Africa's soils, agricultural practices, and climate by being sensitive to any changes in land-use or management practice.

Research on design stormflow and peak discharge rates for small catchments in Southern Africa

A contract was negotiated with the University of Natal for which purpose their Department of Agricultural Engineering will update and revise the SCS manual for the estimation of flood events from small catchments. They will also research the joint association of rainfall and catchment antecedent conditions to be able to estimate more realistic hydrographs for the different regions of South Africa.



Weir in the Ntabamhlope catchment used for the determination of water and sediment yield.



Example of the extent of erosion in the De Hoek catchment where hydrological research is being carried out.

VISITING SCIENTIST

Dr J Roberts of the Institute of Hydrology, Wallingford, United Kingdom who is an authority on evapotranspiration, was invited to South Africa as a consultant to the Water Research Commission. Very useful information on evapotranspiration and modelling was gained from his visit.

LIST OF RESEARCH PROJECTS CN SURFACE HYDROLOGY

- Hydrological investigation of rural catchments in Natal with specific reference to flood events. (Contract with the University of Natal - Department of Agricultural Engineering).
- Hydrological research in Zululand. (Contract with the University of Zululand - Department of Geography).
- Research on urban hydrology and drainage. (Contract with the University of the Witwatersrand - Department of Civil Engineering, Water Systems Research Programme).
- Hydrological research in catchments of the Eastern and Southern Cape. (Contract with Rhodes University - Department of Geography).
- Research on an evaluation of hydrological flood estimation techniques for small ungauged catchments. (Contract with a firm of consulting engineers, Steffen Robertson and Kirsten).
- The establishment of hydrological data banks. (Contract with Department of Water Affairs - Division of Hydrology).
- Research on design stormflow and peak discharge rates for small catchments in Southern Africa. (Contract with the University of Natal - Department of Agricultural Engineering).
- Applied hydrological process and modelling studies for the determination of water and sediment yield. (Contract with the University of Natal - Department of Agricultural Engineering).
- Hydrological research in catchments in North - Eastern Natal. (Contract with the University of Zululand - Hydrological Research Unit).

3 Research on ground water

Ground water is important in South Africa because about 2/3 of the surface area of the country relies heavily on ground water for household use, stock watering, irrigation on a limited scale and supplying relatively small municipalities. However, the total volume of ground water used is only about 10% of the total water used in South Africa.

Generally speaking South Africa's ground-water reserves are limited but there are some areas, such as the dolomite compartments of the Transvaal, that have the potential to supply appreciable amounts of water during periods when surface water supply is inadequate to meet demand. There is also little doubt that the Republic has the potential to make much more use of ground-water resources. In this regard the research programmes financed by the Commission have been designed mainly to improve techniques for determining the exploitation potential of ground water in areas of limited surface water supply.

NEW RESEARCH PROJECTS

During the year the Commission supported three ground-water research projects, of which two commenced at the beginning of the year, *viz.* a project on a national data bank for ground-water data and an investigation into rainfall recharge to ground water.

National data bank for ground-water data

The Institute for Groundwater Studies is developing a national data bank for ground-water data in terms of an agreement between the Commission and the University of the Orange Free State. The investigation is being carried out in close collaboration with the Division of Geohydrology of the Department of Water Affairs. Once the data bank has been established it will be housed in the Division and will provide a vitally important research facility for all geohydrologists in South Africa.

An investigation into rainfall recharge to ground water

This investigation is being carried out by a firm of consulting engineers, Steffen, Robertson and Kirsten. The accurate determination of ground-water recharge by rainfall is important in order to assess the long term yield of the aquifers, either under safe-yield constraints or under conditions where the abstraction rate exceeds the replenishment rate. The primary objective of this study is to examine the potential recharge in three areas, which are hydrogeologically dissimilar and contain a number of

different but commonly-found surface soil-types, using several different numerical models. The end result will be the identification of the best methodology required to enable aquifer recharge estimates to be made with greater confidence and with more general application throughout Southern Africa.

THE EXPLOITATION POTENTIAL OF KAROO AQUIFERS

During the year the Institute for Groundwater Studies at the University of the Orange Free State carried out a feasibility study for the Commission, with the aim of developing a research programme to formulate an objective method of determining the exploitation potential of aquifers in semi-arid areas.

The determination of the exploitation potential of local aquifers is the first step in the development of ground-water resources in areas where surface supplies are limited and, unfortunately, it involves a long and expensive field investigation. The proposed research provides for the determination of the relative importance of the many factors involved and will relate them to easily measured variables. By means of this an estimate of the exploitation potential could be derived from the relatively sparse information that exists.

RESEARCH ON GROUND-WATER RESOURCES OF THE DOLOMITES

The Director of the Geological Survey of Israel, Dr Uri Kafri, arrived in South Africa in September 1984 under contract to the Water Research Commission to undertake research on the dolomite compartments in the Transvaal. During his one year stay Dr Kafri will assist the Division of Geohydrology of the Department of Water Affairs in its research programme on the ground-water resources of the dolomites in the Rand Water Board supply area. The major objective of this research programme will be to install high yield boreholes to tap water from the dolomites during times of crisis. It is envisaged that this ground-water component will eventually be incorporated as an integral part of the Vaal River water supply system.

LIST OF RESEARCH PROJECTS ON GROUND WATER

- The applicability of ground-water models as an aid to the study and evaluation of South African aquifers. (Contract with the University of the Orange Free State - Institute for Groundwater Studies).
- The development of a National Data Bank for ground-water data. (Contract with the University of the Orange Free State - Institute for Groundwater Studies in collaboration with the Department of Water Affairs).
- An investigation into rainfall recharge to ground water. (Contract with a firm of consulting engineers, Steffen, Robertson and Kirsten).

4

Research on hydrometeorology

In view of the fact that South Africa's water supply is derived from the atmosphere and is subject to highly variable conditions in the atmosphere, the Commission also suppcrts research that concentrates on those aspects of atmospheric sciences that have an impact on the water resources. In this field of hydrometeorology two of the research projects deal with rainfall stimulation, one with the revision of the temporal and spatial distribution of precipitation statistics, and one with drought occurrences.

RESEARCH ON RAINFALL STIMULATION

Rainfall stimulation research is being carried out in many countries and it has been clearly demonstrated that the microphysical characteristics of clouds change markedly from one area to another. As a result, it is necessary to determine, firstly, what the dominant local rainfall mechanisms are. Only then one can get some idea of whether or not sufficient potential for beneficial modification exists, to warrant the development of a seeding technology that is applicable to the local clouds. All the research that has been done to date, shows that there is no short cut to this process and an investment must be made to understand the microphysical processes of the local clouds.

The Commission supports two research programmes in connection with rainfall stimulation, one at Nelspruit and the other at Bethlehem. A non-profit company, called Company for Research on Atmospheric Water Supply (CRAWS), is under contract to the Commission to conduct the research programme in the Nelspruit area. This company has contracted overseas consulting meteorologists, namely Simpson Weather Associates of Virginia, USA, as the principle investigators who undertake the research, and Cansas International Corporation who operate the field and aviation equipment under the direction of the principal investigators.

The rainfall stimulation research project in the Bethlehem area is being conducted by the Weather Bureau of the Department of Transport. The contribution of the Commission is by way of secondment of some research staff and the Weather Bureau provides the infrastructure and the bulk of the financial support.

RESEARCH ON PRECIPITATION STATISTICS

The research on the revision of temporal and spatial distribution of precipitation statistics in South Africa is being conducted by the Department of Agricultural Engineering of the University of Natal. The main objective is to re-evaluate the distribution of mean

Aero Commander cloud base aircraft and Lear jet aircraft (in the background) for high level cloud penetration.

annual precipitation and other statistics relating to precipitation in the light of updated data.

RESEARCH ON DROUGHT OCCURRENCES

The research project on drought occurrences which was carried out by the Department of Civil Engineering of the University of Stellenbosch, ended during the year. The objectives were to define droughts, to determine the frequency with which droughts of various intensities occur, to develop methods of drought prediction and to determine the pattern of growth and spatial extent of droughts from historical records.

The final report which is being prepared, will present a daily rainfall model for which the parameter values are provided for any area in the country. By using this model the properties of any drought index based on rainfall data are simple to obtain and this approach is very flexible, allowing the user to specify the characteristics of the type of drought that is relevant to his particular problem.

LIST OF RESEARCH PROJECTS ON HYDROMETEOROLOGY

- Research on the artificial stimulation of rainfall at Bethlehem. (Contract with the Department of Transport - Weather Bureau).
- Programme for atmospheric water supply at Nelspruit.(Contract with the Company for Research on Atmospheric Water Suply (CRAWS), subcontracting Simpson Weather Associates and Cansas International Corporation (Pty) Limited).
- Research on drought occurrences (Contract with the University of Stellenbosch, Department of Civil Engineering).
- Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa. (Contract with the University of Natal - Department of Agricultural Engineering).

5 Research on irrigation

Irrigation is responsible for approximately 70 per cent of South Africa's annual water consumption. It therefore stands to reason that even a modest improvement in the efficiency of water use in irrigation will make relatively large volumes of water available for use where needed. The drought again necessitated the reduction of water allocations to many irrigators and re-emphasized the urgency of defining and pursuing a balanced research approach to improving irrigation efficiency at all levels. This alone can minimize negative impacts of future droughts and also regional water shortages which might result from ever-increasing demands on local water resources.

MASTER PLAN FOR IRRIGATION RESEARCH

With a view to developing a dynamic plan for irrigation research, the Coordinating Committee for Irrigation Research in 1982 initiated a series of workshops on various aspects of irrigation research. Workshops held in 1982 dealt with agronomic and soil science aspects and those in 1983 with engineering aspects of water supply, on-farm application and drainage. The final workshop in the series, on socio-economic and ecological research needs relating to irrigation development, is being held early in 1985. During 1984 some consolidation of the recommendations of past workshops took place and various important research categories, requiring concentrated attention, have been identified.

Certain of the categories are already receiving a considerable amount of attention from current research projects funded by the Commission and new projects, initiated in 1984, succeeded to some extent in addressing other categories. The goal in future will be to maintain a desirable balance between attending to research needs in each of the categories identified in the Master Plan, taking into account research being done independently of the Commission by other responsible research organisations.

QUANTITY AND QUALITY OF IRRIGATION RETURN FLOW

Responding to an earlier request by the Department of Water Affairs, the Commission launched and completed two pilot studies intended to precede a possible research programme to investigate, predict and ultimately regulate the impact of drainage water from irrigated lands on the flow and potential salinisation of receiving rivers. The goal of one study, which was carried out by a firm of consulting engineers, in co-operation with the Geography Department of Rhodes University, was to determine to what extent available information would allow engineers to make meaningful first estimates of

irrigation return flow quantity and quality from major irrigated areas.

The other study was carried out by of the Department of Soil Science and Agrometeorology of Natal University. The aim was to report on the status of irrigation return flow modelling in South Africa and to suggest further research required to provide planners with the necessary models.

Results from the two studies, served to guide participants in a workshop held in Pretoria, the purpose of which was to define research needs relating to the salinisation of surface waters in irrigated catchments and to plan a research strategy for the future.

During the year the Commission financially supported 14 irrigation research projects, including five new ones.

NEW RESEARCH PROJECTS RELATING TO IRRIGATION

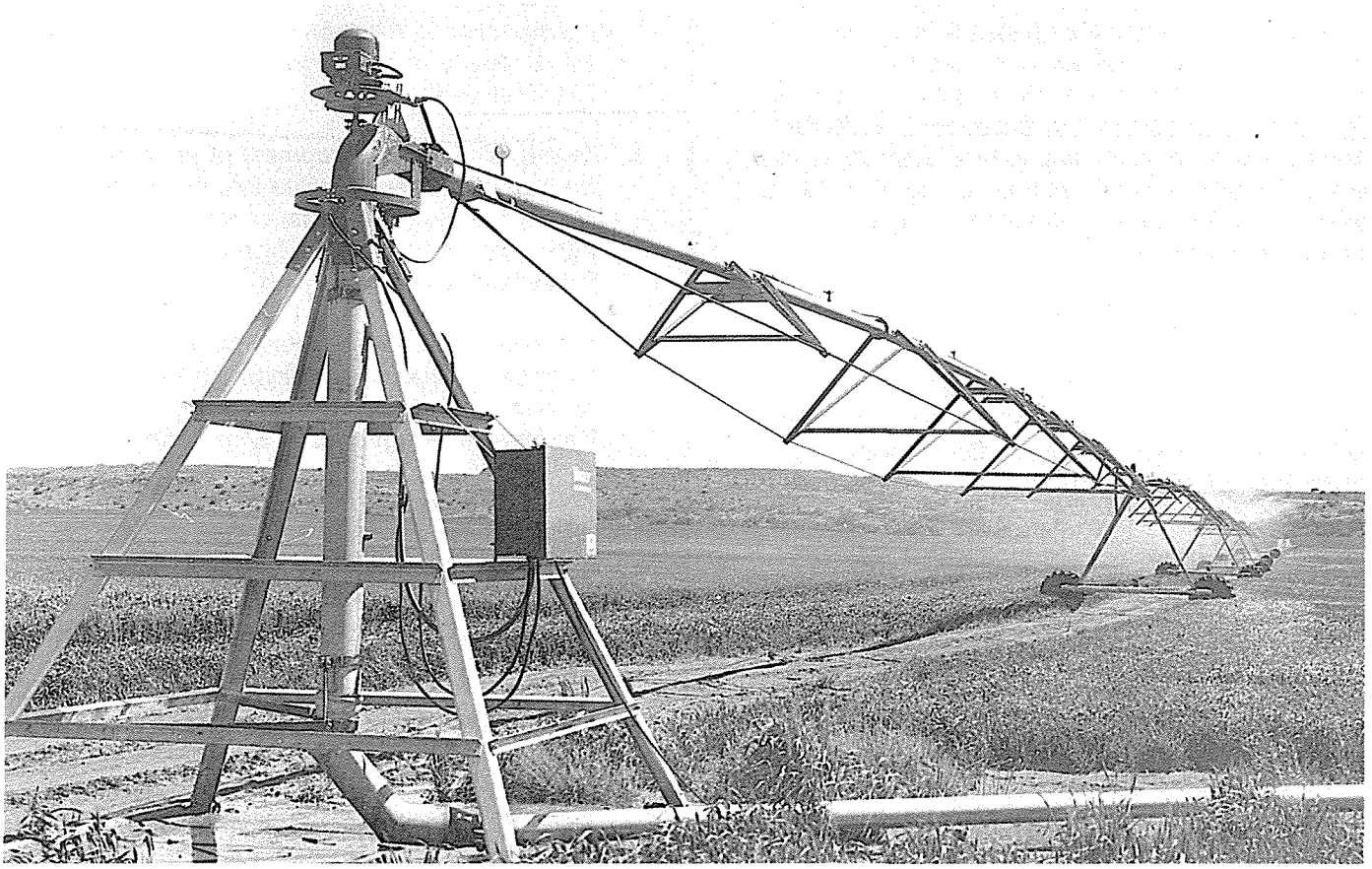
An investigation into water use and productivity of crops under water stress, and the modelling thereof

As a result of a previous project carried out by the Soil and Irrigation Research Institute, certain aspects of crop behaviour under conditions of reduced water supply which require further investigation, were identified. This project consequently aims at quantifying effects of water stress on the development of the crop canopy and root system, which in turn relate to crop water use and yield. Relationships obtained during these and previous investigations will be used to explore different irrigation management options for optimising crop yield and water use under conditions of reduced water supply.

Correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat

The Department of Agrometeorology of the University of the Orange Free State will be investigating the improved use of evaporimeter coefficients (also known as crop factors), which are currently widely employed in the estimation of crop water requirements for both irrigation planning and scheduling purposes. Correction factors will be provided for a set of reference coefficients which will enable more accurate estimates of crop evapotranspiration rates to be made for different climatic areas and growing conditions.

Apparatus used for studying atmospheric, soil and plant effects on crop water stress.



Restriction of water loss under centre pivot irrigation is the object of a new Water Research Commission project.

Research on the quantification and restriction of water losses under centre pivot irrigation systems

Centre pivot irrigation systems have many potential advantages, including ease of management and improved water use efficiency. For these reasons and others, they are rapidly gaining in popularity. In practice, however, many of these potential benefits are often not realized. The Department of Agricultural Engineering at the University of the Orange Free State is, therefore, in terms of a contract with the Commission, investigating the design and use of centre pivot irrigation systems. The objectives are to quantify water losses due to evaporation, interception and runoff; to identify factors which affect these losses; and to provide guidelines for minimizing them.

Research on the practical scheduling of irrigation in the Northern Transvaal

Intensified irrigation research is producing a flow of information on crop water requirements and irrigation scheduling which is, however, slow to find application in irrigation practice. For this reason the Department of Plant Production of the University of the North has put together a team of investigators representing the disciplines of agronomy, soil science and agricultural economics, who, in co-operation with the local farmers' agronomy study group, will investigate on-farm irrigation problems and attempt to provide solutions. More specifically, the aims of this project are to investigate the applicability of irrigation scheduling techniques at farm level; to promote the acceptance of scientific irrigation management methods by involving farmers in the research; and to give special attention to obtaining irrigation scheduling criteria for the mechanized irrigation systems which are rapidly gaining in importance in the area.

Research on the use of the soil/root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil/plant/atmosphere systems

In a previous research project the Department of Soil Science of the University of the Orange Free State established a mathematical relationship for the potential soil water supply to root systems of

crops. The ratio of potential water supply to actual water uptake by roots was generally high under optimal soil water conditions, but declined to a constant threshold value at the onset of water stress. The objective of this follow-up project is to further develop these concepts and extend them to a wider range of crops and soils with a view to their use in refining irrigation system design and irrigation scheduling procedures.

VISITING SCIENTIST

Dr R J Wagenet, a soil physical chemist from Cornell University in the United States, visited South Africa during September as the Commission's consultant on irrigation return flow research and modelling. He also made a major contribution to the workshop on the subject of irrigation return flow, referred to earlier.

LIST OF RESEARCH PROJECTS ON IRRIGATION

- Research on the profile available water capacity of soils. (Contract with the University of Fort Hare - Department of Soil Science).

- Research on a wheat irrigation scheduling service for the Free State region. (Contract with the University of the Orange Free State - Department of Agrometeorology).

- Research on the water requirements of certain agronomic and vegetable crops. (Contract with the University of Pretoria - Department of Plant Production).

- Research on the effect of different times and intensities of internal plant moisture stress on photosynthesis, respiration and water use efficiency of certain agronomic crops. (Contract with the University of the Orange Free State - Department of Agronomy/Horticulture).

- Evapotranspiration and water use studies by means of weighing lysimeters: Evapotranspiration as a function of soil, plant and atmospheric factors. (Contract withthe Department of Agriculture and Water Supply - Soil and Irrigation Research Institute).

- Development of the required apparatus and programmes for the monitoring and management of irrigation systems. (Contract with the University of Stellenbosch - Department of Civil Engineering).

- Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems. (Contract with a firm of consulting engineers, Murray, Biesenbach and Badenhorst).

- A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa. (Contract with the University of Natal - Department of Agricultural Engineering).

- An investigation into the condition of soils irrigated over a protracted period and an evaluation of applicable selection criteria, and reclamation and control measures. (Contract with the Potchefstroom University for CHE - Department of Pedology).

- Research on the use of the soil-root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil-plant-atmosphere systems. (Contract with the University of the Orange Free State - Department of Soil Science.)

- Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat (Contract with the University of the Orange Free State - Department of Agrometeorology).

- Research on the practical scheduling of irrigation in the Northern Transvaal. (Contract with the University of the North - Department of Crop Production).

- Research on the quantification and limitation of water losses associated with centre pivot irrigation systems. (Contract with the University of the Orange Free State - Department of Agricultural Engineering in collaboration with the Department of Agronomy).

- Investigation into water use and productivity of crops under conditions of water stress and the modelling thereof. (Contract with the Department of Agriculture and Water Supply - Soil and Irrigation Research Institute).

6 Research on mineralisation

Mineralisation is a serious problem affecting South Africa's water resources, as it endangers the beneficial use of these limited resources. For many years the Commission has supported research with a view to establishing the necessary expertise to solve problems with respect to increasing mineral pollutant or salt loads reaching the natural water resources.

The Commission currently supports several research projects dealing directly or indirectly with mineralisation and some of these projects are being dealt with in other chapters (e.g. desalination). In this chapter reference is made to mineralisation in the Eastern and South-Western Cape and in the Pretoria-Witwatersrand-Vaal Triangle (PWV) and also to the auto-analysis of sulphate and alkalinity in water. The latter two substances play a major role in the increase of the salinity of surface waters.

MINERALISATION IN THE EASTERN AND SOUTH-WESTERN CAPE

Serious problems are experienced with mineralisation in the Great Fish, Sundays, Berg and Breede Rivers and the Commission is sponsoring two projects in this regard. These projects are aimed at researching the causes and effects of salt mobilisation both from the surface and within the various soil zones.

The Department of Geography at Rhodes University is carrying out integrated studies of the generation of runoff, solutes and sediments in a tributary catchment of the Great Fish River. The primary objective is to collect continuous data on the principal processes associated with the mineralisation of runoff in the semi-arid Ecca research catchments near Grahamstown with a view to developing and testing new models to meet future application requirements.

The second project is being carried out by the Geology Department of the University of Stellenbosch in collaboration with the Department of Water Affairs. The focus is on the salt mobilisation processes within the soil zone and the flow paths of irrigation water under varying conditions in the Poesjenels River catchment in the Breede River Valley. The overall objective is to develop practical mathematical models to study the interaction of the components of an irrigated river system and to simulate the effects of measures for the control of mineralisation.

MINERALISATION IN THE PWV AREA

There has been a marked increase in the salt load

of water in the Vaal Barrage during the last few years and the Commission is actively involved in research to combat the detrimental effect of mineralisation in the PWV area.

One project researches the contribution of mine dumps to the mineralisation of the Vaal Barrage and is carried out in terms of a tripartite agreement with the Department of Water Affairs and a firm of consulting engineers, Steffen, Robertson and Kirsten. In a previous study on water pollution and reuse in the PWV area which was also sponsored by the Commission, it was found that more than fifty per cent of the salt load reaching the Vaal Barrage originated from non-point sources. The relative contribution of stormwater and mine dump leachate to the salt load is, however, unknown.

Another project deals with the inhibition of bacterial oxidation of pyrite and the formation of acid mine waters. This research is carried out in terms of a tripartite agreement with the University of Stellenbosch (Department of Microbiology and Virology and the Institute for Polymer Science) and the Chamber of Mines. The formation of acid mine waters is a problem which occurs widely in coal and gold mining areas and leads to serious mineralisation of water resources. The problem is caused by the natural oxidation of pyrite which is accelerated by the action of certain bacteria.

THE AUTO-ANALYSIS OF SULPHATE AND ALKALINITY IN WATER

Sulphate and alkalinity are important constituents relating to water quality and current methods for analysing these are not satisfactory. In view of this the Department of Chemistry of the University of Pretoria undertook research to improve the auto-analysis of sulphate and alkalinity. The project was successfully completed and methods for the auto-analysis of these two substances in potable, surface, ground and wastewater were developed.

COST IMPLICATIONS AS A RESULT OF AN INCREASE IN THE SALT CONTENT OF THE VAAL RIVER

Since 1955 there has been a continuous increase in the salt content of the Vaal River, stretching from the Vaal Dam to the confluence with the Orange River. In order to supply the PWV area with a good quality water, the Rand Water Board has to abstract more water from the Vaal Dam with its better water quality (currently approximately two thirds of its need).

The Water Research Commission initiated a study in 1976 into the sources and loads of mineral salts entering the Vaal Barrage. A desk study also revealed that should the salt content of the water supplied to the PWV complex rise from the present 300 mg/l to levels of 500 mg/l and 800 mg/l (concentrations already occurring in the Vaal Barrage for short periods), the additional costs for all consumers could reach $R76x10^6$ and $R140x10^6$ per annum respectively.

The Department of Water Affairs is greatly alarmed about the costs and deterioration in water quality and has requested the Commission to determine these costs in greater depth. The Klerksdorp and OFS Goldfields area will also be included in this investigation since they receive water of a poorer quality than the PWV complex. This follow-up study will be completed during 1985. Indications so far are that cost estimates will be much higher that those established in 1980.

VISITING SCIENTIST

As mentioned in Chapter 5, Dr R J Wagenet from Cornell University in the USA, visited South Africa as a consultant to the Commission with respect to irrigation return flow. During his visits to the mineralisation projects in the Eastern and South Western Cape and his attendance at a workshop on mineralisation management options, he was able to make a significant contribution to the solving of problems in this regard.

LIST OF RESEARCH PROJECTS ON MINERALISATION

- Research on integrated studies of the generation of runoff, solutes and sediment in the tributary catchments of the Great Fish River. (Contract with Rhodes University - Department of Geography).
- Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralisation. (Contract with the Department of Environment Affairs - Division of Geohydrology, and the University of Stellenbosch - Department of Geology).
- Research on the contribution of mine dumps to mineral pollution in the Vaal Barrage. (Contract with the Department of Environment Affairs, and a firm of consulting engineers, Steffen, Robertson and Kirsten).
- Research on the inhibition of bacterial oxidation of pyrite and concomitant acid mine water. (Contract with the Chamber of Mines and the University of Stellenbosch - Department of Microbiology and Virology, and the Institute for Polymer Science).
- Research on the auto-analysis of sulphate and alkalinity in water. (Contract with the University of Pretoria - Department of Chemistry).

7

Research on eutrophication

Eutrophication, i.e. the enrichment of water with plant nutrients (mainly nitrogen compounds and phosphates), is one of the best-known symptoms of pollution of the water environment. This is true because the plant nutrients give rise to an excessive growth of algae and nuisance aquatic plants, thereby detrimentally affecting the beneficial utilization of the Republic's water resources.

The Commission has been sponsoring research for many years to combat eutrophication. Firstly, the research concentrates on the elimination of plant nutrients at source and this is reported on in Chapter 8. Secondly, research is directed towards the development of methods for the management of the water environment in order to minimise or eliminate the influence of eutrophication. In this regard, the Commission is currently involved in various activities, including the sponsoring of three research projects.

THE IMPACT OF PHOSPHATE LIMITATION ON THE TROPHIC STATUS OF IMPOUNDMENTS

This project which was carried out jointly by the Institute for Environmental Sciences of the University of the Orange Free State and the Hydrological Research Institute of the Department of Water Affairs, was successfully completed during the year. The decision to introduce a phosphate standard in sensitive catchments, was based on the best available technology for phosphate removal and without an extensive quantitative evaluation of the impact such a standard may have on the trophic status of impoundments. When the authorities involved requested that an evaluation of the impact of phosphate control measures should be made, this tripartite research agreement was entered into.

The results have indicated the extent to which phosphate limitation in effluents will combat eutrophication. For example, various dams have been classified where no phosphate standards up to the year 2 000 will be necessary in their catchments, while control measures might be required in catchments of various other dams. Although highly eutrophic conditions were predicted in certain dams (e.g. Rietvlei, Hartbeespoort, Roodeplaat, etc.), they are expected to show a marked response to the phosphate standard. Others like the Vaal Barrage and Bon Accord receive such large phosphate loads that more stringent standards would be required. The methodology developed has already been applied in-house by the Department of Water Affairs to assist in evaluating actions relating to the implementation of the effluent phosphate standard.

RESEARCH ON EUTROPHICATION IN THE HARTBEESPOORT DAM

This project forms part of an extensive research programme on eutrophication in the Hartbeespoort Dam, being undertaken by the National Institute for Water Research in close collaboration with the Department of Water Affairs, the Committee for Inland Water Ecosystems of the CSIR and the Commission. The main objective of the project is to develop management strategies for eutrophic impoundments on the basis of a quantitative knowledge of their ecological performance, with special attention to the impact of the 1 mg/l phosphate standard for effluents, as well as artificial destratification and aeration as well as several biological management possibilities.

RESEARCH ON THE INHIBITION OF ALGAL GROWTH BY WATER HYACINTH

The Water Research Commission has entered into a new contract with the University of Natal in terms of which its Department of Botany will investigate the potential use of water hyacinth for the improvement of water quality. The main objective of the study will be to establish the mechanisms and processes associated with water hyacinth inhibition of algal growth as experienced in the Shongweni Dam near Durban. The interest in the role of water hyacinth was stimulated during recent years, when it was noted at the Shongweni Dam and also the Hartbeespoort Dam that the occurrence of high concentrations of algae, normally associated with excessive eutrophication, was dramatically reduced when water hyacinth became dominant in these dams. The results would allow the acquisition of information on the possible practical exploitation of the phenomenon in other water supply impoundments in South Africa.

INLAND WATER ECOSYSTEMS

The Commission again made a R100 000 block grant to the CSIR's Committee for Inland Water Ecosystems for 1984. Various programmes sponsored by this committee were completed this year and the final reports were distributed to interested parties. The completed projects include studies on the Midmar, P K le Roux and Hartbeespoort Dam.

LIST OF RESEARCH PROJECTS ON EUTROPHICATION

- Eutrophication research in the Hartbeespoort Dam. (Contract with the CSIR - National Institute for Water Research).
- Evaluation of the impact of phosphate limitation on the trophic status of South African impoundments. (Contract with the Department of Environment Affairs - Hydrological Research Institute, and with the University of the Orange Free State - Institute for Environmental Sciences).
- Research on the inhibition of algal growth by water hyacinth. (Contract with the University of Natal - Department of Botany).

Harvesting of water hyacinths in Shongweni Dam where research on the inhibition of algal growth by water hyacinth is being undertaken.

8

Research on the treatment of municipal wastewater

Since its inception the Commission has been working in close collaboration with local authorities and sponsors various research activities which are not only of direct importance to this sector, but also to the country as a whole. Local authorities have a specific responsibility regarding the prevention of pollution by domestic sewage and industrial effluents, as well as by solid and toxic wastes and sludges.In this regard practical and cost-effective technology is required and this is being developed by means of the various research projects.

The Commission's research related to local authorities covers a broad spectrum, but in this chapter the focus is on the research on the treatment of municipal wastewater. The Commission currently sponsors five research projects in this regard, including three which commenced during 1984.

NUTRIENT REMOVAL IN THE ACTIVATED SLUDGE PROCESS

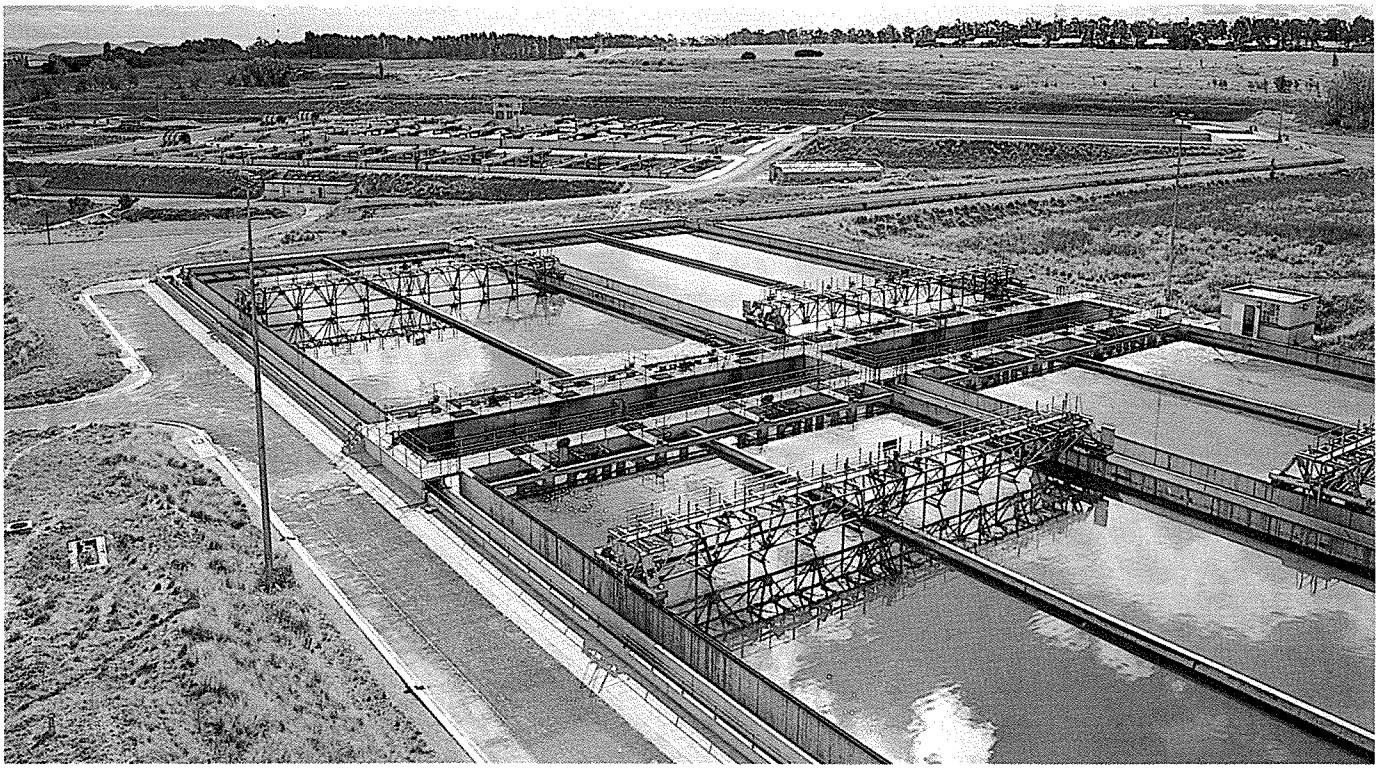
The research by the City Council of Johannesburg on the enhancement of biological phosphate removal from sewage by altering process feed composition, has already resulted in major advances in this regard. The technique offers the possibility of upgrading existing biological phosphate removing works which are currently not successful in meeting the effluent phosphate standard.

Although the knowledge on biological phosphate removal has progressed dramatically, it is not possible with the present state of art to consistently remove phosphate to the 1 mg/l level prescribed by the standard which will be enforced as from August 1985. This means that at times supplementary chemical phosphate removal will be necessary. It is, therefore, important to continue research on biological phosphate removal in order to upgrade the present technology, also because of the fact that an even more stringent standard than 1mg/l could be introduced in certain sensitive catchments. In view of this the Commission has negotiated during the year with the Department of Civil Engineering of the University of Cape Town to further extend its research and a contract for research on biological excess phosphate removal was signed. The University will closely liaise with other research groups working on Commission projects related to nutrient removal in the activated sludge process.

NUTRIENT REMOVAL FROM BIOLOGICAL FILTER EFFLUENTS

A new project on the evaluation and optimization of full-scale chemical phosphate removal in biological filter sewage purification processes commenced

Surface aerators at the Northern Sewage Purification Works, Johannesburg, where research on biological phosphate removal is being carried out.



Primary settling tanks at the Northern Sewage Purification Works, Johannesburg.

during the year. This project will be carried out in terms of a tripartite agreement involving the Boksburg Municipality and a firm of consulting engineers, Scott and De Waal. It is undertaken to meet the needs identified in a previous project on phosphate and nitrogen removal in biological filter sewage purification processes.

The main emphasis in this new project will be to establish criteria for optimal use of chemicals for the removal of phosphates from biological filter effluents. Special attention is to be focused on developing criteria for optimising dosing strategies and for predicting increases in sludge production as a result of the addition of the chemicals. The information will be used for the upgrading of existing works as well as for the design of new works.

SLUDGE BULKING AND BIOLOGICAL FOAM IN THE ACTIVATED SLUDGE PROCESS.

A current project in connection with the activated sludge process by the Department of Civil Engineering, University of Cape Town, has identified sludge bulking and foaming as major problems experienced in sewage works. This causes problems concerning the operation of the works, deterioration in the effluent quality and ultimately pollution of the water environment. A manual on sludge bulking and foaming control will be compiled by Prof D Jenkins of the University of California, Berkeley, USA, a consultant for the Commission.

In terms of a new contract with the University of Pretoria, their Division of Water Utilization Engineering, Department of Chemical Engineering, will carry out research on biological foam in the activated sludge process. Research will concentrate on the reasons for foam formation and on those aspects in the design and operation of activated sludge works which could minimize or eliminate foaming.

VISITING SCIENTISTS

Dr M Richard and Prof D Jenkins of the University of California, Berkeley, USA, visited South Africa at the invitation of the Commission to advise on filamentous micro-organism identification and sludge bulking control. They presented specialized lectures and courses and made several visits to various plants and research centres in South Africa. Their expertise contributed greatly to a better understanding of sludge bulking and foaming and also stimulated the abovementioned research projects in this regard.

MEETINGS WITH REGIONAL BRANCHES OF THE UNITED MUNICIPAL EXECUTIVE

As a result of a need expressed by the United Municipal Executive and many of its members, the Commission in collaboration with the United Municipal Executive, the Department of Water Affairs and the National Institute for Water Research, arranged a number of information transfer meetings in Roodepoort, Cape Town and East London. The purpose was to inform members of the background and implications of the effluent phosphate standard, available phosphate removal technology, operator training needs and operational problems to be expected at nutrient removal works.

LIST OF RESEARCH PROJECTS ON THE TREATMENT OF MUNICIPAL WASTEWATER

- Research on enhancement of biological phosphate removal from sewage by altering process feed composition. (Contract with the City Council of Johannesburg).
- Research on biological excess phosphate removal. (Contract with the University of Cape Town - Department of Civil Engineering).
- Research on the evaluation and optimisation of full-scale chemical phosphate removal in biological sewage treatment processes. (Contract with the City Council of Boksburg and a firm of consulting engineers, Scott and De Waal).
- Research on sludge bulking in the activated sludge process. (Contract with the University of Cape Town - Department of Civil Engineering).
- Research on biological foam in the activated sludge process. (Contract with the University of Pretoria - Division of Water Utilization Engineering, Department of Chemical Engineering).

9

Research on the treatment and disposal of sewage sludge

Sewage sludge, resulting from the treatment of wastewater, cannot be disposed of without undergoing some or other treatment. Without treatment it is a source of pollution to surface and underground water, a health hazard and will give rise to odour and other aesthetic problems.

Sewage sludge treatment and disposal in South Africa has been practised for as long as sewage has been treated. The problems associated with sludge management have, however, intensified in recent years. This is because quantities of sludge have increased, quality of sludge has deteriorated due to more advanced sewage treatment processes, and disposal options for sludge have become more and more restricted due to the public health considerations.

The Commission's research in this area covers a broad spectrum of activities and during the year six research projects have been sponsored. The main aim with the research is to provide local authorities with the appropriate technology for the treatment of sewage sludge in order to render it safe for disposal or utilisation in agriculture and horticulture.

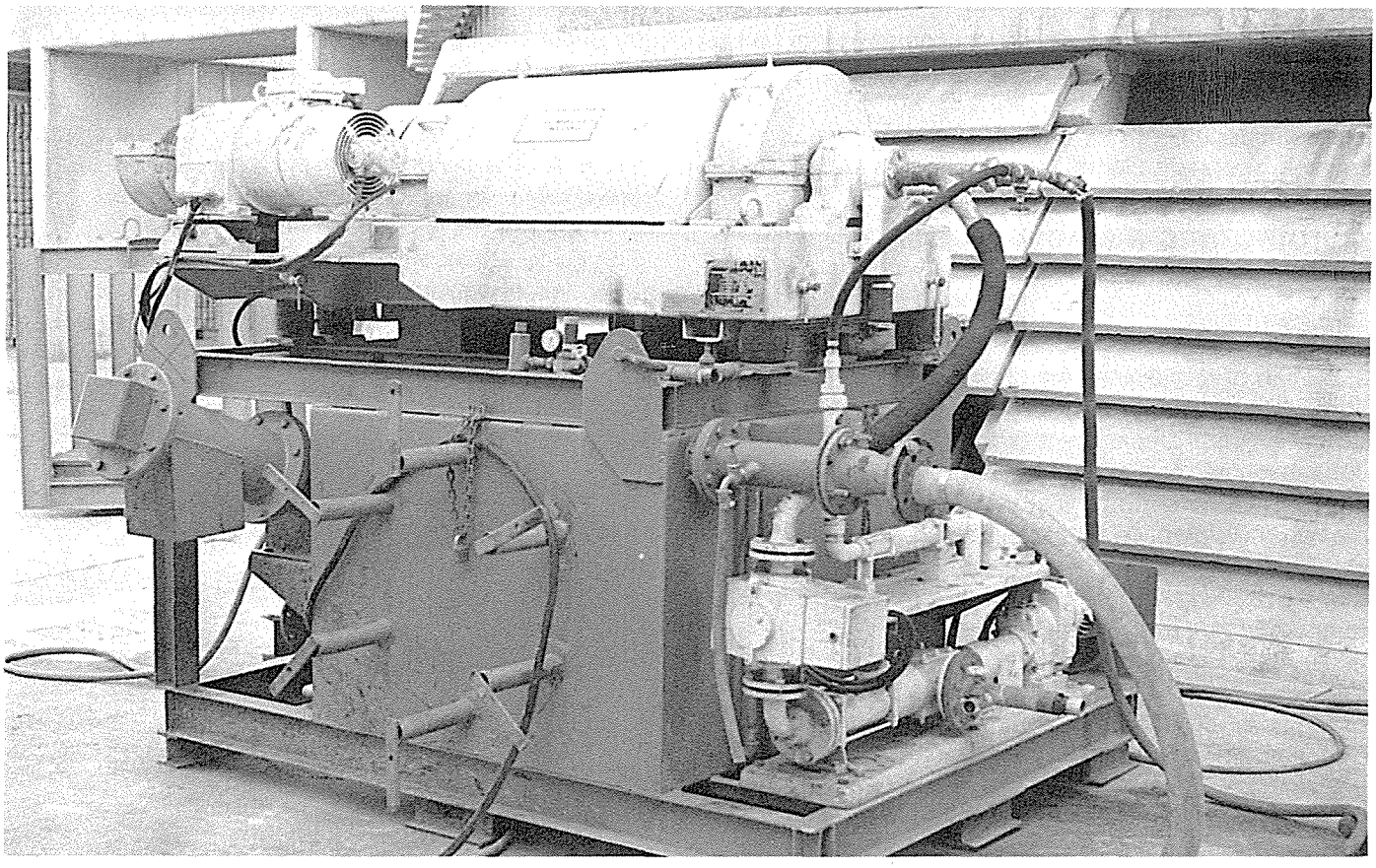
Three of the research projects relate to the disinfection and stabilisation of sludge. Two of these are ongoing research projects and deal with sludge pasteurisation at fullscale and forced aeration stabilisation of sludge. In the former, which is carried out by the City Council of Cape Town, energy in the form of heat is applied to the sludge to disinfect it either before or after it is stabilised by conventional anaerobic digestion. In the case of research on forced aeration stabilisation of sludge by the National Institute for Water Research, heat is generated within the process itself, thereby disinfecting the sludge during the process of stabilisation. The third project which involved autothermal (i.e. selfheating) aerobic stabilisation and disinfection of sludge was completed during the year and is described later.

Two other projects were also completed during the year. These were sludge dewatering and sludge characterization. A new project commenced during the year and relates to marine disposal of wastewater.

COMPLETED PROJECTS

Sludge dewatering and treatment of sludge liquors

The objectives of the research undertaken by the City Engineer's Department of the City Council of Port Elizabeth, were primarily to investigate the suitability of various types of mechanical dewatering plant for the processing of raw and conditioned sludge, the economics of the process, the ability to



An example of a centrifuge used for sludge dewatering.

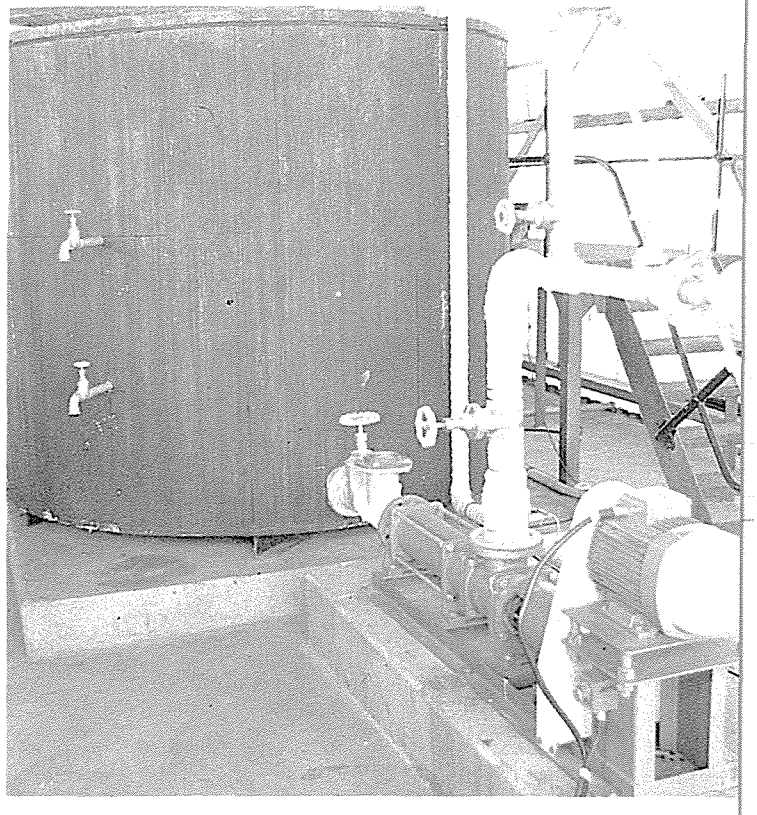
produce a sludge cake of high solids content and the quality and costs of treating process liquors.

The results contribute substantially towards a better understanding of the process of dewatering, and provide several alternative ways to dewater sludge under South African conditions. The final report is expected to be a extremely valuable and useful document for all professionals engaged in the design and operation of sewage treatment plants.

The characterisation of sludge

Research in this regard was carried out by the National Institute for Water Research. The primary aim of this project was to identify those sludge characteristics that are best suited to evaluate the treatability of various sludges and which may be used to assess the effectiveness of various treatment processes.

The study has served to highlight the complexity of sewage sludge systems, especially in the prediction of sludge dewaterability. The results contribute to a better understanding of some of the basic characteristics of sludge and of techniques for its characterisation. However, much more research still needs to be done.



The pilot scale autothermal aerobic digester, used in the research by the City Council of Johannesburg.

The final report and the laboratory manual for the determination of inorganic chemical contaminants and nutrients in sewage sludges, produced by the National Institute for Water Research, are expected to be useful documents for designers and owners of sewage treatment plants.

Autothermic aerobic digestion of sludge

Due to the potential health risk associated with the utilisation of non-disinfected sludge in agriculture and horticulture, this research project, carried out by the City Engineer's Department of the City Council of Johannesburg, had as its aim a study of the effectiveness of autothermal aerobic digestion as a means of disinfection and stabilisation or partial stabilisation of sludge. (Autothermal relates to self heating of sludge to the thermophilic range of temperatures, i.e. above 43°C).

The work was done at pilot scale and temperatures of the order of 60°C were commonly achieved at retention times as low as one day. Interest in the process has focussed on its use as a disinfection and partial stabilisation process and not as a process for the complete stabilisation of sludge. A high degree of pathogenic bacteria destruction was achieved by the process at retention times of one day.

Further research is, however, necessary to improve the viability of the process at full-scale under South African conditions.

RESEARCH ON MARINE DISPOSAL OF WASTEWATER

A new contract was entered into with the CSIR in terms of which their National Research Institute for Oceanology will undertake research on the marine disposal of wastewater. The project consists of two parts, the first of which involves prototype measurements of dilution of effluent discharges from an existing sea outfall sewer. This investigation will be undertaken at the Camps Bay Sea Outfall in conjunction with the City Council of Cape Town. In the second place, they will prepare specialised sections of a guide for the design of marine disposal systems. The investigation at Camps Bay is a prerequisite for the preparation of the guide.

The guide will incorporate the most recent information available, including the findings of the work undertaken off the coast of Durban in terms of a previous contract with the Durban City Council for monitoring the effects of the discharge of sewage to sea.

LIST OF RESEARCH PROJECTS ON THE TREATMENT AND DISPOSAL OF SEWAGE SLUDGE

- Sludge dewatering and the treatment of sludge liquors. (Contract with the City Council of Port Elizabeth).
- Autothermic aerobic digestion of sludge. (Contract with the City Council of Johannesburg).
- Pasteurization and thermophilic anaerobic digestion of sludge. (Contract with the City Council of Cape Town).
- Research into the characterisation of sludge. (Contract with the CSIR - National Institute for Water Research).
- Forced aeration composting of sewage sludge; prototype study. (Contract with the CSIR - National Institute for Water Research).
- Research on marine disposal of wastewaters: A guide for the marine disposal of wastewaters. (Contract with the CSIR - National Research Institute for Oceanology).

10

Research on the treatment of industrial effluents

The industrial sector is an important consumer of water in South Africa. A recent survey has indicated, for example, that 23% of the Rand Water Board's supply is supplied to industry (excluding mining). In order to maintain a healthy economic growth rate, the industrial sector will steadily increase its demand on the available water supplies of the Republic. This sector, therefore, has an important responsibility with respect to the optimisation of water consumption. Another responsibility is effective purification of effluents to prevent pollution of the water environment. On the whole it is important that a short, medium and long term strategy be developed to ensure that industrial water utilisation is optimised.

Since its inception the Commission has sponsored various research programmes with respect to water management and effluent treatment in the industrial sector. Special attention has been paid or is still being paid to the textile, fruit and vegetable processing, tannery, fish and meat industries. Particular attention is also being directed at a comprehensive national survey of industrial water and wastewater with the main objective of developing a strategy for the optimal utilization of water in industry.

During the year the Commission supported ten research projects. Three of these are ongoing projects, three terminated during the year and four new projects were commenced.

ONGOING PROJECTS

Scouring and bleaching effluents in the textile industry

This investigation has indicated that considerable quantities of water can be saved by applying the cascade principle. According to this principle fresh water is supplied to the process which requires the highest quality water while the process with the lowest quality requirements finds itself at the end of the supply line. The application of this principle together with electrochemical oxidation can reclaim as much as 80% of the process water.

Industrial effluents with high salinity and organic content

Problems are experienced in the treatment and disposal of industrial effluents with high salinity and high organic content, *viz.* effluents resulting from the pulp and paper industry, starch manufacture and tanneries. Processes such as reverse osmosis, ultrafiltration, electrodialysis, ion exchange, adsorption, chemical oxidation and evaporation, have been evaluated as unit processes for the treatment of these effluents. Membrane processes have generally been found to be the most appropriate for the removal of both organic and inorganic components from these effluents.

Water and wastewater management in the meat processing industry

Pilot studies at a red meat abattoir have indicated that by using screening, dissolved air flotation and membrane techniques, up to 80% of the process water can be reused. These studies will be pursued at a chicken abattoir in 1985. A survey of water consumption at all large abattoirs in the country has been carried out with the aim of determining the applicability of the treatment processes at each one.

PROJECTS COMPLETED DURING THE YEAR

The treatment of wool scouring effluent

Wool scouring effluents are one of the most difficult industrial effluents to treat because of the high organic content as well as the presence of dirt, wool grease and suint. An ultrafiltration evaporation process has been developed which results in water saving of 85% and a pilot-scale plant has been in operation to develop design criteria for full-scale application.

Treatment of effluents from fish processing factories

The most important result from this investigation is that the pollution load from fish factories on the marine environment can be reduced drastically by separating the blood water and canning factory effluent and by treating these separately with ultrafiltration and dissolved air flotation.

Investigations into the water management and effluent treatment in the processing of pulp and paper, metals, fermentation and pharmaceutical products

For each of these industries literature surveys were undertaken, questionnaires sent out and factories visited in order to collect data relating to water consumption, quantity and types of chemicals used and volumes of effluent produced. This information was used to identify problems experienced by these industries and attention was paid to methods and techniques for improved water and effluent management as well as the treatment of effluents.

PROJECTS WHICH COMMENCED DURING THE YEAR

The development of wastewater pretreatment techniques: cross-flow microfiltration

The technique of cross-flow microfiltration can be applied extensively for the treatment of industrial effluents and in the pretreatment for the desalination of brackish and sea water. Tests with a semi-technical scale unit have indicated that a variety of industrial effluents can be purified successfully and economically. The process can also be used for the thickening of sludges resulting from water and sewage treatment processes.

Water and effluent management for the pulp and paper industry

The effluent from pulp manufacture contains high concentrations of organic material and salts and in the case of the sulfite pulp process, the effluent also contains a considerable amount of lignosulfonates which cause aesthetic problems, especially when discharged to sea.

By using ultrafiltration and reverse osmosis it is possible to reclaim the lignosulfonates as by-products and also to effect considerable water savings through water reuse. Research is continuing in this regard.

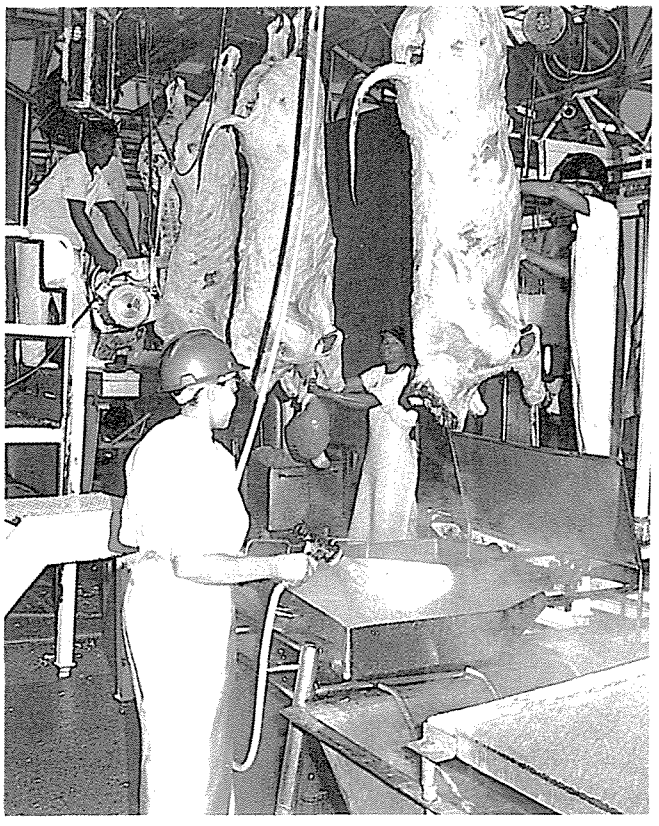
Evaluation of the technical performance of a full-scale plant for the treatment of textile dyehouse effluent

Arising from research by the Pollution Research Group of the University of Natal on behalf of the Commission, a full-scale plant for the treatment of textile dyehouse effluent was erected at a textile factory on the South Coast. The process primarily employs reverse osmosis and evaporation and 95% of the water is reclaimed. The objective of the project is to evaluate the plant's performance over a long period in order to verify design criteria obtained from pilot plant studies.

National industrial water and wastewater survey

The main objective of this survey is to achieve optimal utilisation of water by industry. A data base will be developed by making use of information obtained from industry which relates to the use of water, reuse or disposal of effluents, water pollution

A survey team involved in the national industrial water and wastewater survey.



The Commission supports research on water and wastewater management in the meat processing industry.

and disposal of solid wastes in order to formulate a national strategy for industrial water and wastewater management. The specific water intake (volume of water intake per unit product produced) and specific pollution load (quantity of pollution per unit product produced) will be determined for industries and national averages will be derived.

The survey will be carried out in various phases by a firm of consulting engineers in collaboration with the Department of Water Affairs.

LIST OF RESEARCH PROJECTS ON THE TREATMENT OF INDUSTRIAL EFFLUENTS

- Research on water management and effluent treatment in the textile industry: Wool scouring effluent treatment. (Contract with the University of Natal - Pollution Research Group, Department of Chemical Engineering).

- An investigation into the water and effluent management problems in the fishing industry: Effluent handling at fish processing factories. (Contract with a firm of consulting engineers, Binnie and Partners).

- Investigations into the water management and effluent treatment in the processing of (i) pulp and paper; (ii) metals; (iii) fermentation products; and (iv) pharmaceutical products. (Contract with the University of Natal - Pollution Research Group, Department of Chemical Engineering).

- Water management and effluent treatment in the textile industry; scouring and bleaching effluents. (Contract with the University of Natal, Pollution Research Group, Department of Chemical Engineering).

- Research into the treatment of industrial effluents with high salinity and organic contents. (Contract with the University of Natal, Pollution Research Group, Department of Chemical Engineering).

- Research on and an investigation into the use of physical chemical techniques for water and wastewater management in the meat processing industry. (Contract with a firm of consulting engineers, Binnie and Partners).

- A national industrial water and wastewater survey. (Contract with a firm of consulting engineers, Binnie and Partners).

- Research into the development of wastewater pretreatment techniques : cross-flow microfiltration. (Contract with the University of Natal - Pollution Research Group, Department of Chemical Engineering).

- Water and effluent management in the pulp and paper industry. (Contract with SAICOR).

- The technical performance evaluation of a full-scale industrial wastewater treatment plant: Textile dyehouse effluent treatment by hyperfiltration and evaporation. (Contract with Kluk Textile Industries (Pty) Ltd T/A MYM Textiles and the University of Natal).

11

Research on water purification and reuse

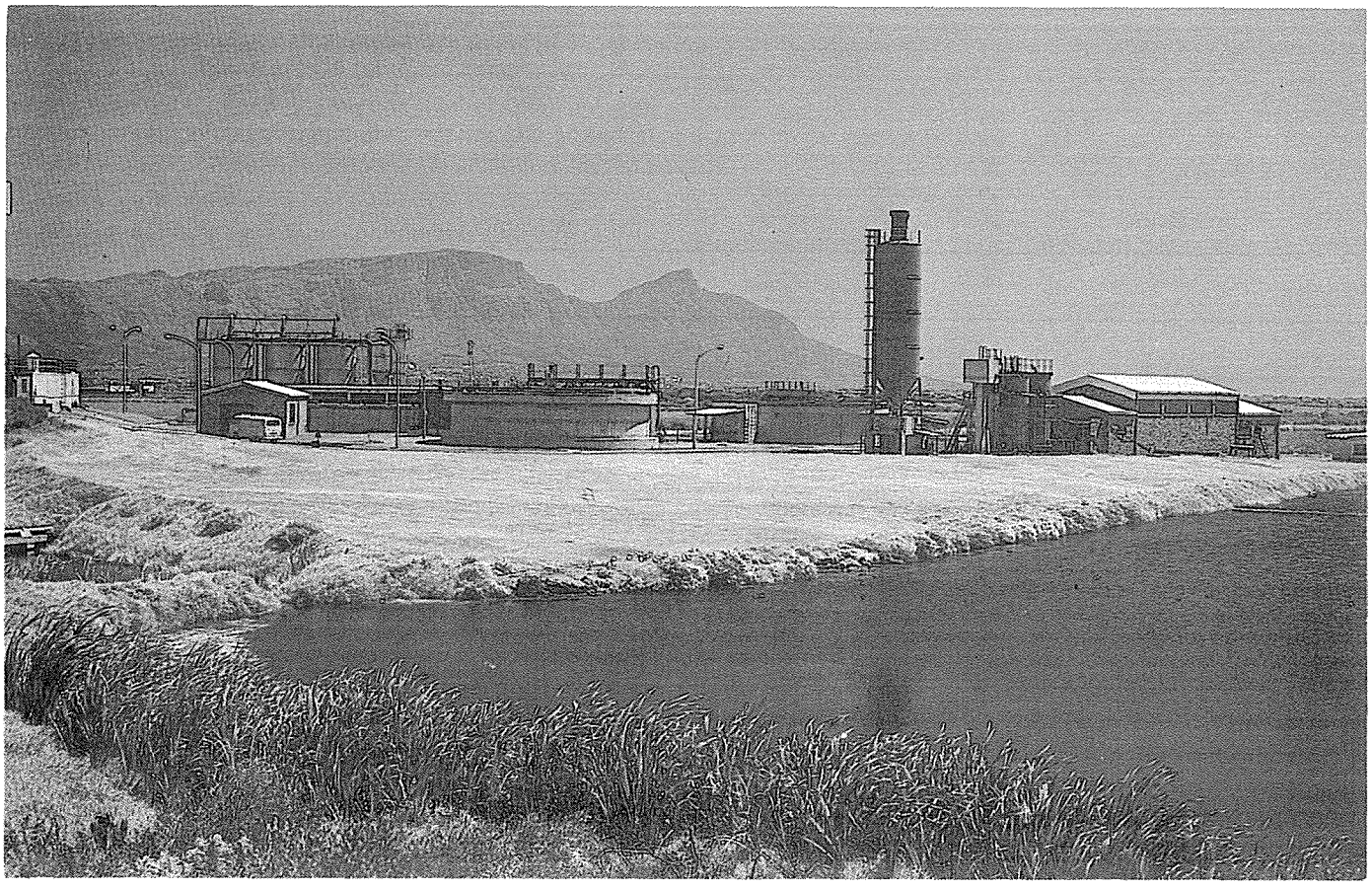
The reuse of water in South Africa can contribute significantly to the better utilisation of the limited available water resources. Reuse can be implemented in various ways, including recycling of water in industry, indirect reuse of purified effluents discharged to rivers and streams, and direct reuse by means of the reclamation of water from effluents (e.g. for use in industries or for potable use as in Windhoek, South West Africa).

The Commission supports various research projects to determine the feasibility of water reclamation from purified sewage and the unrestricted reuse thereof. These studies have adequately demonstrated the technological feasibility of water reclamation and have also shown that, since the commissioning of the Windhoek plant in 1969, no microbiological health hazards have been experienced. It is difficult, however, to reply satisfactorily to the question of whether the long-term use of reclaimed water may have detrimental effects on the consumer, mainly because the studies in this regard have not yet been carried out for a long enough period of time.

The general view is that until such time as the long-term studies have provided the necessary answers, present technology be used for either the complete removal of undesirable substances, or keeping concentrations at such low levels that it is unlikely that they will cause any detrimental effects. There is also sufficient proof that pathogenic micro-organisms and viruses are either removed or killed through disinfection, with the result that these organisms will not cause diseases in man. The presence of synthetic compounds (e.g. pesticides) could create problems but by using activated carbon or membrane processes, they can either be removed or the concentration so reduced that detrimental effects are unlikely.

Results from studies on water reclamation have also found application in fields other than the reclamation of effluents. An important field of application in this respect is the upgrading of existing water purification technology, especially in view of the continued quality deterioration of the country's surface water sources. The technology which has emanated from research on water reclamation is therefore also suitable for water purification, irrespective of the source of the raw water.An example in this respect is that the techniques developed for the continuous surveillance of the quality of reclaimed water can be used unaltered at water purification works. By using these techniques such as biological sensors and methods for the analysis of chlorine content, organic carbon and chlorinated compounds, the quality of the final water can be determined continuously.

During the year under review the Commission supported eight research projects in connection with water purification and reuse.



The pilot water reclamation plant on the Cape Flats.

TECHNOLOGICAL ASPECTS OF WATER RECLAMATION

A research project on the technological development of water reclamation for direct reuse at the Windhoek plant is carried out in terms of a tripartite agreement by the National Institute for Water Research (NIWR) and the Municipality of Windhoek. A dissolved air flotation process for removing algae by means of flotation and which has been developed by the NIWR, is now being installed.

In collaboration with the City Council of Cape Town a pilot water reclamation plant was constructed on the Cape Flats. The ultimate aim of this research is to develop information and expertise required for decisions on the possible application of full-scale reclamation in various areas of the country.

HEALTH ASPECTS OF RECLAIMED WATER

Microbiological, epidemiological and virological studies are carried out in Windhoek and Cape Town as part of investigations on the health aspects of water. The South African Institute for Medical Research, the University of Cape Town and the NIWR are involved in this research. To date the microbiological tests have indicated that the reclaimed water complied with the microbiological standards for drinking water.

The epidemiological studies conducted so far have confirmed that there is no connection between the distribution and occurrence of chronic diseases and the quality of potable water in Windhoek.

An extensive investigation into the occurrence and distribution of certain diseases is being carried out in Cape Town and a complete data base for the last five years has been compiled. The possible effect of a change in the quality of water on the consumer can be studied by means of this data base. The methodology which has been developed can be employed on a larger scale in other parts of the country since these studies are not confined to the area. The data base will also be used for comparative studies with other communities.

THE USE OF ACTIVATED CARBON FOR THE PURIFICATION OF WATER

The Commission supports two research projects in this regard which involve the NIWR, the Rand Water Board and National Chemical Products.

Fundamental studies have continued during the year on the characterization of activated carbon and on the improvement of the definition for carbon saturation. The use of carbon remains the most expensive step in water purification. It is desirable therefore to improve on carbon selection for a specific use and to extend its use by reducing the organic material load. Attention has also been given to the optimization of processes, such as membrane technology and flocculation, in order to remove organic material which will react with chlorine resulting in the formation of chlorinated compounds.

LIST OF RESEARCH PROJECTS ON WATER TREATMENT AND REUSE

- Technological development of water reclamation on the basis of the Windhoek plant. (Contract with the Municipality of Windhoek and the CSIR - National Institute for Water Research).

- Research on the microbiological quality and health aspects of water for reuse. (Contract with the South African Institute for Medical Research).

- Epidemiological studies pertaining to the reclamation and reuse of purified sewage effluent in the Cape Peninsula. (Contract with the University of Cape Town - Department of Community Health).

- The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality. (Contract with the City Council of Cape Town).

- Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant. (Contract with the University of Cape Town - Department of Bacteriology).

- Research on the reclamation of secondary sewage effluent by reverse osmosis. (Contract with the CSIR - National Institute for Water Research).

- Research on the characterisation, evaluation and regeneration of activated carbon for water reclamation and water purification. (Contract with the CSIR - National Institute for Water Research; The Rand Water Board; and National Chemical Products).

- Research on the effect of adsorption-oxidation process configurations on the quality of reclaimed water. (Contract with the CSIR - National Institute for Water Research).

12 Research on desalination

There are a number of factors which favourably encourage the potential application of desalination technology in South Africa and these include the continued decrease in real cost of desalination and the gradual improvement in performance and reliability of the technology. Furthermore the extended drought urges water suppliers to consider alternative sources, including the desalination of sea and brackish water. There is also increasing concern about the detrimental economic effect of high salt concentration in the country's water sources, and the desalination of effluents is an obvious approach to solve this problem. Industry and the mining sector are also being encouraged to recirculate water and to limit water pollution and in this respect desalination can play a key role.

Basic desalination technology has largely been developed and is being successfully applied in various countries, primarily for the desalination of sea and brackish water. In view of this, the Commission's desalination research focusses mainly on two aspects, firstly, on the evaluation of existing technology in new applications and, secondly, on the development and manufacture of ultrafiltration and reverse osmosis membranes in order to promote local production expertise.

During 1984 the Commission sponsored six research projects in connection with desalination. Three of these projects were completed during the year, two others commenced, while the project on the desalination of underground mine water using ion exchange continued.

COMPLETED RESEARCH PROJECTS

Research on the desalination of mine water

Underground mine water is a large point source that contributes to the salt load of the Vaal River system. As a result and with a view to the reclamation and use of underground mine waters to enable mines to become more self-sufficient with respect to their water requirements, the Commission supported research by the Chamber of Mines on the desalination of underground mine water.

Two processes were tested at pilot scale (5 m^3/d) at the ERPM mine, namely the electrodialysis reversal process (EDR) and seed slurry reverse osmosis (SRO). (In the latter process sodium sulphate crystals are introduced to prevent membrane fouling). The EDR process, which had already proved to be a successful process for the desalination of cooling

tower blow-down, also performed well in the initial tests with mine water. However, membrane fouling occurred and it was decided not to proceed with full-scale experimentation until the cause of the fouling has been identified.

The unit for the SRO process was operated for a period of 5 000 hours. In spite of minimal pre-treatment no scale formation or other fouling problems were encountered. The performance of the unit proved to be so satisfactory that the Chamber of Mines, in collaboration with the firm Resources Conservation Co, is planning a larger plant in order to obtain information on costs and on design and operation criteria for full-scale plants.

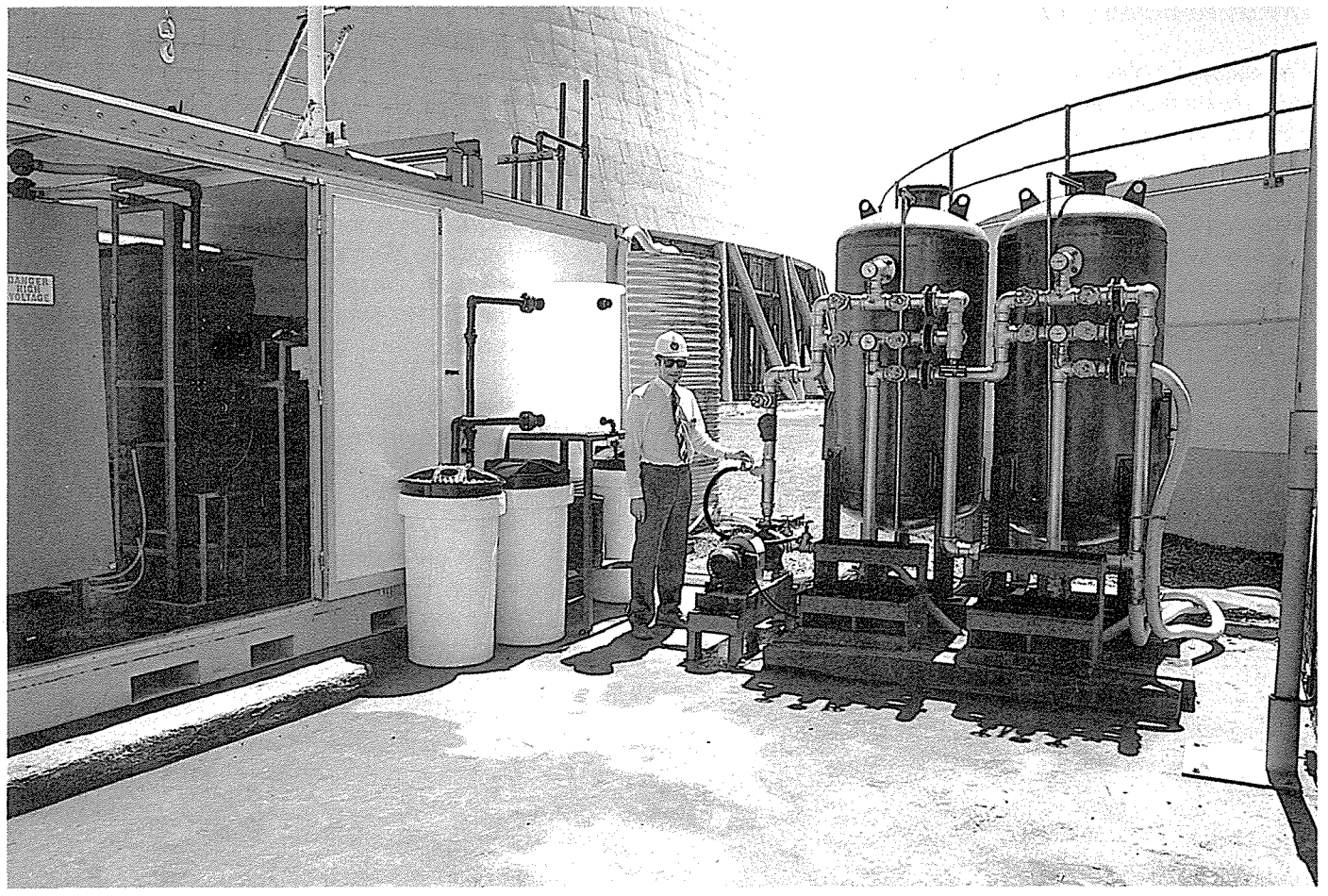
Desalination of cooling tower blow-down

Cooling tower blow-down contains high concentrations of dissolved salts and can therefore cause serious pollution of water sources. As a result, research was carried out on the desalination of this water in terms of an agreement with ESCOM. This forms part of a project on the evaluation of the electrodialysis reversal process (EDR) for the desalination of effluents and brackish water.

The results of this investigation proved so successful that a full-scale unit for the desalination of boiler water was commissioned by ESCOM at their Kriel power station. A further full-scale unit for the desalination of cooling tower blow-down is also being installed at their Tutuka power station.

Research on and development of polymeric membranes and supplemental coating for reverse osmosis (RO) and ultrafiltration (UF)

This research was carried out by the Institute for Polymer Science of the University of Stellenbosch in terms of two separate agreements. The projects were to a large extent inter-dependent since the development of membranes necessarily precedes the development of membrane support systems.



The electrodialysis reversal unit at the Grootvlei Power Station, used for research on desalination of cooling tower blow-down.

The main objective of the research was the development of thin film composite tubular membranes, while attention was also paid to plate membranes relating to spiral systems. Thin film composite membranes have advantages over cellulose acetate membranes, because under certain conditions they are chemically more resistant and can also be operated at a lower pressure. In previous research which was also supported by the Commission, the results led to the commercialization of cellulose acetate RO membranes.

Success was achieved with the synthesis of new thin film composite membrane systems and one system was patented. Good progress has also been made with the development of equipment for the manufacture of these membranes. The research is now being pursued in terms of a new contract.

NEW RESEARCH PROJECTS

Research on membrane development and fabrication for reverse osmosis and ultrafiltration

The main objective of this consolidated project, being carried out by the Institute for Polymer Science, is to take the technology for the manufacture of the various membrane types and systems that have been developed to the commercialization stage, taking into account correct membrane types for specific applications.

Research on the development of polymers for the formation of dynamic membranes

Newer types of membranes which make it possible to purify effluents with high alkaline or acid content at high temperature, are dynamic membranes. These troublesome effluents cannot be treated by conventional reverse osmosis and ultrafiltration membranes.

Dynamic membranes are formed in supporting tubes with the aid of chemical solutions. When such a membrane becomes fouled or damaged, it can be dissolved chemically and a new membrane formed on the same supporting tube - hence the name "dynamic" membrane.

An improvement in salt rejection and flux capability can promote the application potential of dynamic membranes. This is the objective of the new project being carried out by the Institute for Polymer Science of the University of Stellenbosch, for which purpose new polymers are being developed for dynamic membranes.

LIST OF RESEARCH PROJECTS ON DESALINATION

- Research on the desalination of mine water. (Contract with the Chamber of Mines).
- Evaluation of electrodialysis reversal for the desalination of effluents and brackish water. (Contract with ESCOM).
- Research on and development of polymeric membranes and supplemental coatings for reverse osmosis and ultrafiltration. (Contract with the University of Stellenbosch - Institute for Polymer Science).
- Research on and development of membrane support systems for reverse osmosis and ultrafiltration. (Contract with the University of Stellenbosch - Institute for Polymer Science, and the CSIR - National Institute for Water Research).
- Research on the development for the formation of dynamic membranes. (Contract with the University of Stellenbosch - Institute for Polymer Science).
- Research on membrane development and fabrication for reverse osmosis and ultrafiltration. (Contract with the University of Stellenbosch - Institute for Polymer Science).

13

Research on water economy in urban areas

The need to economise on water was stressed repeatedly during the recent drought and everybody was urged to contribute to this end. Total urban water consumption is rising steadily and water savings, not only during periods of drought, are essential to alleviate South Africa's critical water balance. The Commission has for many years been involved in an active research programme with respect to water economy measures, not only in the urban sector but also in the industrial and agricultural sectors. In this chapter the emphasis is on water economy in urban areas.

During the year the Commission sponsored three relevant research projects *viz.* water economy measures in urban areas; leak detection; and loss analysis in distribution systems. The first two projects ended during the year while the latter project commenced at the end of 1984.

WATER ECONOMY MEASURES IN URBAN AREAS

The project was completed during the year and was carried out in terms of a tripartite agreement between the CSIR (through its National Building Research Institute - NBRI), the SABS and the Commission.

The primary goal of the research project was to achieve meaningful savings of water through the improved design and use of water supply fittings and to assist in the development of a national consciousness of the importance of efficient water use and waste prevention.

An important aspect of the research has been an ongoing technology transfer by the NBRI in the sense that manufacturers have incorporated several recommendations in the design of various water supply fittings. Also based on the research findings, a variety of proposals have been formulated for inclusion in the National Water Regulations and for updating SABS standard specifications for water supply fittings.

A set of guidelines to assist gardeners in urban areas to reduce garden water consumption has been developed in collaboration with the Botanical Research Institute. In addition two other publications namely, *How to save water : Hints to householders* and *Water economy measures - Guidelines for local authorities,* are being prepared by the NBRI for general distribution.

RESEARCH ON LEAK DETECTION

This one year research project, which was carried out by the NBRI on leak detection in water supply distribution systems, also ended during the year.

Leak detection and repair programmes in water supply distribution systems overseas are fairly

A mobile water control unit used in Europe for water loss analysis in municipal water supply systems. A similar unit will be used in the local research project on water loss analysis.

common, but very little has been done in this regard in South Africa. Local authorities rely almost entirely on surface wetness to detect and locate leaks, notwithstanding the fact that overseas experience points to water losses as high as 30%.

In view of this, this pilot investigation was carried out into the detection of unseen leakage from water reticulation systems, using the latest available equipment. Several demonstrations of a leak noise correlator took place in various centres in the Republic. The leak noise correlator is a sophisticated electronic device used for pinpointing the position of a leak in an underground pressure pipeline.

Guidelines for use by local authorities in the development of leakage control programmes were prepared. These guidelines were published in a special issue of the *SA Waterbulletin* which was widely distributed. A procedure for implementing an ongoing water loss control programme, was also devised.

NEW RESEARCH PROJECT INTO LOSS ANALYSIS ON WATER DISTRIBUTION SYSTEMS

This research project will be carried out in terms of a contract with Castle Brass Holdings (Pty) Ltd of Krugersdorp and the City Council of Johannesburg.

From a previous project it became evident that the question of leakages in pipe networks in South Africa, requires a thorough in-depth investigation in order to adapt the techniques already developed overseas for application under South African conditions and to develop a practical guide on the use of these techniques and procedures.

To achieve these objectives suitable localities which will provide the necessary variety and spectrum of conditions, have been selected. Castle Brass Holdings will undertake the responsibility for the supply of the necessary equipment and the execution of the research programme. The full support and collaboration of the City Council of Johannesburg within whose boundaries the project is to be carried out, has been obtained.

Lectures and demonstrations will be arranged during the period of the contract and a manual on the planning, programme design, equipment requirements and procedures to be followed in the detection, quantification and repair of leakages in water reticulation systems under South African conditions, will be prepared.

LIST OF RESEARCH PROJECTS ON WATER ECONOMY IN URBAN AREAS

- Research on water economy measures for water distribution systems in urban areas. (Contract with the South African Bureau of Standards and the CSIR - National Building Research Institute).

- Research to investigate leak detection in water supply distribution systems. (Contract with the CSIR - National Building Research Institute).

- Research into water loss analysis on municipal water distribution systems. (Contract with Castle Brass Holdings (Pty) Ltd and the Johannesburg City Council).

14

Research on water economy at power generating stations

It is estimated that approximately two-thirds of the water used by industry in South Africa (excluding mining) is required for cooling purposes, especially at power generating stations. However, large volumes of water are lost during the wet cooling process. It is calculated that in a 3 600 MW wet cooled power station the volume of water lost through evaporation (together with relatively small volumes of water used for other purposes) amounts to 120 000m^3 per day. If dry cooling is used instead of wet cooling, it can result in a water saving of approximately 75%.

Dry cooling differs from wet cooling in that the water flows through cooling elements and is therefore air-cooled without evaporation taking place. Although dry cooling effects considerable water savings, the capital cost for a dry cooling unit greatly exceeds that of wet cooling. Dry cooling is also somewhat less efficient, necessitating the use of more coal for the same amount of energy generation than with wet cooling. Dry cooling systems, therefore, should be made to operate as efficiently as possible.

During the year the Commission supported four research projects in connection with water economy measures at power stations, including one new project.

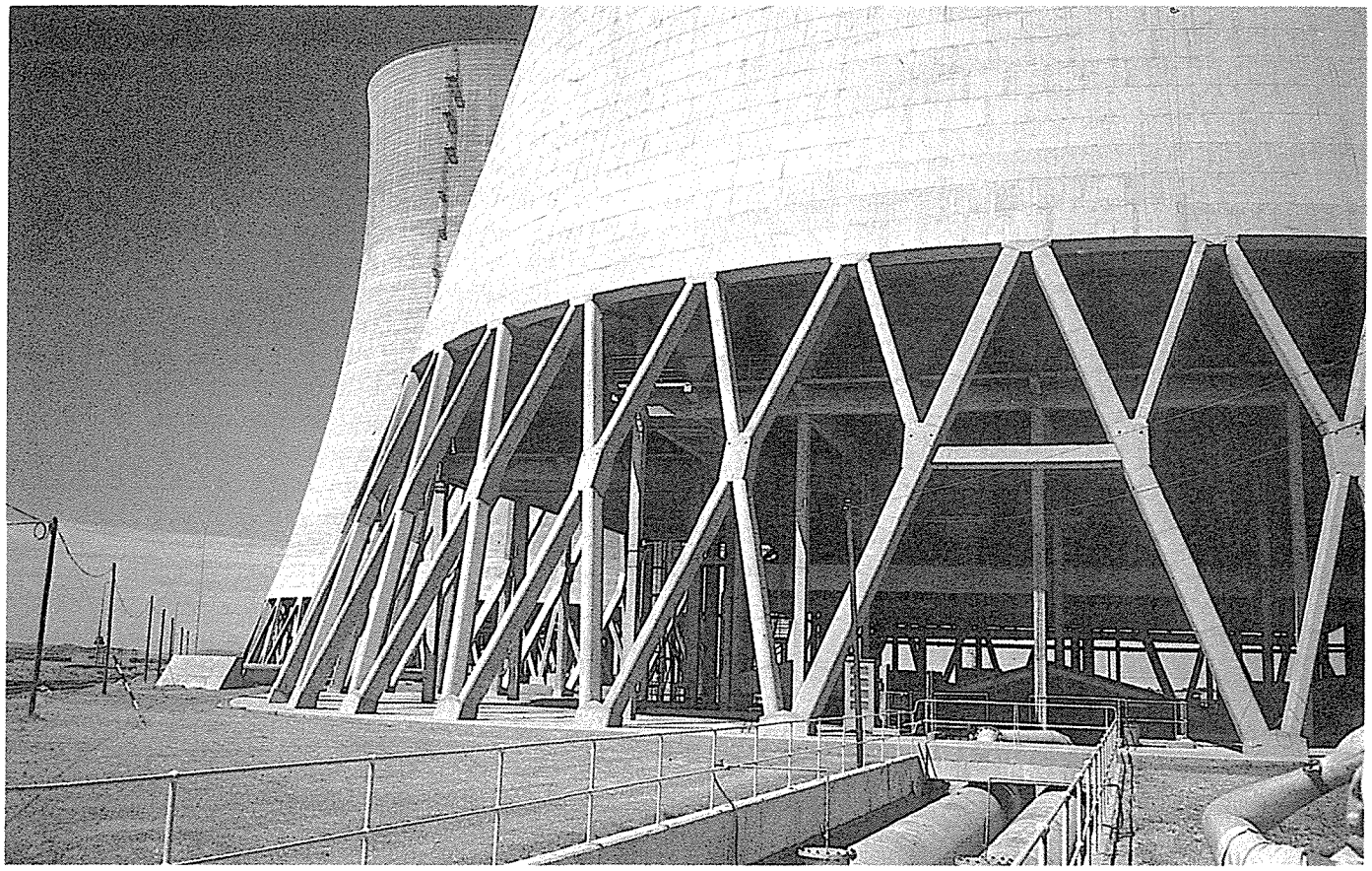
OPTIMISATION OF DRY AND DRY-WET COOLING

In terms of an agreement with ESCOM and the CSIR, research is directed at two aspects. First, the effect of atmospheric conditons such as wind and temperature inversions on the efficiency of cooling is being investigated. The second aspect being investigated is the effect of various environmental factors such as moisture content and pollution on the corrosion of various types of cooling elements.

In terms of another agreement with ESCOM and the CSIR the optimal siting of dry cooling units is being investigated (with a view to the prevention or suppression of warm air circulation) which will result in more effective cooling. The studies which were supposed to be investigated by means of a wind tunnel, are now being carried out by using a water tunnel technique. This technique was used to investigate the extent of re-circulation of hot air which is expected under various conditions at the existing Grootvlei power station and the planned Kendal power station.

COMPUTER PROGRAM FOR EVALUATING DRY COOLING SYSTEMS

The cooling elements used for dry cooling play on important role in the process since they represent a considerable part of the capital cost involved and



The two dry cooling towers at ESCOM's Grootvlei Power Station where research is being carried out on dry cooling.

their characteristics affect cooling efficiency. In view of the fact that a variety of cooling systems and cooling elements are available, it is important that techniques be developed for the evaluation and possible optimisation of the various possible combinations of systems and elements. The only way in which all variables can be accommodated in such an evaluation technique is by means of a computer program and the aim of the work being undertaken by the University of Stellenbosch is to develop such a program.

NEW PROJECT ON THERMAL FEEDBACK IN DRY COOLING

The Matimba power station (3 900 MW) which is currently being erected near Ellisras by ESCOM, will make use of dry cooling only. It is expected that the discharge of large quantities of waste heat into the atmosphere, will have a pronounced effect on air temperatures in the environment. This may not only reduce the performance of the power station but could have a detrimental effect on the local meso-climate.

It is essential for the planning and siting of future dry cooling power stations, to determine the real impact of the dry cooling system at Matimba. The environment is relatively untouched and, therefore, it presents an ideal and unique opportunity to collect base line data against which future changes can be measured.

The investigation is being carried out by the National Physical Research Laboratory of the CSIR, in terms of a tripartite agreement with the Commission and ESCOM.

LIST OF RESEARCH PROJECTS ON WATER ECONOMY AT POWER GENERATING STATIONS

- Research on the optimisation of dry and dry-wet cooling systems at power stations in South Africa. (Contract with ESCOM and the CSIR - Atmospheric Sciences Division, and Corrosion Research Division).
- Wind tunnel studies on the effect of the orientation of cooling units on warm air recirculation and efficiency of air cooled systems. (Contract with ESCOM and the CSIR - National Mechanical Engineering Research Institute).
- The development of computer evaluation techniques for dry cooling systems. (Contract with ESCOM and the University of Stellenbosch - Bureau for Mechanical Engineering).
- Research on thermal feedback caused by dry cooling at power generating stations. (Contract with ESCOM and the CSIR - National Physical Research Laboratory).

15

The transfer of information and technology

The world is experiencing an information explosion and more and more information and knowledge is being developed and released daily. The question could indeed be raised how this information is being used and what steps are being taken towards effective practical application of the available results. The Commission also compiles and generates information on a continuous basis. During the year under review the 81 Commission supported research projects resulted in a mass of information being produced and even more will become available. It is not only a challenge but a function of the Commission in terms of the Water Research Act, that the Commission shall "accumulate, assimilate and disseminate knowledge in regard to the results of such research and the application thereof, and promote development work for the purpose of such application."

The following avenues are used by the Commission for promotion of its information and technology transfer programme (application of research results): partnership research, the South African Water Information Centre, various publications, conferences, seminars, workshops, demonstrations, the mass media, utilisation of overseas expertise, etc.

PARTNERSHIP RESEARCH

Partnership research is regarded as the most effective method for successful technology transfer. The partnership principle is incorporated, as far as possible, in research contracts, which means that the potential user of the results becomes involved in the planning, formulation and execution of research.

THE SOUTH AFRICAN WATER INFORMATION CENTRE

The South African Water Information Centre was established in 1974 by the Water Research Commission after consultation with the CSIR and the Department of Water Affairs. It is operated as an independent unit on behalf of the Commission, and under contract by the Centre for Scientific and Technical Information of the CSIR, and provides various information services in the water and related fields.

The Centre has developed a computerised bibliographic data base *Waterlit* and during the year approximately 560 scientific and technical journals were selected by a team of graduate indexers for articles on water to be included in the data base. In addition to these articles, reports, theses, books, patents and conference proceedings are also indexed. The data base already contains about 100 000 items and approximately 15 000 new items

were added during the year. Since May 1983 American reports on water, supplied by the American National Technical Information Service, are also being included in *Waterlit.* These reports are derived from the Government Report Announcements (GRA) data base.

The Centre does approximately 55 retrospective searches monthly while more than 240 SDI (selective dissemination of information) profile holders are informed monthly of publications in their specific field of interest. However, searches are also done on *Waterlit* by other organisations such as the Centre for Scientific and Technical Information's regional offices in Durban and Port Elizabeth, the library of the Department of Water Affairs and at some of the Universities' libraries.

Table 1 contains information on how the services of the centre are being used. From the table it follows that universities still remain the largest user.

TABLE 1
USE OF THE CENTRE'S SERVICES BY THE VARIOUS SECTORS

Waterlit users	Retro-spective searches	SDI-profiles
	%	%
Universities	28,2	31,8
CSIR	15,4	20,4
Department of Water Affairs and other Government organisations	14,2	19,2
Industry and private companies	18,0	9,0
Consultants	7,1	4,1
Municipalities	6,4	9,0
Others	10,7	6,5

Table 2 gives information of the fields of interest for which information is requested most frequently.

Since September 1981 *Waterlit,* in terms of an agreement with System Development Corporation (SDC) in die USA, has been made available on a world-wide basis through SDC's on-line information retrieval service. An additional contract has also been negotiated for the rendering of SDI services on *Waterlit.* The contract with SDC was terminated towards the end of the year and negotiations are under way to enter into a new contract with Pergamon Infoline in the United Kingdom.

Apart from the services on *Waterlit* the centre also provides a current awareness service.

TABLE 2
FIELDS OF INTEREST FOR WHICH INFORMATION IS REQUESTED MOST FREQUENTLY

Field of interest	Retro-spective searches	SDI-profiles
	%	%
Limnology, biology, ecology and aquaculture	23,2	31,0
Effluent treatment and pollution	20,5	22,0
Hydrology and ground water	9,6	13,9
Resources, storage, distribution and use	9,6	9,5
Water treatment, analysis, chemical quality and desalination	13,4	5,7
Agriculture and irrigation	1,7	5,3
Others	22,0	12,6

PUBLICATIONS

The Commission's publications provide for three levels, *viz.* pure scientific, popular scientific and practical scientific levels.

Water SA

Water SA is the Commission's scientific journal which contains original research articles and review articles on all aspects of water science, technology and engineering. The first edition was launched in 1975 and the journal appears quarterly. All articles submitted for publication in *Water SA* are referred to referees first and thereafter a decision is taken on publication.

Water SA has an extensive local as well as overseas readership. It enjoys world-wide coverage and is included in the following abstracting services: Chemical Abstracts, Biological Abstracts, Engineering Index, Pollution Abstracts, Oceanic Abstracts, Current Contents Science Citation Index, Water Resources Abstracts (American Water Resources Association), Hydata, Selected Water Resources Abstracts, Desalination Abstracts, Waterlit, WRC Information, Aqualine, Abstracts Journal (Institute of Scientific Information of the USSR Academy of Science), Soils and Fertilizers (including Irrigation and Drainage Abstracts), Information Eaux, ISP Index and Abstracts, Cambridge Scientific Abstracts, Documentation Wasser, Institute for Scientific Information, Abstracts of Commonwealth Bureau of Nutrition, Current Advances in Plant Science, Current Advances in Ecological Sciences, Fertilizer Abstracts and Waternet.

SA Waterbulletin

This bilingual newsletter which was launched in August 1975 by the Commission and which appears quarterly contains articles, news snippets and items of interest on local as well as overseas aspects of water. Activities of various institutions in the water field in the Republic are highlights in the Bulletin. During the year under review the Bulletin has succeeded increasingly in bridging the gap between the water researcher and the mass media, thereby promoting a general water awareness amongst the South African public. Many Bulletin articles have been used by other journals and newspapers. A special edition was published early in the year with the aim of introducing the benefits of leak detection programmes to local authorities.

Manuals, guidelines and reports

At the conclusion of a project, and also whilst research is still under way, results are evaluated in respect of possible use and application and depending on the nature of the results a decision is taken on its publication, dissemination and application. More information on these publications appears in the relevant chapters and in the Appendix.

LIST OF PUBLICATIONS OF THE COMMISSION

The Appendix to this Annual Report contains a list of publications (articles, papers and published reports) which appeared during 1984 and which emanated from research supported wholly or in part by the Commission.

COLUMN IN IMIESA

Since January 1979 a column on the Water Research Commission has been appearing monthly in IMIESA, the official organ of the Institution of Municipal Engineers of Southern Africa. Since its inception in 1971 the Commission has developed a wide range of activities which are of direct importance to local authorities. The column endeavours to provide a continuous feedback of information to local authorities in an effort to inform them regularly of the activities and research being done in their interest.

CONFERENCES, SEMINARS, WORKSHOPS AND DEMONSTRATIONS

From time to time the Commission, on its own or in cooperation with other organisations, arranges such meetings. These afford ideal opportunities for promoting personal contact between research scientists or between research scientists and the users of research results. In this way the transfer of information and technology is greatly enhanced. More information on meetings held during the year is contained in the individual chapters.

MASS MEDIA

In this regard the accent falls on information transfer and press releases, radio and television are used to this end.

UTILISATION OF OVERSEAS EXPERTISE

It is in the national interest that overseas expertise and knowledge be used where these are not available locally and the Commission has developed various methods to achieve this. Overseas specialists, for example, are used as consultants and the Commission from time to time sends study groups overseas in order to obtain information on a specific problem area. More information in this regard appears in the individual chapters.

16 Financial Statements

The Statement of Income and Expenditure and the Balance Sheet have drawn up in terms of section 14(2) of the Water Research Act, 1971, (Act no. 34 of 1971), as amended and certified by the Auditor-General and cover the period 1 January 1984 to 31 December 1984.

The Commission derives its income from rates and charges on water usage and on scheduled irrigation land. The tariffs for the 1984 financial year were 0,40 c/m³ for water supplied for urban, industrial or domestic use, and 70 c/ha of land scheduled for irrigation.

WATER RESEARCH COMMISSION
STATEMENT 1
Balance Sheet as at 31 December 1984

1983	Liabilities	1984		1983	Assets		1984	
R		R	R	R		R	R	R
	Sundry creditors –				*Capital assets –			
109 652	Revenue paid in advance		68 249,87	5 000	Land (Cost)		5 000,00	
	Fund account –				Motor vehicles	11 615,72		
8 687 174	Balance at 31/12/83	8 687 174,19		11 616	*Less:* Depreciation	2 716,98	8 898,74	
	Plus: Excess of income over expenditure 1984	1 543 334,91	10 230 509,10		Office equipment	122 370,49		
				98 051	*Less:* Depreciation	5 848,10	116 522,39	
					Office furniture	34 422,51		
				30 057	*Less:* Depreciation	1 637,08	32 785,43	163 206,56
				1 944 406	Loan			3 642 249,11
					Investments		2 935 422,41	
				4 259 393	*Plus:* Accrued interest – 1/10/84 – 31/12/84		150 755,69	3 086 178,10
					Current assets –			
					Sundry debtors –			
					Outstanding revenue:			
					Prior to 1984	44 013,43		
				793 918	1984	799 095,13		
					In transit	192 627,90	1 035 736,46	
				1 424 058	Project advances (Statement 3)	2 111 585,10		
				3 264	Subsistence and transport advances	12 960,30		
				43 996	Motor financing	15 878,50		
				200	Deposits	300,00	2 140 723,90	
				150	Cash on hand		150,00	
				182 717	Cash in bank		230 514,84	3 407 125,20
R8 796 826			R10 298 758,97	R8 796 826				R10 298 758,97

*Capital assets purchased by organisations by means of research grants are not included.

(Sgd.) J P Kriel
Chairman

Pretoria, 28 March 1985

The above Balance Sheet has been audited in accordance with the provisions of section 42(4) of the Exchequer and Audit Act, No. 66 of 1975, read with section 14(1) of the Water Research Act, No. 34 of 1971, and in my opinion it has been drawn up as to reflect a true and fair view of the financial affairs of the Water Research Commission.

(Sgd.) A P Ellis
Auditor-General

Office of the Auditor-General,
Cape Town, 15 April 1985

WATER RESEARCH COMMISSION

STATEMENT 2

Income and Expenditure Account for the year ended 31 December 1984

1983	Expenditure		1984
R			R
1 224 660	Salaries and allowances		1 658 305,91
37 339	Subsistence		35 859,03
3 765	Motor transport		3 923,79
146 398	General transport		199 425,31
1 850	Commission members' allowances		2 400,00
8 890	Postal and telegraph services		11 994,49
22 557	Telephone services		25 575,93
15 085	Printing and stationery		22 069,17
5 274	Advertisements		4 248,49
117 232	Publications and Information		126 790,13
27 347	Tegnology and information transfer		7 860,44
12 520	Lease and maintenance of office equipment		17 671,53
9 964	Entertainment		8 391,43
41 420	Office rental		47 269,77
2 697	Maintenance of and alterations to offices		3 661,16
4 702	Electricity		5 912,08
—	Maintenance and lease of furniture		7,84
822	Typing services		—
4 685	Insurance and licenses		5 110,83
70 280	Collection fees		75 698,64
1 065	Audit fees		2 032,00
12 740	Legal costs		—
13 303	Registrations and subscriptions		14 544,85
7 472	Miscellaneous petty expenses		5 882,39
9 300	Depreciation		10 202,16
3 488 849	Research projects (Statement 3)		3 990 839,13
	Contracting of researchers and expertise:	R	
181 610	Weather modification at Bethlehem	129 978,22	
70 971	Evapotranspiration and water use studies by means of weighing lysimeters	20 083,93	
2 538	Digitizing of autographic raingauge data	—	
16 001	Establishment of Hydrological data banks	22 408,23	
—	Investigation into water use and productivity of crops under conditions of water stress and the modelling thereof	70 267,77	
—	Research on the dolomite groundwater resources in the supply area of the Rand Water Board	13 707,45	256 445,60
214 339	Research and other grants		140 147,10
307 406	Specialist and consultation services		194 244,02
1 322 271	Excess of income over expenditure		1 543 334,91
R7 405 352			R8 419 848,13

1983	Income			1984	
R		R	R		R
	Rates				
	Government irrigation schemes with canal systems:				
	Received	48 597,86			
	Plus: Adjustment in respect of previous years	223,60	48 821,46		
127 808	*Plus:* Outstanding 1984		104 462,46		153 283,92
	Irrigation Board Schemes:				
	Received	108 434,86			
	Less: Adjustment in respect of previous years	200,00	108 234,86		
71 380	*Plus:* Outstanding 1984		2 019,21		110 254,07
	Charges				
	Metered water from Government schemes:				
	Received	5 014 899,37			
	Plus: Adjustment in respect of previous years	57 794,77	5 072 694,14		
5 203 163	*Plus:* Outstanding 1984		691 166,06		5 763 860,20
	Municipalities:				
	Received	1 691 077,42			
	Plus: Adjustment in respect of previous years	13 025,26	1 704 102,68		
1 484 170	*Plus:* Outstanding 1984		1 447,40		1 705 550,08
	S.W.A.:				
47	Received				3 720,80
31 264	Unallocated rates and charges				76 509,16
3 817	Interest on rates and charges in arrear				2 668,84
	Interest on investments:				
	Received		426 029,71		
454 075	Accrued		150 755,69		576 785,40
15 750	Research contributions				—
13 878	Sundry income				27 215,66
R7 405 352					R8 419 848,13

WATER RESEARCH COMMISSION

STATEMENT 3

Statement of Project Expenditure and Advances for the year 1984

Project	Expenditure		Total advances outstanding as at 31.12.84
	1984	Total to 31.12.84	
	R	R	R
Technological development of water reclamation on the basis of the Windhoek plant	6 417,65	787 197,61	280,74
South African Water Information Centre	245 885,12	471 384,37	*(59 078,17)
Research on the microbiological quality and health aspects of water for reuse	—	913 279,60	2 075,16
Water pollution and effluent reclamation in the Pretoria-Witwatersrand-Vereeniging-Sasolburg Complex	—	576 889,13	731,31
Research on the development and application of aspects of equilibrium chemistry and precipitation kinetics to water stability problems encountered in water reclamation	6 715,55	40 646,16	3 000,00
Research on the optimization of dry and dry-wet cooling systems at power stations in South Africa	106 562,00	646 222,85	*(8 497,00)
Research on the optimization of the modified activated sludge process for nutrient removal (Johannesburg City Council)	3 698,66	175 551,15	—
Hydrological investigation of rural catchments in Natal with specific reference to flood events	83 055,45	295 735,77	57 044,55
Hydrological research in Zululand	—	115 841,00	17 906,52
Wind tunnel studies on the effect of the orientation of cooling units on hot air recirculation and efficiency of air cooled systems	25 000,00	25 000,00	*(8 340,00)
Research on economy measures for water distribution systems in urban areas	18 883,47	584 321,07	9 116,53
Epidemiological studies pertaining to the reclamation and reuse of purified sewage effluent in the Cape Peninsula	65 770,59	261 767,15	50 285,97
The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality	28 067,70	615 375,14	171 000,00
Optimization of the modified activated sludge process for nutrient removal (University of Cape Town)	80 054,31	388 091,89	—
Research on water management and effluent treatment in the textile industry: Wool scouring effluent treatment	166 675,46	464 940,20	115 364,04
Research on continuous streamflow modelling of South African rivers	13 210,97	75 750,00	—
The treatment and disposal of municipal sludges: Sludge dewatering and the treatment of sludge liquors	5 133,97	10 904,67	2 701,03
Research on the water requirements of certain agronomic and vegetable crops	127 738,95	229 216,00	*(2 123,95)
Research on the influence of different times and intensities of internal plant moisture stress on photosynthesis, respiration and water use efficiency of certain agronomic crops	18 280,90	241 511,03	23 802,66
The treatment and disposal of municipal sludges: Pasteurisation and thermophilic anaerobic digestion of sludge	12 444,53	24 163,63	336,37
The treatment and disposal of municipal sludges: Autothermic aerobic digestion of sludge	22 718,27	53 720,18	3 969,97
The treatment and disposal of municipal sludges: The characterisation of sludge	8 877,00	73 859,00	*(2 430,00)
Research on biochemical processes which result in phosphate and nitrogen removal in the modified activated sludge process	813,24	36 480,60	2 842,14
Research on drought occurrences	13 070,25	130 006,37	5 293,63
Research on and development of polymeric membranes and supplemental coatings for reverse osmosis and ultra filtration	82 765,08	303 240,44	*(1 565,08)
An investigation into the water and effluent management problems in the fruit and vegetable processing industry: In-house optimisation of water use and effluent treatment in fruit and vegetable processing	4 134,39	147 148,02	—
An investigation into the water and effluent management problems in the fishing industry: Effluent handling at fish processing factories	69 987,04	195 497,40	—
Research on the profile available water capacities of soils	65 049,75	140 601,40	64 700,25
Eutrophication research on the Hartbeespoort Dam	110 658,00	245 925,00	5 175,00
Research on integrated studies of the generation of runoff, solutes and sediment in tributary catchments of the Great Fish River	56 852,94	224 139,95	16 060,05
The treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge, prototype study	13 516,00	76 241,06	23 873,00
Development of the required apparatus and programmes for the monitoring and management of irrigation systems	116 193,97	292 004,36	19 765,64
Research on and development of membrane support systems for reverse osmosis and ultrafiltration	286 256,20	328 680,15	16 243,80
Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant	17 939,30	35 303,46	13 686,99
Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa	44 817,37	67 653,34	55 646,66
Research on the applicability of groundwater models as an aid to the study and evaluation of South African aquifers	104 577,00	303 388,28	—
Research on sludge bulking in the activated sludge process	7 057,29	7 057,29	37 417,83
Research on urban hydrology and drainage	98 322,81	224 851,93	*(4 851,93)
Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems	174 091,30	383 671,75	*(2 221,75)

STATEMENT 3 (continued)

Project	Expenditure		Total advances outstanding as at 31.12.84
	1984	Total to 31.12.84	
	R	R	R
Research on an irrigation scheduling service for the Free State region	35 064,80	71 898,59	5 471,41
A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa	11 710,50	14 106,66	14 643,34
Research on the characterization, evaluation and regeneration of activated carbon for water reclamation and water purification	1 637,00	169 592,00	408,00
Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization	57 152,15	120 647,36	*(25 774,36)
Research on the auto-analyses of sulphate and alkalinity in water	3 364,77	9 200,88	799,12
Water management and effluent treatment in the textile industry: Treatment of scouring and bleaching effluent	173 497,58	173 497,58	136 802,42
Research into the treatment of industrial effluents with high salinity and organic contents	141 016,03	141 016,03	149 420,00
Research on the desalination of minewaters (RCC)	5 000,00	25 000,00	—
Research on the reclamation of secondary sewage effluent by reverse osmosis	10 814,00	64 773,00	2 347,00
Research on an investigation into the use of physical/chemical techniques for water and wastewater management in the meat processing industry	109 875,00	109 875,00	195 000,00
Research on the desalination of minewaters (University of Cape Town)	—	—	8 845,00
Evaluation of the impact of phosphate limitation on the trophic status of South African impoundments	7 672,81	19 800,00	—
Research on the effect of adsorption-oxidation process configuration on the quality of reclaimed water	3 919,00	38 133,00	1 767,00
Research on the inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage	51 432,75	62 263,22	6 760,78
Construction of a dissolved air flotation pilot scale unit for application for research on industrial effluents	4 032,65	39 953,23	—
An investigation into the condition of soils irrigated over a protracted period and an evaluation of applicable selection criteria, and reclamation and control measures	7 958,11	16 220,65	4 279,35
Research on the contribution of mine dumps to mineral pollution in the Vaal Barrage	51 756,41	72 534,23	1 470,77
Research on enhancement of biological phosphate removal from sewage by altering process feed composition	137 964,97	140 529,75	1 435,45
Hydrological research in catchments of the Eastern and Southern Cape	95 985,69	95 985,69	4 244,31
Research on an evaluation of hydrological flood estimation techniques for small ungauged catchments	80 776,03	116 631,19	*(131,19)
Research to investigate leak detection in water supply distribution systems	21 943,74	21 943,74	17 056,26
The development of computer evaluation techniques for dry cooling systems	154 960,31	154 960,31	3 757,37
Research on the inhibition of algal growth by water hyacinth	—	—	18 050,00
Research on the development of polymers for the formation of dynamic membranes	—	—	20 000,00
Research on the use of the soil/root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil/plant/atmosphere systems	92 543,24	92 543,24	7 913,48
A national industrial water and wastewater survey	168,31	168,31	315 940,00
Research into the development of wastewater pretreatment techniques: Cross-flow microfiltration	—	—	54 774,00
Research on biological foam in the activated sludge process	23 289,47	23 289,47	10 191,53
Research on biological excess phosphate removal	—	—	74 852,69
An investigation into rainfall recharge to groundwater	208 842,00	208 842,00	8 435,40
Research on the development of a national data bank for groundwater data	128 600,95	128 600,95	17 399,05
Research on the practical scheduling of irrigation in the Northern Transvaal	—	—	64 000,00
Research on the quantification and limitation of water losses associated with centre pivot irrigation systems	21 307,04	21 307,04	9 667,96
Applied hydrological process and modelling studies for the determination of water and sediment yield	—	—	206 000,00
Research on design stromflow and peak discharge rates for small catchments in Southern Africa	—	—	43 000,00
Hydrological research in catchments in North-Eastern Natal	—	—	42 000,00
Research on thermal feedback caused by dry cooling at power generating stations	28 928,00	28 928,00	*(28 928,00)
Research on the evaluation and optimisation of full-scale chemical phosphate removal in biological sewage treatment processes	—	—	33 000,00
Research on marine disposal of wastewaters: A guide for the marine disposal of wastewater	—	—	34 500,00
Water and effluent management in the pulp and paper industry	8 333,34	8 333,34	—
The technical performance evaluation of a full-scale industrial wastewater treatment plant: Textile dyehouse effluent treatment by hyperfiltration and evaporation	—	—	22 975,00
	R3 990 839,13	R12 403 832,86	R2 111 585,10

*Excess expenditure over advances for projects.

WATER RESEARCH COMMISSION
STATEMENT 4
Budget 1985

	R	R
ESTIMATED INCOME		
Rates and charges in terms of Section 11 of the Water Research Act		10 000 000
Interest on investment		250 000
		10 250 000
Appropriation from accumulated funds		1 366 000
TOTAL ESTIMATED INCOME		11 616 000
ESTIMATED EXPENDITURE		
Administrative expenses:		
Salaries and allowances	1 686 000	
Subsistence and travelling expenses	197 000	
Postal, telegraph and telephone	41 000	
Printing, stationery, advertisements and publications	252 000	
General expenditure	254 000	
		2 430 00
RESEARCH PROJECTS		
Approved projects		
Technological development of water reclamation on the basis of the Windhoek plant	17 000	
South African Water Information Centre	342 000	
Research on the optimization of dry and dry-wet cooling systems at power stations in South Africa	20 000	
Epidemiological studies pertaining to the reclamation and reuse of purified sewage effluent in the Cape Peninsula	89 000	
The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality	150 700	
Research on the water requirements of certain agronomic and vegetable crops	84 500	
Research on the influence of different times and intensities of internal plant moisture stress on photosynthesis, respiration and water use efficiency of certain agronomic crops	15 500	
The treatment and disposal of municipal sludges: Pasteurisation and thermophilic anaerobic digestion of sludge	17 780	
Research on the profile available water capacities of soils	2 698	
Research on integrated studies of the generation of runoff solutes and sediment in tributary catchments of the Great Fish River	81 500	
The treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge, prototype study	45 000	
Development of the required apparatus and programes for the monitoring and management of irrigation systems	124 000	
Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant	30 800	
Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa	59 500	
Research on the applicability of groundwater models as an aid to the study and evaluation of South African aquifers	30 000	
Research on urban hydrology and drainage	77 000	
Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems	96 500	
Research on an irrigation scheduling service for wheat in the Free State region	33 000	
A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa	13 550	
Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization	44 000	
Water management and effluent treatment in the textile industry: Scouring and bleaching effluents	160 490	
Research into the treatment of industrial effluents with high salinity and organic contents	44 563	
Research on an investigation into the use of physical/chemical techniques for water and wastewater management in the meat processing industry	16 500	
Research on the inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage	29 300	
CRAWS	1 575 140	
An investigation into the condition of soils irrigated over a protracted period and an evaluation of applicable selection criteria, and reclamation and control measures	29 200	
Research on the contribution of mine dumps to mineral pollution in the Vaal Barrage	65 000	
Research on enhancement of biological phosphate removal from sewage by altering process feed composition	38 000	
Hydrological research in catchments of the Eastern and Southern Cape	103 700	
Research on evaluation of hydrological flood estimation techniques for small ungauged catchments	78 600	
The development of computer evaluation techniques for dry cooling systems	110 000	
Research on the inhibition of algal growth by water hyacinth	15 950	
Research on the development of polymers for the formation of dynamic membranes	10 000	
Research on the use of the soil/root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil/plant/atmosphere systems	58 500	
A national industrial water and wastewater survey	673 600	
Research on biological foam in the activated sludge process	40 000	
Research on biological excess phosphate removal	132 000	

STATEMENT 4 (continued)

	R	R
An investigation into rainfall recharge to groundwater	112 600	
Research on the development of a national data bank for groundwater data	179 000	
Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat	54 100	
Research on the practical scheduling of irrigation in the Northern Transvaal	48 000	
Research on the quantification and limitation of water losses associated with centre pivot irrigation systems	58 000	
Applied hydrological process and modelling studies for the determination of water and sediment yield	147 000	
Research on design stormflow and peak discharge rates for small catchments in South Africa	76 000	
Hydrological research in catchments in North-Eastern Natal	103 000	
Research into water loss analysis on municipal water distribution systems	176 550	
Research on thermal feedback caused by dry cooling at power generating stations	35 000	
Research on the evaluation and optimisation of full-scale chemical phosphate removal in biological sewage treatment processes	49 500	
Research on marine disposal of wastewater: A guide for the marine disposal of wastewater	26 350	
Research into the treatment of wool scouring effluents	153 300	
Evaluation of the technical performance of a full-scale plant for the treatment of textile dyehouse effluent	28 000	
	5 800 971	
Possible projects	2 436 029	8 237 000
Contracting of researchers and expertise		499 000
Research and other grants		200 000
Specialist and Consultation Services		250 000
TOTAL ESTIMATED EXPENDITURE		R11 616 000

17 Appendix

Publications emanating from research financed wholly or partially by the Commission.

This appendix contains a list of publications released in 1984. Requests for publications should be directed, as far as possible, to the authors themselves.

PUBLICATIONS FOR 1984

ARTICLES AND PAPERS

Annandale, J.G., Hammes, P.S. and Nel, P.C. (1984) Effect of soil fertility on the vegetative growth, yield and water use of wheat *(Triticum aestivum) S.Afr. J. Plant and Soil 1* 96-97.

Berliner, P.R. and Oosterhuis, D.M. (1984) Responses of wheat grown in a shallow lysimeter and in the field to water stress. *Proc. Crop Prod. Soc. South Africa 13* 9.

Berliner, P.R., Oosterhuis, D.M. and Green, G.C. (1984) Evaluation of the infra-red thermometer as a crop stress detector. *Agric. and Forest Meteorol. 31* 219-230.

Blackbeard, J.R. and Ekama, G.A. (1984) Survey of activated sludge bulking and foaming in Southern Africa, *IMIESA 9* (3) 20-25.

Bourne, D.E. and Watermeyer, G.S. (1984) Epidemiological planning for potable reuse. *Proceedings of the Water Reuse Symposium III,* San Diego.

Bourne, L.T. and Watermeyer, G.S. (1984) Water consumption patterns among individuals. *Proceedings of the Water Reuse Symposium III,* San Diego.

Buckley, C.A. and Groves, G.R. (1984) The use of ultra-filtration for the closed loop recycle and treatment of industrial effluents with chemical recovery. *IMIESA 9* (3) 51-59.

Cochrane, K.L. (1984) The impact of some aspects of the Hartbeespoort Dam environment on production of the major fish species. *J. Limnol. Soc. Sth. Afr. 10*(1) 11-15.

Dent, M.C. (1984) Estimation of irrigation water requirements for planning - a sensitivity analysis model. *Proc. South African Institute of Agricultural Engineers' Symposium,* Pretoria.

Dold, P.L. and Marais, G.v.R. (1984) The kinetics of carbonaceous material removal in the activated sludge process. Presented at 1st meeting of IAWPRC Task Group on activated sludge process modelling.

Dold, P.L., Buhr, H.O. and Marais, G.v.R. (1984) An equilization control strategy for activated sludge process control. Presented at 12th IAWPRC Conference, Amsterdam.

Eastham, Judy, Oosterhuis, D.M. and Walker, Sue. (1984) Leaf water and turgor potential threshold values for leaf growth of wheat. *Agron. J. 76* 841-847.

Eastham, Judy, Proffitt, A.P.B. and Berliner, P.R. (1984). The effects of spatial variability in soil physical properties on wheat growth under a uniform irrigation application *Proc. Crop Prod. Soc. South Africa 13* 11.

Ekama, G.A. and Marais, G.v.R. (1984) Two improved activated sludge settle-ability parameters, *IMIESA 9* (6) 20-27.

Emmitt, G.D. (1984) Behavior of cylindrical dry ice pellets - field, laboratory and model experiments. *Proceedings of Ninth Conference on Planned and Inadvertent Weather Modification,* Salt Lake City, Utah, May.

Fischer, H.H. en Nel, P.C. (1984). Waterverbruik deur tamaties *(Lycopersicum esculentum) Handelinge van SA Vereniging vir Gewasproduksie 13* 10.

Gabrial, K.R. and Mather, G.K. (1984) Some analyses of summer precipitation at Nelspruit. *Proceedings of Ninth Conference on Planned and Inadvertent Weather Modification,* Salt Lake City, Utah, May.

Groves, G.R. and Buckley, C.A. (1984) Applications of advanced wastewater treatment technologies to industrial effluents for water reuse. 4th Nat. Meeting of SAIChE, Potchefstroom University for CHE, Potchefstroom, 13-15 March.

Groves, G.R., Buckley, C.A., Cox, J.M., Kirk, A. and Simpson, M.P.J. (1984) The treatment of industrial effluents by dynamic membrane technology. 4th Nat. Meeting of SAIChE, Potchefstroom University for CHE, Potchefstroom, 13 - 15 March.

Groves, G.R., Buckley, C.A., Treffry-Goatley, K., Simpson, M.P.J. and Bindoff, A.L. (1984) Pretreatment, fouling and cleaning in the membrane processing of industrial effluents. ACS-I&EC Symposium on Reverse Osmosis and Ultrafiltration. Philadelphia, August 26-31.

Groves, G.R., Townsend, B., Simpson, M.P.J., Treffry-Goatley, K., and Buckley, C.A. (1984) Dynamic membrane treatment of industrial effluents. SA International Filtration Society Symposium, Johannesburg, August.

Groves, G.R., Treffry-Goatly, K., Simpson, M.P.J., Bindoff, A.L. and Buckley, C.A. (1984) Pretreatment method for reverse osmosis of industrial effluents. SA International Filtration Society Symposium, Johannesburg, August.

Hart, O.O. (1984) Factors to be considered in deciding on water reclamation for potable reuse. 63rd Annual Municipal Engineer's Conference, Cape Town, 9 - 11 May.

Hart, O.O. (1984) Water - the need and care. Institute of Brewing, Parktown, Johannesburg, 20 June.

Hart, O.O. and Squires, R.C. (1984) A strategy for optimising water and effluent management by industry. IAWPRC Conference, Amsterdam, 17-20 September.

Hattingh, W.H.J. (1984) Gesondheidsaspekte van drinkwatervoorsiening en storting van afvalwater. Referaat gelewer by Konferensie oor Dienstevoorsiening, Standaarde en Toepaslike Tegnologie vir Plaaslike Owerhede. Windhoek, 30 Oktober.

Hattingh, W.H.J. (1984) Health aspects of potable water. Paper presented to a Department of Water Affairs symposium on Pollution Control, held at the Hydrological Research Institute, Roodeplaat Dam. 29 October.

Hodgkiss, M.T. and Moodie, J.W. (1984) Genomic analysis of RNA viruses isolated from water. Poster presented at 12th Biennial International Conference on Water Pollution Control, Amsterdam, 1984.

Hope, A.S. (1984) Estimation of stormflow volumes from small semi-arid catchments using the R-index method. *Journal of Hydrology 67* 129-139.

Hughes, D.A. (1984) An isolated event model based upon direct runoff calculations using an implicit source area concept. *Hydrological Sciences Journal 29*(3) 311-326.

Hughes, D.A. and Guthrie, B.K. (1984) The continuous monitoring of rainfall: A technical discussion. *Water SA 10*(2) 75-80.

Isaäcson, M. and Sayed, R. (1984) An epidemiological study on the incidence of gastroenteritus in an urban population and its relation to consumption of recycled sewage effluent. Paper presented at the 63rd Annual Conference of Municipal Engineers, Cape Town, 8-11 May.

Lötter, L.H. (1984) The role of bacterial phosphate metabolism in enhanced phosphorus removal from the activated sludge process. Paper presented to IAWPRC Seminar, Paris

Lynch, S.D., Hodgson, F.D.I., Dziembowski, Z.M. and Vegter, J.R. (1984) Management of the Sishen aquifer by finite element modelling. Paper presented at the International Conference on Ground-water Technology, Johannesburg.

aquifer by finite element modelling. Paper presented at the International Conference on Ground-water Technology, Johannesburg.

Malan, G.J. (1984). Conserving water. *Castle News 6,* May. NBRI publication R/BOU 1223.

McGlashan, J.E. (1984) Sewage sludge management and research in South Africa. Institute of Water Pollution Control Yearbook 1984/85.

Moolman, J.H. (1984) Spatial variability of two selected soil properties in a semi-arid sub-catchment of the Great Fish River. Paper presented at the 12th Conference of the Soil Science Society of South Africa, Bloemfontein, July

Morgan, G. and Mather, G.K. (1984) The measurement of liquid water content in Transvaal storms. *Proceedings of Ninth Conference on Planned and Inadvertent Weather Modification,* Salt Lake City Utah, May.

Morrison, B., Finnegan, W.G., Horn, R.D. and Grant L.O. (1984) A laboratory characterization of dry ice as a glaciogenic seeding agent. *Proceedings of Ninth Conference on Planned and Inadvertent Weather Modification,* Salt Lake City, Utah, May.

Müller, J.L. and Botha, J.F. (1984) Modelling ground-water response in the Atlantis aquifer. Paper presented at the International Conference on Ground-Water Technology, Johannesburg.

Nicholls H.A., Pitman, A.R., and Osborn, D.W. (1984) The readily biodegradable fraction of sewage : its influence on phosphorus removal and measurement. Paper presented to IAWPRC Seminar, Paris.

Odendaal, P.E. (1984) Water management and industry in the Republic of South Africa: What does the future hold? Paper presented at the Conference on Water Pollution : The Multi-million Rand Remedy, organised by the Manpower and Management Foundation of Southern Africa, Sandton, 24 May.

Oosterhuis, D.M. (1984) Crop water use efficiency. SA *Waterbulletin.* May, pp. 23-28

Oosterhuis, D.M. (1984). Stomatal responses to water stress in field crops. *Proc. Crop Prod. Soc. South Africa 13* 1.

Oosterhuis, D.M. and Walker, S. (1984) Changes in the soybean leaflet pulvinule during inversion with water stress. *Plant Physiol. Suppl. 75* (1) 176.

Pitman, A.R. (1984) Settling of nutrient removal activated sludges. *Wat. Sci. Tech. 17* 493-504.

Proffitt, A.P.B., Berliner, P. and Oosterhuis, D.M. (1984) A comparative study of root distribution and water extraction efficiency by wheat grown under high and low frequency irrigation. *Proc. Crop Prod. Soc. South Africa 13* 3.

Robarts, R.D. (1984) Factors controlling primary production in a hypertrophic lake (Hartbeespoort Dam, South Africa). *J.Plank. Res. 6* 91-105.

Robarts, R.D. and Sephton, L.M. (1984) Heterotrophic activity and seasonal cycles of bacteria in a hypertrophic, African lake (Hartbeespoort Dam, South Africa). *Verh. Internat. Verein. Limnol. 22* 1204-1207.

Robarts, R.D. and Zohary, T. (1984) *Microcystis aeruginosa* and underwater light attenuation in a hypertrophic lake. (Hartbeespoort Dam, South Africa). *J.Ecol. 72.* 1001-1017.

Roberts, P J.T. (1984) The need to adapt research effort in deterministic hydrology to meet changing requirements for water resource management in South Africa. South African National Hydrological Symposium - Proceedings. Department of Water Affairs/Water Research Commission Technical Report No. TR 119 pp. 109-112.

Schonau, A.P.G. and Schulze, R.E. (1984) Climatic and altitudinal criteria for commercial afforestation with special reference to Natal. Int. Union For.Res.Org., *Proc. Symp. on Site and Productivity of Fast Growing Plantations, 2* 551-563 Pretoria.

Schultz, C.B. and Schulze, R.E. (1984) The sensitivity of output from a distributed model to rainfall input and antecedent moisture conditions : Initial results. South African National Hydrological Symposium - Proceedings. Department of Water Affairs/Water Research Commission Tech. Rep. No. TR 119 pp. 146 - 160.

Schulze, R.E. (1984) Depth-duration-frequency studies in Natal, based on digitized data. South African National Hydrological Symposium - Proceedings. Department of Water Affairs/Water Research Commission Tech. Rep. No. TR 119 pp.214-235.

Schulze, R.E. (1984) Hydrological processes : Concept and thoughts, with reference to Southern Africa. South African National Hydrological Symposium - Proceedings. Department of Water Affairs/Water Research Commission Tech. Rep. No. TR119 pp. 18-67.

Seed, A.W., Dent, M.C., Schulze, R.E. and Murgatroyd, E. (1984) An assessment of techniques for synthesising annual rainfall data. Proceedings of the South African National Hydrological Symposium. Dept. Environment Affairs/Water Research Commission. Tech. Rep. No. TR 119 pp. 94-101.

Simpson, M.P.J., MacMillan, C.D. and Groves, G.R. (1984) The treatment of wool scouring effluent with water reuse. 4th Nat. Meeting of SAIChE, Potchefstroom University for CHE, Potchefstroom, 13-15 March.

Stephenson, D (1984) Kinematic analysis of the effect of storm dynamics on runoff hydrographs. *Water SA 10*(4) 189-196.

Stephenson, D. (1984) Kinematic analysis of storage. *Proc. Stormwater and Water Quality Users Group Meeting,* Detroit, E.P.A.

Steynberg, R.E., Nel, P.C. en Hammes, P.S. (1984). Die invloed van grondvrugbaarheid en vogvoorsiening op reproduktiewe opbrengskomponente en vogverbruikspatroon by mielies. *Handelinge van SA Vereniging van Gewasproduksie 13* 14.

Taylor, R., Best, H.J. and Wiechers, H.N.S. (1984) The effluent phosphate standard in perspective. Part I : Impact, control and management of eutrophication. *IMIESA 9*(10) 43-56.

Trim, B.C. and McGlashan, J.E. (1984) Sludge stabilization and disinfection by means of autothermal aerobic digestion with oxygen. *Wat. Sci. Tech. 17* 563-573.

Twinch, A.J. and Ashton, P.J. (1984) A simple gravity corer and continuous flow adapter for use in sediment/water exchange studies. *Wat. Res. 18* 1529-1534.

Van Staden, J.F. en Van Vliet H.R. (1984) Vloei-inspuit analise vir die bepaling van die totale alkaliniteit in oppervlakte-, grond- en huishoudelike water volgens die geoutomatiseerde bromokresolgroen metode. Water SA 10(3) 168-174.

Van Steenderen, R.A., Genthe, B., Nupen, E.M. and Van Leeuwen, J. (1984) Final disinfection with chlorine and chlorine dioxide in relation to THM production in water reclamation. *Proceedings AWWA Reuse III Conference,* San Diego, 26-31 August.

Van Vliet, B.M. and Venter L. (1984) Infrared thermal regeneration of spent activated carbon from water reclamation. *Wat.Sci.Tech. 17* 1029-1042

Van Vliet, B.M., Venter, L. and Vennekens, M.J.A. (1984). Rapid regenerability assessment for particulate activated carbons. *Proceedings AWWA Water Reuse III Conference,* San Diego 26-31 August.

Walker, S., Oosterhuis, D.M. and Savage, M.J. (1984). Thermocouple psychrometers for measurement of leaf water potential components. *South African J. Sci. 80* 268.

Watermeyer, G.S. (1984) Epidemiological research and water supply. *Proceedings of the 63rd annual conference of Municipal Engineers,* Cape Town May 8 -11.

Weaver, A van B. and Hughes, D.A. (1984) Continuous moni-toring of rainfall, streamflow and suspended sediment con-centration in semi-arid environments. Challenges in Africanhydrology and water resources. *Proc. Harare Symp.*, July. IAHS Publ. No. 144.

Wentzel, M.C., Dold, P.L., Ekama, G.A. and Marais, G.v.R. (1984) Kinetics of biological phosphorus release. Presented at 12th IAWPRC post conference seminar on biological phosphorus removal, Paris.

Wiechers, H.N.S. (1984) Biological nutrient removal in South Africa. *IWPC 1984 Yearbook,* 47-50.

Wiechers, H.N.S., Louw, A.S., Thirion, N.C. and Brodisch, K.E.U. (1984) Upgrading of biological filter sewage purification processes for phosphate and nitrogen removal. *Water SA 10*(4) 205-210.

Wiechers, H.N.S., Taylor, R. and Best, H.J. (1984) The effluent phosphate standard in perspective : Part II : State-of-the-art of technology for limiting phosphate discharge to the water environment. *IMIESA 9*(11) 27-35.

REPORTS RELEASED

Blackbeard, J.R. and Ekama, G.A. (1984) Preliminary report on filamentous micro-organisms responsible for bulking and foaming in activated sludge plants in Southern Africa. Research Report No. W 49, Dept. of Civil Eng., University of Cape Town.

Ekama, G.A. (1984) Final report to the Water Research Commission on a four year contract on research on the optimization of the modified activated sludge process for nutrient removal (1980-1983). Research Report No. W52, Dept. of Civil Eng., University of Cape Town.

Funke, J.W., Knoesen, J.G. and Venter, J.C. (1984) *Code of practice for the handling of manure from intensive animal feeding units.* Water Research Commission and Department of Agriculture, Division of Agricultural Engineering, Pretoria.

Green, I.R.A. (1984) WITWAT Stormwater drainage program - theory, applications and user's manual. Report 1/1984, Version II, Report 2/1984.

Grobler, D.C. and Silberbauer, M.J. (1984) Impact of eutrophication control measures on the trophic status of South African impoundments. Water Research Commission Report No. 130/1/84.

Hope, A.S. (1984) Simulation of stormflow volumes from small catchments. Water Research Commission, Pretoria. Report Number 66/2/84.

Hope, A.S. (Editor) (1984) Selected hydrological studies using multivariate statistical techniques. Water Research Commission. Pretoria. Report Number 66/3/84.

Mellish, F.C.S. and Marais, G.v.R. (1984) An investigation into an integrated physical chemical biological wastewater treatment process. Research Report No. W51, Dept. of Civil Eng., University of Cape Town.

Mulder, G.J. (1984) Die invloed van infiltrasie op stormwaterafloop in die opvanggebied van die Ntuzerivier (Zoeloelandse kusstrook). Water Research Commission,Pretoria, Report No. 66/4/84.

Müller, J.L. and Botha, J.F. (1984) A preliminary investigation of modelling the Atlantis aquifer. Institute for Groundwater Studies, University of the Orange Free State.

National Institute for Water Research and the National Research Institute for Oceanology (1984) Experimental disposal of sewage to sea. Final collaborative report to the Durban Corporation and the Water Research Commission.

Pegram, G.G. and Kunst, P.G. (1984) Continuous streamflow modelling of South African rivers. Final report to the Water Research Commission by the Department of Civil Engineering, University of Natal.

Schmidt, E.J. and Schulze, R.E. (1984) Improved estimates of peak flow rates using modified SCS lag equations. Water Research Commission, Pretoria, Report No. 63/1/84.

Schulze, R.E. (1984) Hydrological models for application tosmall rural catchments in Southern Africa : Refinements and development. University of Natal, Pietermaritzburg, Department of Agricultural Engineering, Water Research Commission, Pretoria. Report No. 63/2/84.

Slim, J.A., Devey, D.G., and Vail, J.W. (1984) Sludge dewatering and the treatment of sludge liquors. Final report to the Water Research Commission by the City Engineer's Department, Port Elizabeth. Water Research Commission Report No. 82/1/84.

Trim, B.C. (1984) Autothermal aerobic digestion using oxygen. Final report to the Water Research Commission by the City Engineer's Department, Johannesburg. Water Research Commission Report No. 87/1/84.

Water Research Commission (1984). *Theory, Design and Operation of Nutrient Removal Activated Sludge Processes.* Information document in collaboration with the University of Cape Town, City Council of Johannesburg and the National Institute for Water Research of the CSIR.