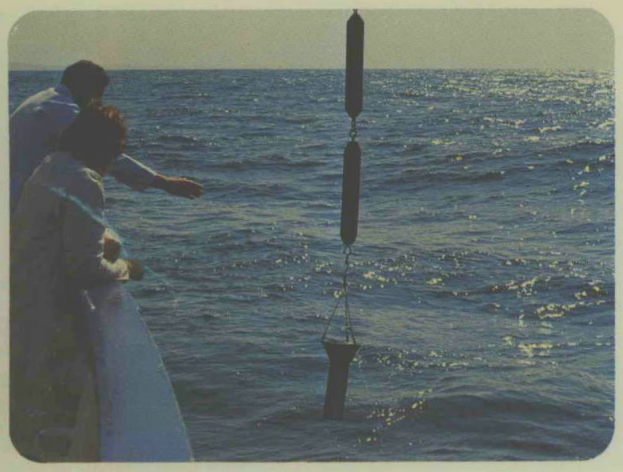
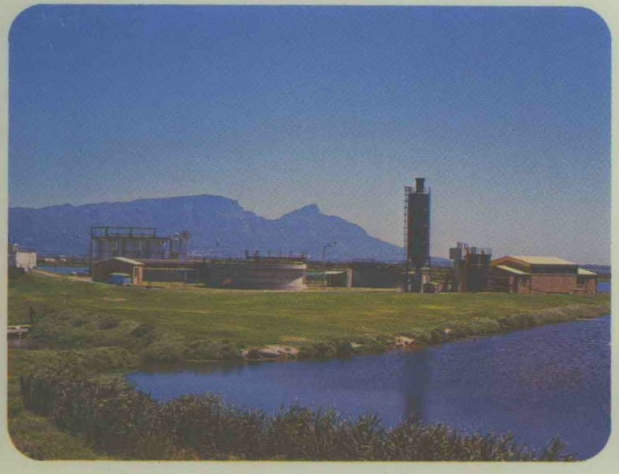




Water Research Commission

ANNUAL REPORT

1 January to 31 December 1982

Contents

Water Research Commission
PO Box 824
PRETORIA
0001
8 April 1983

Dear Sir

We take pleasure in submitting to you, herewith, the report of the Water Research Commission. This report covers the period 1 January 1982 to 31 December 1982.

The balance sheet and statement of revenue and expenditure for the financial year 1 January 1982 to 31 December 1982, as certified by the Auditor-General, are furnished in Chapter 13 of this report.

Yours respectfully

MR Henzen
CHAIRMAN

JF Otto
VICE CHAIRMAN

The Honourable SAS Hayward, MP
Minister of Environment Affairs and Fisheries
PO Box 23
CAPE TOWN
8000

MEMBERS OF THE WATER RESEARCH COMMISSION

Dr MR HENZEN
Chairman: Chief Executive Officer

MR JF OTTO
Vice Chairman
Director-General: Department of Environment Affairs

DR CF GARBERS
President: Council for Scientific and Industrial Research

MR EJ HALL
Former City Engineer of Johannesburg and now consultant with a firm of consulting engineers

DR DW IMMELMAN
Director-General: Department of Agriculture

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

PROF DJ SCHOEMAN
Dean: Faculty of Engineering
University of Pretoria

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

MR JG DU PLESSIS
Deputy Director-General: Department of Environment Affairs (Co-opted member)

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

Chapter 1

The year in review

The Water Research Act (Act No 34 of 1971), in terms of which the Water Research Commission was established, was enacted to make provision for the promotion of research with regard to water matters. This task requires a multi-disciplinary approach to all aspects relating to the beneficial use and supply of water. For the implementation of the Water Research Act and this multi-disciplinary approach the main task areas of the Commission were determined and tabled in Parliament by way of the first annual report in 1973.

These task areas are still applicable today but it is obvious that modifications may be required and that the order of priorities may be changed with the passage of time and as circumstances change. The result has been that the relative expenditure in various research areas has undergone certain changes over the years. This trend is illustrated in the table showing the financial contributions of the Commission to water research during the last decade.

The table clearly indicates how the investment in specific areas has varied. For example, 63% of the investment in 1972 was in water reclamation whereas this figure was only 15% in 1982. Research on rainfall stimulation received 2% of the allocation in 1976 against 23% in 1982. It should be noted, however, that a reduction in expenditure in a specific area does not necessarily imply that a lower priority has been accorded to that area. It could, however, mean that research results are now successfully being applied in practice resulting in a reduced demand for further research.

New research activities

Several research projects were successfully completed during 1982 and the Commission currently supports 65 projects including 15 new ones which commenced during the year. The new projects are:

- Research on integrated studies of the generation of runoff, solutes and sediment in tributary catchments of the Great Fish River. (Contract with Rhodes University — Department of Geography).
- 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 treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge; prototype study. (Contract with the CSIR — National Institute for Water Research).

EXPENDITURE ON RESEARCH AREAS IN R × 10^3

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	TOTAL
1. Water reclamation	20 (63%)	238 (57%)	314 (41%)	577 (35%)	1 654 (48%)	1 116 (36%)	532 (18%)	679 (23%)	484 (16%)	619 (18%)	725 (15%)	6 958 (26%)
2. Ground water	–	–	47 (6%)	255 (15%)	469 (14%)	454 (15%)	591 (20%)	358 (12%)	270 (9%)	210 (6%)	120 (2%)	2 774 (11%)
3. Water environment (incl. eutrophication)	7 (22%)	51 (12%)	62 (8%)	91 (6%)	272 (8%)	384 (12%)	469 (16%)	269 (9%)	281 (10%)	154 (5%)	371 (8%)	2 411 (9%)
4. Municipal wastewater	–	7 (2%)	92 (12%)	127 (8%)	115 (3%)	136 (4%)	161 (6%)	227 (7%)	262 (9%)	381 (11%)	372 (8%)	1 880 (7%)
5. Industrial effluents	–	7 (2%)	60 (8%)	76 (4%)	139 (4%)	278 (9%)	301 (10%)	412 (14%)	511 (17%)	593 (17%)	514 (11%)	2 891 (11%)
6. Desalination	5 (15%)	88 (21%)	118 (15%)	192 (12%)	185 (5%)	155 (5%)	195 (7%)	236 (8%)	180 (6%)	212 (6%)	366 (8%)	1 932 (7%)
7. Water consumption (incl. dry cooling and water economy)	–	15 (3%)	7 (1%)	36 (2%)	63 (2%)	86 (3%)	80 (3%)	52 (2%)	219 (8%)	314 (9%)	270 (5%)	1 142 (4%)
8. Irrigation	–	–	–	29 (2%)	68 (2%)	112 (4%)	129 (4%)	177 (6%)	197 (7%)	250 (7%)	556 (11%)	1 518 (6%)
9. Surface hydrology	–	11 (3%)	72 (9%)	264 (16%)	413 (12%)	252 (8%)	255 (9%)	319 (11%)	366 (12%)	460 (13%)	422 (9%)	2 834 (11%)
10. Rainfall stimulation	–	–	–	–	50 (2%)	144 (4%)	232 (8%)	248 (8%)	190 (6%)	267 (8%)	1 112 (23%)	2 243 (8%)
TOTAL	32	417	772	1 647	3 428	3 117	2 945	2 977	2 960	3 460	4 828	26 583

- Investigations into the use of physical-chemical techniques for the treatment and management of industrial effluents with high organic contents, preliminary investigation to define problem areas. (Contract with a firm of consulting engineers, Binnie and Partners).

- Investigations into 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).

- 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).

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

- 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).

- Research on urban hydrology and drainage. (Contract with the University of the Witwatersrand — Department of Civil Engineering).

- Research on weather modification at Nelspruit. (Contract with a firm of consulting meteorologists, Simpson Weather Associates, USA).

- 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.

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

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

- Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization. (Contract with the Department of Environment Affairs — Division of Geohydrology, and the University of Stellenbosch — Department of Geology).

- Research on the desalination of mine waters (Contract with the Chamber of Mines).

Technology transfer by means of demonstrations

Technology transfer, i.e. the application of research results, enjoys a high priority and the Commission has developed several strategies for its promotion. The adoption of the partnership principle in research agreements is the most important of these, since it involves the potential user of the results as partner in the planning and execution of the research.

During the year another method of promoting technology transfer received considerable attention, namely that of open days at which the research scientists involved in the development of the new technology present papers followed by practical demonstrations of the technology on experimental or full scale. On three occasions during the year technology developed with financial aid from the Commission with respect to the treatment of municipal and industrial effluents (reported later in this chapter), was demonstrated to interested persons during open days. It was found that these open days were particulary useful in promoting personal contact between the research scientist and the end user and that the visual experience contributed greatly towards further application of the results in practice.

Highlights

The Commission's various activities in the water field are presented in the respective chapters of this report. Certain developments during the year which are deserving of special mention, however, are discussed in this chapter:

Guide on water reclamation now available

An important milestone in the process of technology transfer with regard to water reclamation was reached when a guide entitled *Guide for the planning, design and implementation of a water reclamation scheme* was published. This guide was officially released when the Honourable SAS Hayward, Minister of Environment Affairs and Fisheries, received it officially on behalf of the Commission on 17 November 1982. The presentation took place during an open day at the Goudkoppies and Bushkoppie sewage purification works. The venue for the presentation of this guide was not a chance one, however, it was planned, since sewage purification plays a very important role in the whole process of water reclamation. An optimised sewage purification plant such as Goudkoppies produces an effluent which is eminently suitable for water reclamation.

This guide on water reclamation was compiled, on behalf of the Commission, by a firm of consulting engineers viz. PGJ Meiring and Partners, with a view to effective transfer and application of the technology

The Honourable S A S Hayward, Minister of Environment Affairs and Fisheries, receiving the manual on water reclamation from Mr Piet Meiring of the firm P G J Meiring and Partners who compiled the manual on behalf of the Commission.

developed and optimised in South Africa over a period of more than two decades. It provides guidelines and methods for the planning, design and commissioning of water reclamation schemes.

The guide has been directed mainly at the following professional groups who will all play key roles in any water reclamation scheme:

- the planner and decision-maker who will have to decide on the objectives and implementation of water reclamation and who will coordinate and control the project;
- the process engineer who has to determine the appropriate process configuration in order to achieve the objectives; and
- the design engineer responsible for the design of the plant.

In an effort to effectively transfer this information to these groups, the guide has been divided into six parts, namely planning; processes; guidelines for design; operation and maintenance; cost estimation; and water reclamation in Southern Africa which provides information on local research and full-scale water reclamation plants.

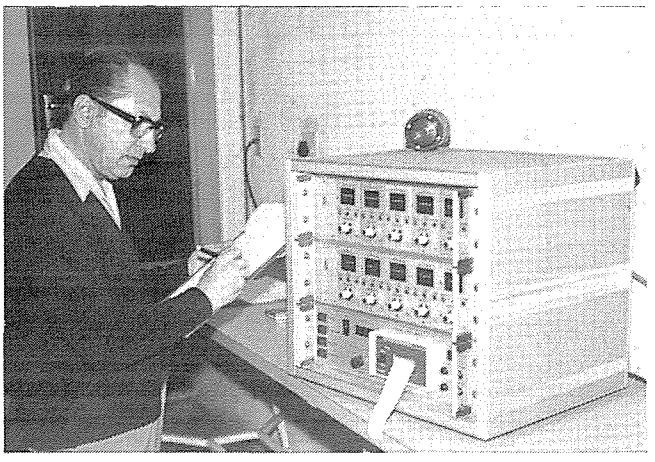
Fish used as a sensor for continuous testing of reclaimed water quality

An additional system, viz. fish biomonitoring, has been introduced in the existing monitoring programme for reclaimed water in Windhoek.

The reclamation of wastewater in Windhoek is unique in the sense that this was the first and still is the only plant in the world where waste water is recycled directly for potable reuse. To ensure that the reclaimed water complies with the standards for potable use, an extensive quality surveillance programme is being done including chemical, bacteriological and virological programmes. Therefore, the introduction of a fish biomonitoring system is a further safeguard in this respect.

This work forms part of a project which is carried out by the National Institute for Water Research in terms of a contract between the Commission and the CSIR.

Mr Steve Morgan of the National Institute for Water Research checking data from the fish biomonitoring system.



Conventional microbiological and physical-chemical quality surveillance programmes are not continuous processes because of intervals inherent in sampling procedures. Therefore, it does not continuously allow for the detection of toxic compounds which may constitute a serious hazard. Biological monitoring, on the other hand, is continuously in operation and can detect hazardous conditions and provide advance warning of toxic substances.

The National Institute for Water Research in collaboration with the National Electrical Engineering Research Institute, also of the CSIR, have since 1971 been investigating methods of monitoring water quality by means of biological sensors. Interest centred particularly around reclaimed water and industrial wastewaters discharged into rivers and dams. Minute concentrations of e.g. heavy metals and pesticides cause a marked deviation in the rhythm of gill movement, heart rate and relative activity of fish. Continuous electronic monitoring of one or more of these functions therefore allows early detection of potentially hazardous situations and consequently timeous steps may be taken to prevent either pollution of the environment or the passage of toxic substances into domestic water supply systems.

The monitoring system at the Windhoek Water Reclamation Plant employs the locomotory behaviour pattern of fish.

Information on nutrient removal in activated sludge plants becomes available

The technology for biological nutrient removal in the activated sludge process has reached such an advanced stage that it can now successfully be applied by local authorities. This was the message to about 300 people at an open day and demonstation arranged by the Water Research Commission and the City Council of Johannesburg on 17 November 1982. Results of research on biological nutrient removal by the City Council of Johannesburg, the National Institute for Water Research and the Universities of Cape Town and Pretoria, with financial support from the Commission, were presented and visits to the Goudkoppies and Bushkoppie Sewage Works took place to demonstrate full-scale nutrient removal.

The presence of nutrients, especially phosphates and nitrates, in effluents causes eutrophication. The Water Research Commission has anticipated the need for technology for nutrient removal from effluents and already initiated research in this regard since 1973. At that stage the technique of biological nutrient removal, and especially phosphate removal, presented itself as a technique with considerable potential as an economic and technically feasible means of dealing with this problem. Consequently, a number of projects were launched by the Commission to develop this technique for full-scale application. The removal of nutrients from effluents comes even more to the fore since legislation was promulgated to the effect that the phosphate standard in effluents must be less than 1 mg/ℓ by 1 August 1985.

A considerable body of information is now available on biological nutrient removal. In order to inform those involved in this field, i.e. city engineers and chemists, consulting engineers, government agencies, instrument and plant suppliers and research organizations, this open day was arranged.

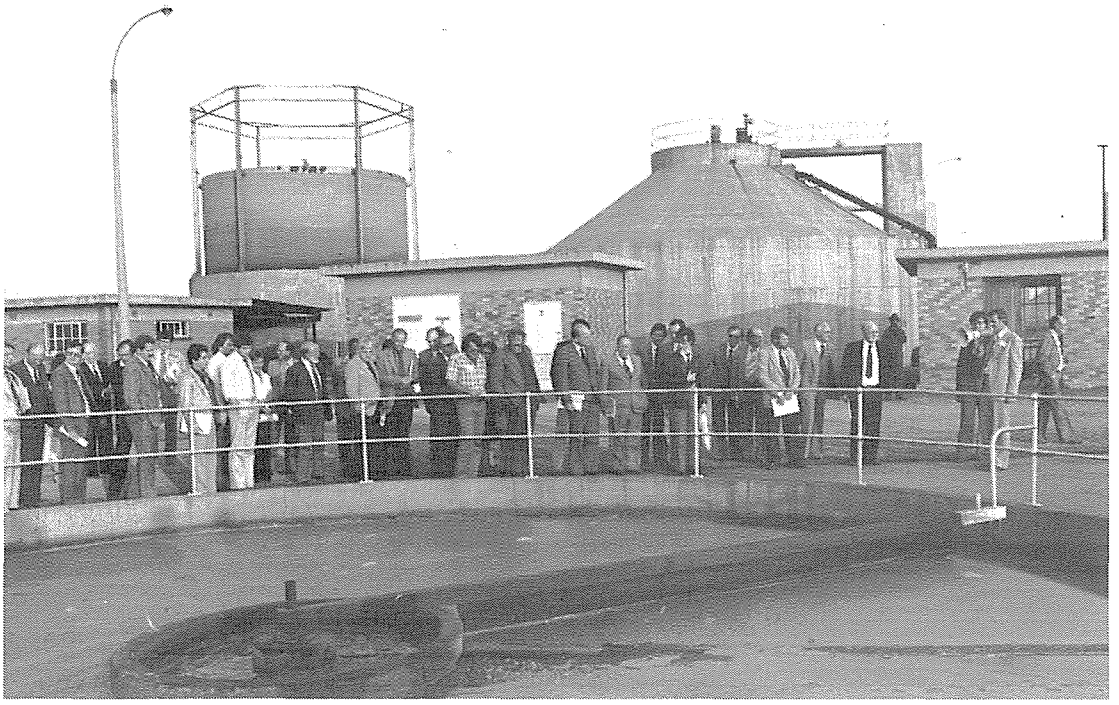
The open day and demonstration form part of the technology transfer programme of the Commission and other activities to promote the application of the research results in this regard are to follow. In this connection the results of the research are currently being compiled in the form of a comprehensive information document and a short course is planned on the use of this technology transfer document in order to promote the planning, design and operation of biological nutrient removal schemes.

Existing biological filter systems can be used for phosphate removal

Techniques for the chemical removal of phosphates from biological filter effluents, were demonstrated during an open day at the Vlakplaats sewage works, Boksburg on 26 May 1982. This open day was arranged by the Water Research Commission and the City Council of Boksburg.

The presence of phosphates in effluents discharged to the water environment results in one of the best-known symptoms of pollution, namely eutrophication, i.e. the enrichment of water with plant nutrients which promote the excessive growth of algae and nuisance aquatic plants such as the hyacinth. In order to combat this pollution the Department of Environment Affairs in 1980 announced limiting phosphates in effluents to less than 1 mg/ℓ. Although relaxation of the date of implementation of this standard has been granted to local authorities, the standard will be strictly enforced from August 1985.

It is estimated that approximately 65 per cent of the sewage works in the Republic's senstive catchment areas are still utilizing biological filter systems and the removal of phosphates from effluents derived from these systems is, especially from an economic point of view, of extreme importance. It is, therefore, indeed fortunate that the technology to achieve this has become available. The research of the City Council of Pretoria and the National Institute for Water Research in terms of a contract with the Commission in collaboration with the City Council of Boksburg has resulted in the development of this technology for full-scale application.



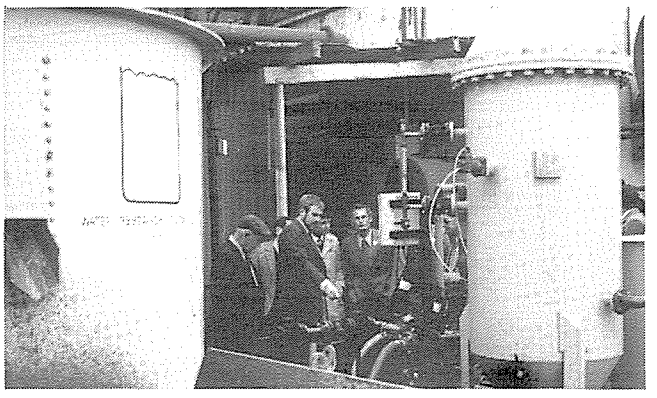
Many visitors attended the open day at the Vlakplaats Sewage Works, Boksburg during which chemical phosphate removal from biological filter works effluents was demonstrated.

This open day constituted a first effort at publicising on a wider basis and in a practical manner, the technology for nutrient removal at biological filter systems. The final results of the current research programme will be collated in a technical guide and will be available for general distribution, which will be aimed especially at the municipal engineer and his consultant.

Pollution by fish processing effluents can now be successfully combated

As part of its technology transfer programme, the Commission arranged during the year a demonstration of a pilot scale dissolved-air flotation plant for the treatment of fish processing effluents at Suid-Oranje Fisheries, St Helena Bay. The technology in this regard resulted from research which had been and is still being sponsored by the Commission and which forms part of its comprehensive research programme on the treatment and management of industrial effluents.

The effluents from fish processing plants are high in organic content (fats and proteinous substances), leached or expelled during handling and processing of the fish. Contact between fish and water is unavoidable which means that if pollution of processing effluent-receiving waters is to be avoided, a method must be found to separate the pollutants from the water.



The pilot plant for the treatment of fish processing effluent at St Helena Bay.

The pollutants so separated are useful substances and can be returned to the fish meal and oil process thereby increasing the yield and hence profitability of the entire process.

As the contaminants present in the effluents are more prone to float than to settle, the process of separation becomes one of improving the efficiency of the naturally-occurring floating process.

The plant has been operated on effluents originating from dry and wet offloading systems and canneries; both pilchard and anchovy effluents have been treated. It has shown that it is capable of removing up to 60% of the chemical oxygen demand and the suspended solids in the effluents and of producing a sludge with a high protein content.

Desalination of mine waters is necessary for combating mineralisation

During the year agreement was reached between the Commission and the Chamber of Mines for a research project on the desalination of underground mine waters to be initiated on a partnership basis. In terms of the agreement the Commission will make available the pilot-scale equipment for the desalination investigations and the expertise for its operation and the Chamber of Mines will provide for the installation and operation of the units.

Underground mine water makes a considerable contribution to the salt load entering the Vaal River system. Studies of the water status of the Pretoria-Witwatersrand-Vaal Triangle (PWV) area showed that the contribution of underground mine waters to the mass of salts finding its way to the Vaal Barrage amounted to between 30 and 40% of the total, whilst representing approximately 5% of the volume of the inflow. These studies were financed by the Commission and included the development of suitable models to project the availability and quality of water in the PWV area. These models are currently being used by the Directorate of Water Affairs as a planning aid. The model studies also showed that concentration of dissolved salts in the Vaal Barrage and downstream in the Vaal River will steadily increase with increasing reuse and an increase in the population and industrial activities in the PWV area, unless salts are removed from the system.

An increase in the concentration of dissolved salts has a detrimental effect on the efficient utilisation of water in the Vaal River system, on the Republic's limited water resources as a whole and also has significant cost implications for the water consumer.

In the case of the PWV area the problem of the steadily increasing concentration of dissolved salts can be alleviated by dilution, i.e. importing additional fresh water into the system, or by pumping mineralised effluents from the catchment, or by desalination of the effluents and evaporation or removal of the concentrates. At this stage it would seem that the latter alternative, i.e. desalination of these waters will contribute greatly to the stabilisation of the dissolved salts content of Vaal River water. The Commission consequently decided to initiate and support research on the desalination of mine waters.

Desalination and reuse of underground mine water will be beneficial to the mining industry, especially as far as mine service water is concerned. It will result in savings in fresh water intake and impoved control of dissolved salts concentrations in mine service water which will assist in limiting corrosion.

Techniques refined for more accurate prediction of flood occurrences

In terms of a contract with the Commission the Hydrological Research Unit (HRU) of the University of the Witwatersrand commenced with research on flood occurrences in 1977. The project was successfully completed during the year and 11 reports were released during the term of the contract.

The principal results include the development of programmes for flood forecasting, reservoir routing and flood gate operation. Point-rainfall and large-area storm studies were also undertaken.

One of the major objectives of the research was to overcome certain shortcomings that were recognised in the well-known HRU Report 1/72 *Design flood determination in South Africa.* In brief, these shortcomings encompassed errors in estimating floods for small catchments and errors in real time prediction of floods. In the final years of the project, the HRU was requested to extend its investigations to include the arid regions of the Republic and South West Africa/ Namibia which have generally been excluded from previous research programmes. This resulted in a design flood manual for this region.

The results of this research project are already being used extensively by South African hydrologists, but much research is required to further refine flood estimation techniques.

The 11 reports were presented to the Minister of Environment Affairs at a ceremony at the University of the Witwatersrand on 14 July 1982.

Guidelines now available for the estimation of water resources in South Africa

A research project on water resources by the Hydrological Research Unit of the University of the Witwatersrand in terms of a contract with the Commission was successfully completed during the year.

The final report of this research takes the form of a six volume series presenting guidelines for estimating water resources in South Africa. The refinement of estimates of South African water resources constitutes a long term research effort and the report is regarded as a major contribution in this regard.

In the research an appraisal of the Republic's water resources was made and methods have now been provided whereby hydrologists can generate the streamflow history, predict stream behaviour and analyse the interplay of complex water supply and demand systems. There is no doubt that hydrologists will rely heavily on the guidelines for water resource analysis, planning and management in the future. The six volumes contain such a great deal of hydrological information that it was decided to produce a users guide to the series in order to facilitate effective use of the material. The production of the guide is now in progress.

The final reports were presented to the Minister of Environment Affairs at a ceremony at the University of the Witwatersrand on 14 July 1982.

A national data bank of digitized rainfall records now available

A national data bank of digitized rainfall records has been developed by the South African Weather Bureau in terms of a contract between the Department of Transport and the Commission.

The two major tasks involved in initiating the data bank were, firstly, digitising of a multitude of raingauge charts that had been collected by several agencies over the years and, secondly, developing the computer programs for the orderly storage, retrieval and analysis of the data.

This project has worked in close collaboration with a similar project undertaken by the Department of Agricultural Engineering at the University of Natal. The latter undertook the task of digitizing rainfall charts (from Natal initially) to provide the Weather Bureau with the necessary information in a format to be stored in the data bank.

There are still historical records that require processing but a great deal of progress has been made and the objective of initiating the development of the data bank has been achieved.

It is now possible for researchers to acquire the data from the data bank in a wide variety of forms and it is expected that the availability of the data will give much impetus to research on depth/duration/frequency relationships for South African rainfall. This information will largely facilitate the proper estimation and planning of water resources.

Establishment of a research plan to comply with research requirements with regard to irrigation

The first two of five planned workshops for identifying irrigation research requirements were held during the year. These workshops were arranged at the request of the Coordinating Committee for Irrigation Research (CCIR) which functions under the control of the Department of Agriculture and comprises representatives from inter alia the Department of Environment Affairs and the Commission. This Committee has, as one of its primary tasks, the identification of shortcomings and priorities in irrigation research. Aspects to be covered during the proposed five workshops are agronomic aspects of irrigation; soil aspects of irrigation; impact studies of irrigation development; agricultural-economical and management aspects of irrigation systems; and irrigation and drainage systems.

The two workshops already held covered the following:

Agronomic aspects of irrigation

- Water requirements of different types of crops
- Climatological factors in irrigation
- Irrigation scheduling
- Technology transfer in irrigation

Soil aspects of irrigation

- Irrigation development and soil classification
- Soil physics
- Soil chemistry
- Soil fertility

Stemming from these workshops recommendations were formulated which will be submitted to the CCIR in 1983 and, if accepted, will serve as master plans of research for each of the fields of activity. As such they will serve as guidelines to the Commission in its financing of research.

New terminal facilitates entry to *Waterlit*

During the year a new computer terminal, on-line to *Waterlit,* was installed in the library of the Directorate of Water Affairs of the Department of Environment Affairs. For several years now indexers in the Directorate have been making an input to *Waterlit* but this has been cumbersome in that the input had to be punched on computer cards for entry into the data base. New input is now entered via the new terminal.

Waterlit is a computerised bibliographic data base developed by the South African Water Information Centre. This information centre is operated by the CSIR in terms of an agreement with the Commission. The data base already contains 60 000 items and provides for retrospective searches and offers SDI (selective dissemination of information) services.

The terminal is also available for retrospective searches and as soon as the required personnel have been trained, these searches for the Directorate of Water Affairs will be done from its own library. Currently all searches are being done at the South African Water Information Centre.

The *Waterlit* data base is of value to the scientific and technical staff of the Directorate and it is hoped that the new liaison will further enchance the utilisation of the data base.

Briefly

- **Information session on the activities of the Water Research Commission**

  During the year an information session was arranged by the Commission in order to inform those persons working in the water field and those who liaise with the Commission of the activities of the first ten years of its existence. All the advisers of the Commission had an opportunity of discussing their relevant task areas with those present, amongst whom was the Minister of Environment Affairs.

- **Participation in international meetings**

  Some members of staff attended certain international meetings locally and overseas during the year and in the case of the IAWPRC (International Association of Water Pollution Research and Control) the following direct contributions were made to its international conference in Cape Town: Mr PE Odendaal was chairman of the organising committee and also read a paper, whilst Dr MJ Pieterse and Messrs CF Schutte and JJC Heynike also read papers.

Chapter 2

Research on water reclamation

The direct reuse of reclaimed water for domestic and industrial purposes can play an important role in ensuring the efficient utilisation of the Republic's water resources. As a result the Commission, since its inception, has accorded a high priority to the promotion of water reclamation and is currently supporting seven research projects in this regard.

The research centres mainly on technological aspects as well as on water quality and health aspects relating to water reclamation and reuse.

Guide on water reclamation

During the year a guide entitled: *A guide for the planning, design and implementation of a water reclamation scheme* was published. It was compiled on behalf of the Commission by a firm of consulting engineers, PGJ Meiring and Partners, and provides practical guidelines for the planning, construction and operation of a water reclamation scheme.

Water reclamation in Windhoek

As a result of the serious, long-lasting drought being experienced in South West Africa, reclaimed water has been used continuously during the year as an additional source of water to that derived from conventional sources. Despite the fact that the most recent technology regarding water reclamation is being applied, the utmost care is taken to ensure that the quality of the reclaimed water complies with potable water standards at all times. The latter aspect is carried out in collaboration with individual organisations, *viz* the South African Institute for Medical Research, National Institute for Water Research, Windhoek Municipality and the Department of Water Affairs (South West Africa).

All the results obtained thus far have shown that the water produced by the plant meets all the requirements for potable water. It was found that the occurrence of bacterial and virus diseases amongst the community was unrelated to the use of reclaimed water. Epidemiological studies were also continued on the possible long term effect of the use of reclaimed water on the health pattern of the population. Tests have shown that to date there is no relationship between the distribution and occurrence of chronic disease and the quality of drinking water in Windhoek.

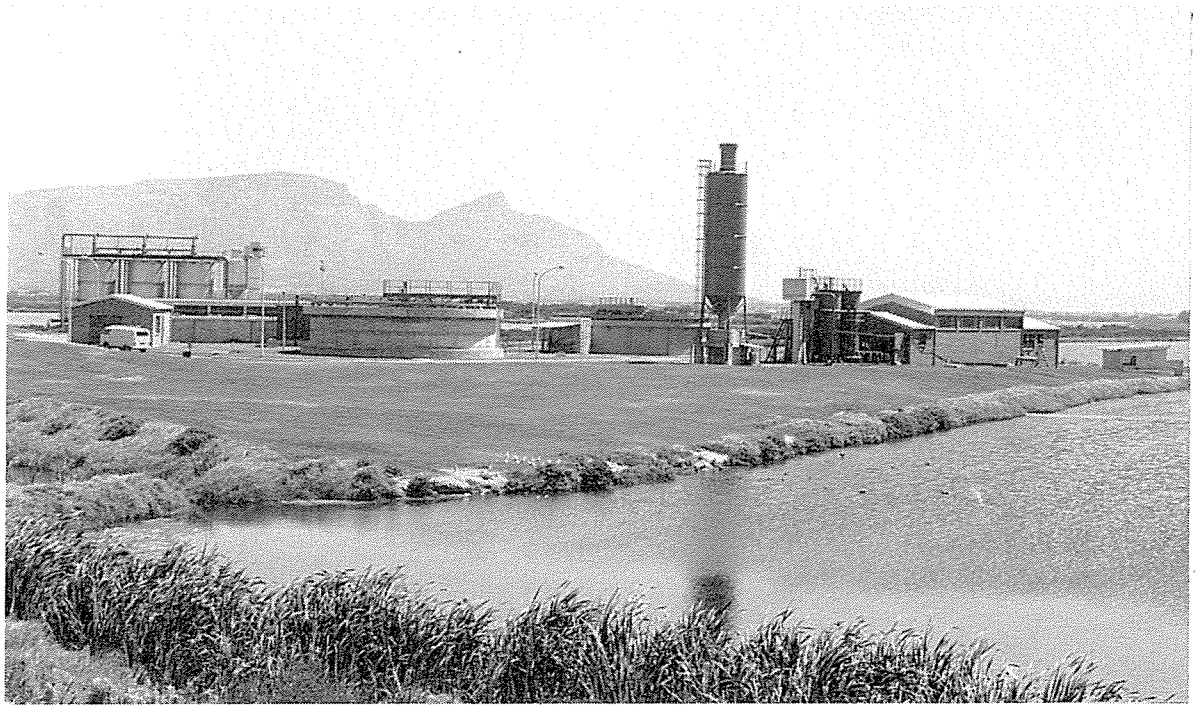
An additional method of monitoring reclaimed water has also been implemented with the installation of a system of fish biomonitoring.

Water reclamation in Cape Town

During the year the water reclamation plant erected on the Cape Flats for research and demonstration purposes was completed and initial test runs have commenced with a view to optimising the various processes. The eventual objective of this research is to develop the information required for a decision on the possible application of full-scale water reclamation in Cape Town and environs.

An epidemiological study of the inhabitants of Cape Town is being conducted as part of the water reclamation activities. This is a basic study for the determination of prevailing patterns of diseases occurrence with which future patterns may be compared when the source of water supply is changed.

Studies on reclaimed water quality surveillance will be undertaken, including a study of the virological quality of the water produced by the reclamation plant. This work will be done by the Department of Bacteriology of the University of Cape Town in terms of an agreement between the University and the Commission.



The water reclamation plant on the Cape Flats which has been erected for research and demonstration purposes.

The application of reverse osmosis as a water reclamation process

Reverse osmosis is a well-known desalination process extensively used for the desalination of sea water, brackish water and some effluents with a high salinity. Since the feed water in the process is forced through a physical obstruction in the form of a membrane, not only dissolved inorganic salts are held back but also dissolved and colloidal organic material and other suspended matter and a product water of high quality is obtained. In view of the possibility that reverse osmosis may be used for water reclamation, the Commission has entered into a new agreement with the CSIR in terms of which the National Institute for Water Research will conduct research in this regard. The aim is to demonstrate the economic viability of the process with an experimental plant.

List of research projects on water reclamation

- Technological development of water reclamation on the basis of the Windhoek plant (Existing project: 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 (Existing project: 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 (Existing project: Contract with the University of Cape Town — Department of Community Health).
- The constuction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality. (Existing project: Contract with the City Council of Cape Town).
- Research on the development and application of aspects of equilibrium chemistry and precipitation kinetics to water stability problems encountered in water reclamation. (Existing project: Contract with the University of Cape Town — Department of Civil Engineering).
- Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant (New project: Contract with the University of Cape Town — Department of Bacteriology).
- Research on the reclamation of secondary sewage effluent by reverse osmosis. (New project: Contract with the CSIR — National Institute for Water Research).

Chapter 3

Research on ground water

In view of the increasing stress on the Republic's water resources the role of ground water is becoming more important and much research is required to gain knowledge of the extent and distribution of ground-water resources and particularly the variability of the rate at which ground water is replenished by rainfall.

In European countries the contribution of ground water to the total water supply is often as high as 80 percent but in South Africa the contribution is of the order of 10 percent. This is mainly because South Africa is poorly endowed with suitable aquifers and most boreholes are in fractured hard rock. Under these conditions, many boreholes are required to extract adequate volumes of water in a short period of time for urban, industrial or irrigation use. Consequently, the major thrust of ground-water programmes supported by the Commission in the past has been to improve techniques for determining the exploitation potential of ground water in areas where surface supplies are limited. Much work remains to be done before the extent of ground-water supplies can be adequately assessed and the way determined in which development of the supplies should be integrated with the available surface water.

During the year the master plan for ground-water research (which was developed by a study group appointed by the Commission in collaboration with the Division of Geohydrology of the Department of Environment Affairs) was widely distributed to research organisations.

Negotiations are currently in progress to initiate several new research programmes which will be aimed at advancing the knowledge of the ground-water quantity and quality aspects.

Ground-water investigations in the Southern Free State and the Northern Cape

The project on the development and evaluation of techniques for determining the exploitation of ground-water resources in the Southern Free State and in the Northern Cape has been completed and the final report was distributed by the Commission during the year. The project was carried out by the Institute for Ground-water Studies in terms of a contract between the Commission and the University of the Orange Free State. Extensive research was done on a variety of aspects and large areas in the Southern Free State and the Northern Cape were surveyed by means of geohydrological mapping.

Detailed and regional investigations were done in the Southern Free State at Philippolis and the Northern Cape at Vryburg. It was found that with judicial placement of boreholes the ground water of the Southern Free State could be utilized effectively and water shortages for villages and stock watering could be alleviated.

A large number of computer simulation models were developed relating to ground-water movement and water quality changes in the ground-water system.

The applicability of ground-water models as an aid to the study of South African aquifers

The Commission is also supporting another project at the Institute for Ground-water Studies which deals with the applicability of ground-water models as an aid to the study of South African aquifers. The use of ground-water models for the evaluation and management of ground-water resources is becoming increasingly popular in developed countries. Many of the models used for various purposes overseas have been obtained and mounted on the computer at the University but much research is required regarding the testing of the models under South African conditions and their modifications for general use.

Unfortunately, the acquisition of sufficient data of adequate quality for testing the models is an expensive procedure that requires many years of measurement. It has therefore been decided to select specific problem areas that have been well monitored in the past as sources of data for model testing and in this way the time and cost of data collection can be minimised.

It has been decided to undertake the application and testing of the models in the following three problem areas where each area requires a different type of model:

- the Sishen Aquifer which is made up of a primary aquifer of Kalahari deposits above a secondary aquifer of hard fractured rock;
- the Crocodile River system which involves modelling the interaction between a river and an aquifer; and
- the Atlantis Aquifer which is a coastal aquifer and involves modelling interaction with the sea.

The evaluation of the geohydrological system in the Sishen area has been completed and a fair amount of success has been achieved with the calibration of the model. By using the calibrated model it is possible to predict the inflow rates and levels of dewatering for various mining activities until the year 1990.

The model can be used to provide guidelines for mining authorities regarding future dewatering policy in that area.

Research project on ground water

- The applicability of ground-water models as an aid to the study and evaluation of South African aquifers. (Existing contract with the University of the Orange Free State — Institute for Ground-water Studies).

Chapter 4

Research on the water environment

The optimal utilization potential of the Republic's water resources is adversely affected by pollution of the water environment. This pollution is a result of a human activity, caused by e.g. the discharge of municipal and industrial effluents (which have received various degrees of treatment) to streams, pollutants of human origin washed from the surface by storm water runoff, runoff from agricultural land which carries with it fertilizers from cultivated fields, and mineral salts which are mobilized by natural and irrigation waters. Two of the major problems caused by such pollution are eutrophication (which results in the excessive growth of algae and nuisance aquatic plants in impoundments), and mineralisation. In view of these problems the Commission sponsors several projects dealing with various aspects related to the water environment. In this chapter particular attention is given to eutrophication, mineralisation and inland water ecosystems in general.

Research on eutrophication in the Hartbeespoort Dam

A three year cooperative programme between the Water Research Commission, the National Institute for Water Research and the Cooperative Scientific Programmes of the CSIR was launched this year. The objective with this research is to obtain the necessary knowledge of the functioning of eutrophic impoundments in the RSA with a view to developing appropriate management strategies and techniques. The programme comprises a number of projects which addresses specific limnological issues. The results will be used to evaluate management techniques to deal with the effects of eutrophication. The specific tasks in this comprehensive programme which are being carried out are —

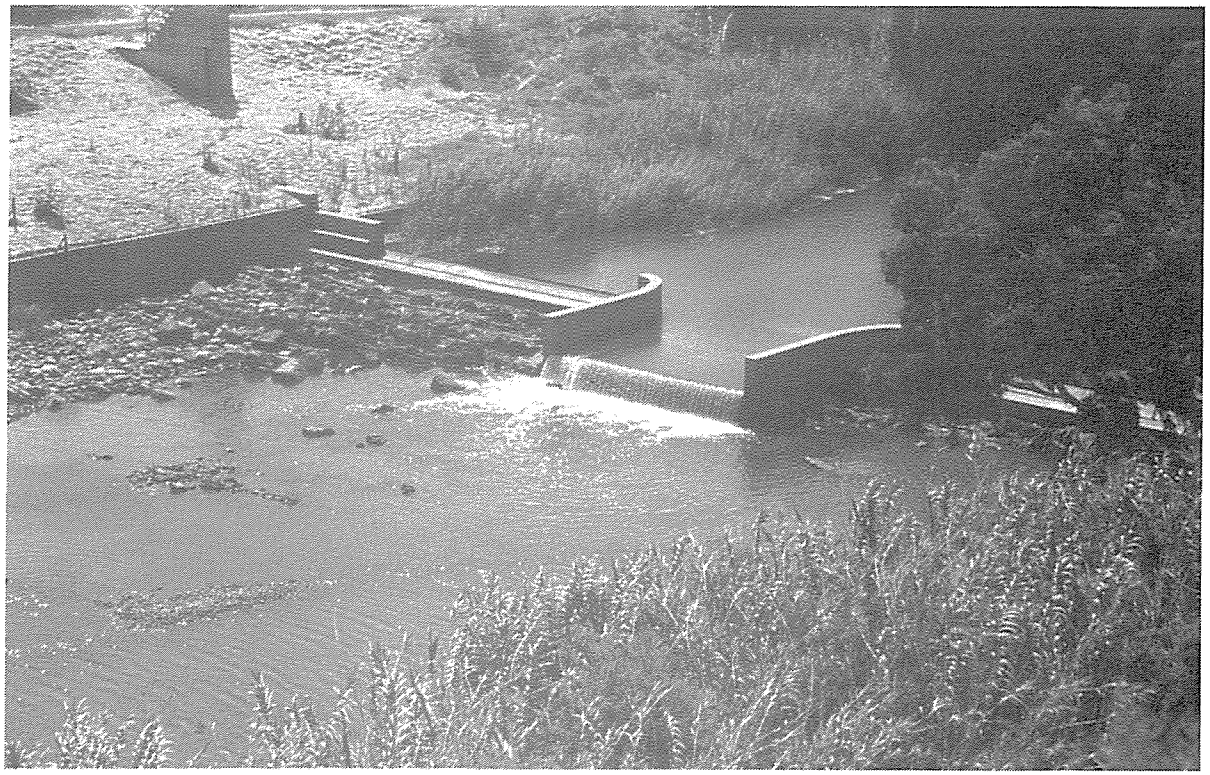
- an evaluation of the impact of the effluent phosphate standard of 1 mg/ℓ on the Hartbeespoort Dam ecosystem;
- a desk feasibility study on aeration and destratification;
- a desk feasibility study on biological management of the ecosystem;
- and an assessment of the protein production potential of the Dam.

The data collected under the programme are also being used to test existing predictive water quality models, and if considered necessary, will be used to refine existing models or to develop new ones.

Impact of phosphate limitation on eutrophic status of impoundments

Towards the end of 1982 a project was launched to evaluate and predict the impact of phosphate limitation on the trophic status of South African impoundments. This is done in view of the fact that a phosphate standard of less than 1 mg/ℓ in effluents discharged to critical catchments in the Republic will be strictly implemented from August 1985. The study is being jointly undertaken by the Hydrological Research Institute of the Department of Environment Affairs and the Institute of Environmental Sciences of the University of the Orange Free State with financial support by the Commission.

Based on the results of this study a first impression of the impact of the standard will be obtained, which may serve as a basis for deciding whether any revision of the standard or of present techniques for limiting the discharge of phosphates to the water environment, should be considered.



A weir in the Breede River. Geohydrological surveys with special reference to mineralisation are being carried out in the catchment of the Breede River Valley.

Mineralisation in the Eastern and Southern Cape

During the latter part of the 1960's and the early 1970's, serious problems experienced with mineralisation in the Great Fish, Sundays, Berg and Breede Rivers, gave rise to collaborative research programmes on river mineralisation from non-point sources in these catchments. These research programmes were coordinated by the Water Research Commission and involved the National Institute for Water Research as well as several state departments and universities. The main thrust of the research was the development and application of computerised mathematical models of limited complexity to shed more light on the principle mineralisation processes and areas, as well as to provide a means for predicting future water supply and mineral quality conditions. These hydro-salinity models are, however, empirical and have several shortcomings when their application is considered.

In view of the above a new project has been entered into with Rhodes University in terms of which its Department of Geography will carry out integrated studies of the generation of runoff solutes and sediment in tributary catchments of the Great Fish River. The aims of the project are to collect continuous data on the principal processes associated with the mineralisation of runoff in the existing semi-arid Ecca research catchments near Grahamstown; to test and improve existing hypotheses regarding natural mineralisation; to incorporate these hypotheses in the improvement of the existing hydro-salinity models; and to develop and test new models to meet future application requirements.

Complementary to this new project a tripartite contract was negotiated with the Department of Environment Affairs and the University of Stellenbosch for research to be carried out on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization. A practical mathematical model will be developed by means of which measures for controlling mineralization will be simulated. The results will also be published as guidelines to assist the Department of Environment Affairs, Department of Agriculture, farmers and other interested parties, in solving mineralization problems.

Inland water ecosystems

The Commission supports research on the water environment in an indirect way by means of an annual block grant to the Committee for Inland Water Ecosystems (CIWE) of the Cooperative Scientific Pro-

grammes of the CSIR. The CIWE is concerned with the stimulation and coordination of research directed at problems relating to the management and utilisation of the Republic's water resources. Research programmes, projects and studies currently being coordinated by the CIWE include the following:

- the effect of the environment on the catchments of the Upper Olifants, Buffalo, Mooi and Modder Rivers; eutrophication in the Hartbeespoort Dam and the Mgeni system;
- the role of suspended matter in turbid impoundments; and
- research on the potential of fish production in dams.

List of research projects on the water environment

- Eutrophication research in the Hartbeespoort Dam (Existing contract with the CSIR — National Institute for water Research).
- Evaluation of the impact of phosphate limitation on the trophic status of South African impoundments (New project: 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 integrated studies of the generation of runoff, solutes and sediment in the tributary catchments of the Great Fish River. (New project: 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 mineralization. (New project: Contract with the Department of Environment Affairs — Division of Geohydrology, and the University of Stellenbosch — Department of Geology).

Chapter 5

Research on the treatment of municipal wastewater

The Commission has for many years closely collaborated with local authorities and initiated and sponsored several research programmes which are not only of direct importance to this sector, but also to the country as a whole. This is being done because local authorities play a key role in the optimization of water utilization in the Republic and because they have a primary interest in and responsibility for the prevention of pollution by domestic sewage and industrial effluents, as well as by solid and toxic wastes and sludges.

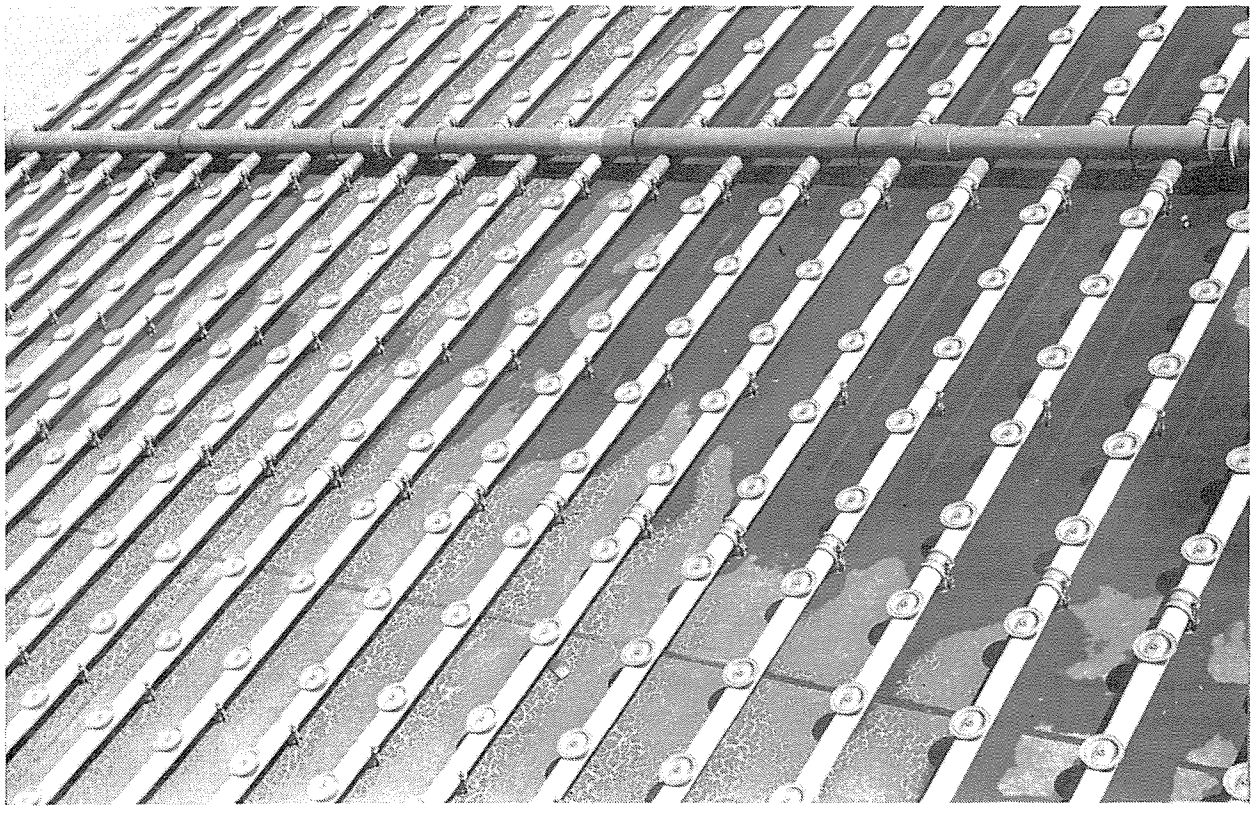
A major part of research financed by the Commission concerns local authorities directly but in this chapter, only those projects which deal with municipal wastewater are discussed. These projects may be classified into two categories *viz* research on the treatment of wastewater with the aim of removing nutrients which cause pollution and/or eutrophication, and research on the treatment and disposal of sewage sludge. In the first category two aspects are receiving attention, *viz* nutrient removal in the activated sludge process and nutrient removal from biological filter effluents.

Nutrient removal in the activated sludge process

The Commission is currently financing four projects on the optimisation of the activated sludge process for biological nutrient removal. The objective with these projects is to develop a sound basis for the planning, design and operation of nutrient removal activated sludge plants. The research is being carried out jointly by the City Council of Johannesburg, the National Institute for Water Research and the Universities of Cape Town and Pretoria.

The two projects being carried out by the City Council of Johannesburg and the National Institute for Water Research were concluded in 1982 while the other two will be concluded at the end of 1983. Excellent progress has been made with the research and the Commission has initiated a technology transfer programme to ensure that the findings of the research are available to the end user for application in practice. This will contribute significantly to the prevention and control of water pollution and/or eutrophication. The programme includes the following:

- An ''open day'' was arranged with the City Council of Johannesburg in November 1982 where research findings were presented to approximately 300 people. Visits were also arranged to the Goudkoppies and Bushkoppie Works where full-scale biological nutrient removal was demonstrated.
- The results are currently being compiled in the form of a guide for the planning, design and operation of activated sludge processes for the removal of plant nutrients. This guide will be of great value to the municipal and consulting engineer as well as to management and operational staff of sewage works.



Bubble aerators at the Bushkoppie Works. These Works have been designed for biological phosphate removal from effluents.

- The Commission in collaboration with the researchers active in this field will offer a one week course on the use of the guide mentioned above. This will give users an opportunity to undergo intensive training in the use of the information contained in this guide.

Nutrient removal from biological filter effluents

Research on the removal of plant nutrients from existing sewage works which comprise biological filters is nearing completion with the contract due to terminate in 1983.

Three organizations are actively involved in the project, *viz* the National Institute for Water Research and the City Councils of Pretoria and Boksburg.

In-depth evaluations have been done on the chemical removal of phosphates at the biological filter works at Daspoort, Pretoria and Vlakplaats, Boksburg. A full-scale study on nitrogen removal is still underway at the Daspoort Works.

In order to promote the application of the research results the Commission decided on the following steps:

- An "open day" was held in May 1982 at the Vlakplaats sewage works, Boksburg where the results were presented and chemical phosphate removal was demonstrated to more than 300 people.

- A guide is currently being prepared for chemical phosphate removal.

- As in the case of the guide on biological phosphate removal by the activated sludge process, a short course is planned to give users intensive training in the use of this guide.

The treatment and disposal of sewage sludge

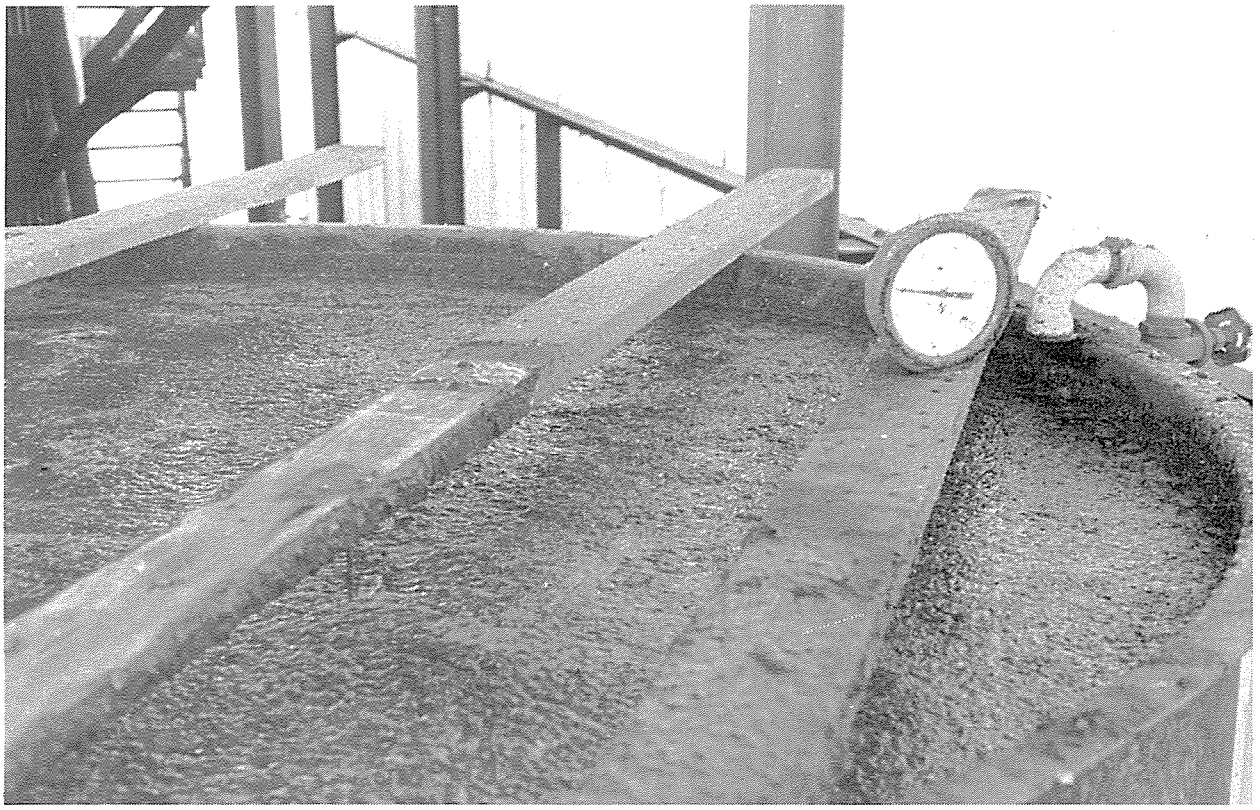
Sewage sludge, resulting from the treatment of wastewater, cannot be disposed of to land without undergoing some or other treatment. Without treatment it is a source of pollution to surface and underground water, a health hazard and will give rise to odour and other aesthetic problems.

The treatment and disposal of sewage sludge has long been a major problem for local authorities and in order to alleviate the current difficulties experienced by the municipalities in this respect, the Commission has initiated a research and development programme in this field. This programme is aimed at the development of processes which could be used independently or in combination with other processes, to ensure satisfactory solutions to the problems. The ultimate aim is to develop guidelines to be used on a national basis for the planning, design and operation of a full-scale plant.

Seven research projects were initiated on a partnership basis with local authorities and research institutes. Work is being conducted at laboratory-scale, pilot-scale and at full-scale and whereas certain aspects of the work have been subjected to delays due to commissioning difficulties of full-scale plant, other work has progressed unhindered.

Four of the projects relate to the stabilisation and disinfection of sludge and are being carried out by the City Council of Cape Town, the City Council of Johannesburg, the Institute for Environmental Sciences of the University of the Orange Free State and the National Institute for Water Research. Three of these are sludge stabilisation processes which are operated at relatively high temperatures in order to achieve a specific time/temperature relationship to destroy pathogenic micro-organisms contained in sludge. Two other projects relate to sludge characterisation and mechanical dewatering and are being carried out by the National Institute for Water Research and the City Council of Port Elizabeth respectively.

The remaining project involves the disposal of sludge to sea which is being conducted in terms of an agreement with the City Council of Durban. Settled sewage has been discharged to the sea by the City Council since 1968, but in terms of this contract sludge which was previously removed before discharge, is now returned to the effluent stream for sea discharge. The extensive monitoring programme has to date not indicated any deleterious effects in the region due to the altered nature of the discharge through the deep sea outfall sewers. Results have at all times been satisfactory and the quality of the sea water and bathing beaches have consistently been of perfectly acceptable standard.



Research on the autothermic aerobic digestion of sludge is being carried out at the Olifantsvlei Sewage Purification Works.

New project on composting of sludge

A new contract was concluded during the year with the CSIR in terms of which the National Institute for Water Research will carry out a prototype study of forced aeration composting of sludge. The primary objectives of the study are to assess the effectiveness of the process in stabilising sludge under various operating conditions and to optimise these conditions in order to ensure the most effective pathogen inactivation and stabilisation. It is a process that appears to hold considerable merit for application on a wide scale in South Africa.

List of research projects on the treatment of municipal wastewater

- Research on the optimization of the modified activated sludge process for nutrient removal. (Existing project: Contract with the CSIR — National Institute for Water Research).
- Research on the optimization of the modified activated sludge process for nutrient removal. (Existing project: Contract with the City Council of Johannesburg).
- Research on the optimization of the modified activated sludge process for nutrient removal. (Existing project: Contract with the University of Cape Town — Department of Civil Engineering).
- Research on biochemical processes which result in phosphate and nitrogen removal in the modified activated sludge process. (Existing project: Contract with the University of Pretoria — Department of Biochemistry).
- The removal of nitrogen and phosphate from biological filter effluents. (Existing project: Contract with the CSIR — National Institute for Water Research, and the City Council of Pretoria).
- The stabilisation of sludge by means of photosynthetic bacteria. (Existing project: Contract with the University of the Orange Free State — Institute for Environmental Sciences).
- Sludge dewatering and the treatment of sludge liquors (Existing project: Contract with the City Council of Port Elizabeth).
- Sludge disposal to sea. (Existing project: Contract with the City Council of Durban).
- Pasteurization and thermophilic anaerobic digestion of sludge. (Existing project: Contract with the City Council of Cape Town).
- Autothermic aerobic digestion of sludge. (Existing project: Contract with the City Council of Johannesburg).
- Research into the composting of sludge by means of forced aeration. (Existing project: Contract with the CSIR — National Institute for Water Research).
- Research into the characterisation of sludge. (Existing project: Contract with the CSIR — National Institute for Water Research).
- The treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge; prototype study. (New project: Contract with the CSIR — National Institute for Water Research).

Chapter 6

Treatment of industrial effluents

The discharge of inadequately purified industrial effluents into the water environment causes a serious problem to the limited water resources in many parts of the Republic. These problems are expected to increase with the increasing socio-economic development of the country and it is, therefore, essential that research in this regard be intensified. In view of this the Commission has for many years been supporting research on a national basis in connection with water management and effluent treatment in industry.

The Commission currently supports nine research projects concerning industrial effluents. Of these projects three are associated with textiles, one with the fellmongery and tanning industry, two with the fish industry, one with the fruit and vegetable processing industry, and two new projects dealing with effluents with high organic contents and effluents from the pulp and paper; metals; fermentation; and pharmaceutical products.

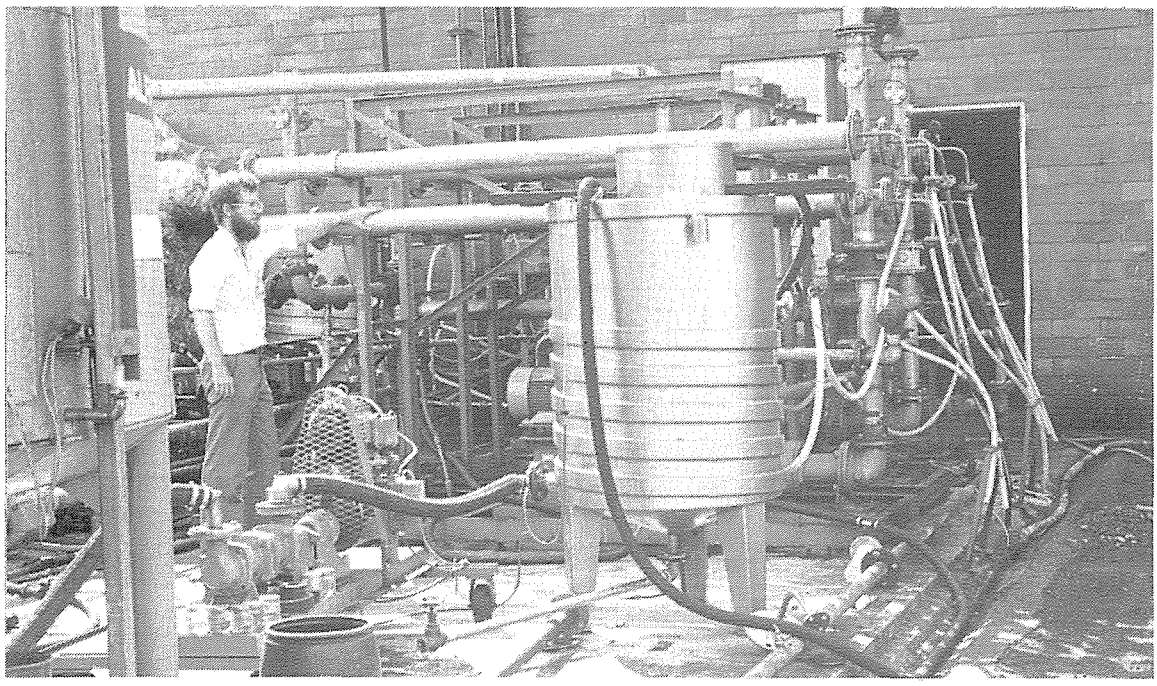
Treatment of effluent from the textile industry

The textile industry in South Africa is a large user of water (200 to 400 ℓ are necessary to produce 1 kg of fabric) and its effluent discharges, containing a wide variety of chemicals, create many problems in terms of water quality protection.

The main objectives with the research projects are to optimise processes developed for increasing the efficient use of water, i.e. to effect maximum production per unit volume of water by ensuring maximum reuse of water and the reuse and recovery of chemicals thereby also reducing pollution. Guidelines will be developed for the planning, design and operation of systems for full-scale application.

The process technology developed under the project in connection with the wool/synthetic fibre dyehouse effluent has been used by Veldspun for the design of a full-scale effluent treatment plant in Uitenhage. The results of the research on the sizing/desizing effluent treatment and reuse, have also been so promising that a large textile mill of David Whitehead and Sons, has decided to construct a full-scale ultrafiltration treatment plant and several others are assessing the system for their mills.

The treatment process developed for the wool scouring effluent provides an effective and practical solution and major savings are generated in terms of water recycle, heat energy savings, increased wool through-put and water savings. Also in the case of the research on cotton/synthetic fibre dyehouse effluent excellent results have been obtained. A factory of Ninian and Lester has decided to proceed with a full-scale hyperfiltration plant while several others are assessing the possibility.



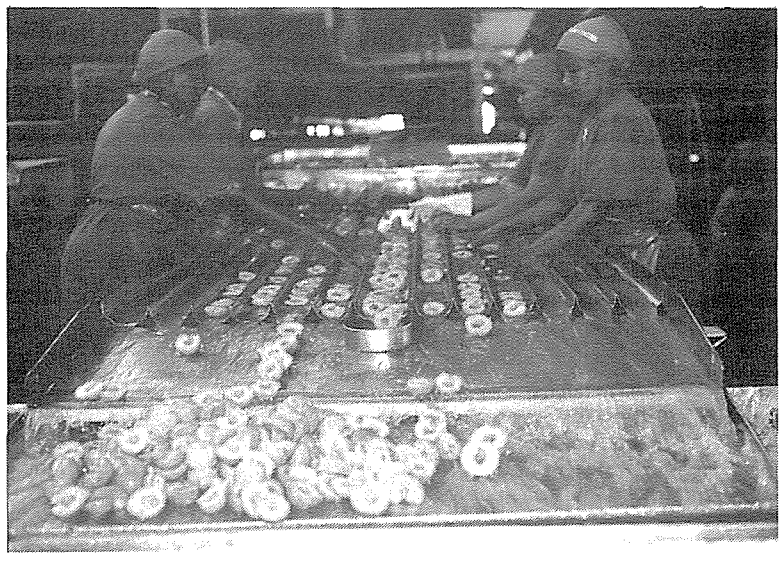
The ultrafiltration pilot plant for the treatment of sizing/desizing effluent at D Whitehead Ltd in Tongaat, Natal.

Treatment of effluents from the fellmongery and tanning industries

Based on the results obtained from research supported by the Commission a full-scale plant has already been commissioned at Silverton Tannery in Pretoria. It is now possible to treat the effluent from the plant to such a degree that it complies with the requirements for disposal to the municipal sewer. This example of the application of the research results is now being contemplated by other tanneries in their treatment of effluents.

Treatment of effluents from the fruit and vegetable processing industry

Good progress has been made with this research and a pilot dissolved-air flotation plant was designed, manufactured and operated. As a result of the research supported by the Commission a full-scale plant is to be installed at a vegetable freezing plant of Irvin and Johnstone in Johannesburg. It is also the aim to prepare a manual of practice to advise industry how water usage and pollution may be minimised.



The Commission supports research on the treatment of effluents from the fruit and vegetable processing industry to promote water savings and pollution control.

New contracts concerning industrial effluents

Two new contracts have been entered into during the year. The first is a contract with the University of Natal in terms of which its Pollution Research Group of the Department of Chemical Engineering will prepare a situation report on water management and effluent treatment in the processing of pulp and paper, metals, fermentation and pharmaceutical products.

The main objectives of the project are to collate the existing knowledge on water and effluent problems of these industries and to develop guidelines for improved effluent treatment, water management and the disposal of effluents. The investigations are carried out on a national basis and in close cooperation with the relevant trade associations, government departments, local authorities and the industries concerned.

The second contract involves a firm of consulting engineers, Binnie and Partners, to investigate the potential for applying physical/chemical effluent treatment processes to industrial waste waters with a high organic content.

This investigation is directed at assessing the performance of membrane and other processes such as flotation and ion exchange when applied to the various waste streams encountered in the meat, dairy, brewery, glucose-starch, bakery yeast processing and margarine industries.

List of research projects on the treatment of industrial effluents

- Water management and effluent treatment in the textile industry: Sizing and desizing effluent. (Existing project: Contract with the University of Natal — Pollution Research Group, Department of Chemical Engineering).

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

- Water management and effluent treatment in the textile industry: Pilot plant treatment of cotton/synthetic fibre dyehouse effluents with water reuse. (Existing project: Contract with the University of Natal — Pollution Research Group, Department of Chemical Engineering).

- Research on the purification and reuse of effluents from the hides and skins curing, fellmongery and tanning industries. (Existing project: Contract with the Leather Industries Research Institute).

- An investigation into the water and effluent management problems in the fishing industry. Shortcomings in dry offloading systems for unloading fishing vessels. (Existing project: Contract with a firm of consulting engineers, Binnie and Partners).

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

- 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. (Existing project: Contract with a firm of consulting engineers, Binnie and Partners).

- Investigations into the use of physical-chemical techniques for treatment and management of industrial effluents with high organic contents, preliminary investigation to define problem areas. (New project: Contract with a firm of consulting engineers, Binnie and Partners).

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

Chapter 7

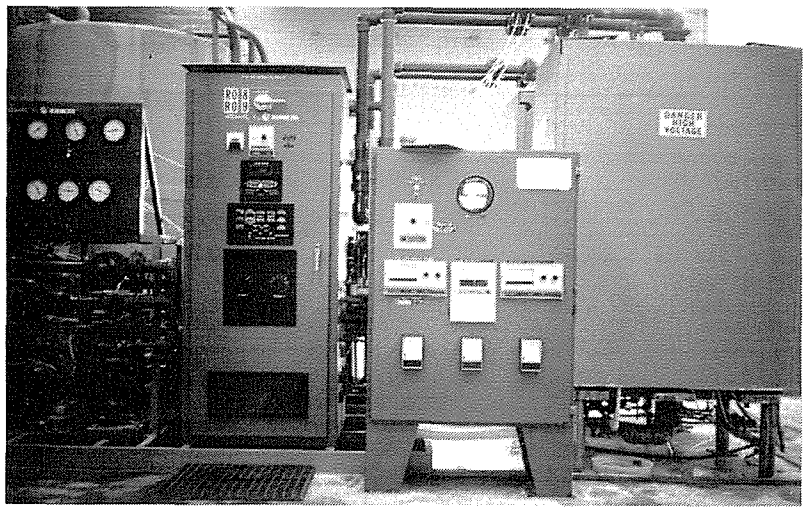
Research on desalination

The steady increase in the dissolved salts concentration in most of South Africa's inland water resources is a matter which requires immediate attention because it limits effective utilisation of these resources and also because of the significant economic implications involved.

The Commission is financing research into various aspects of desalination and the two existing research projects deal, firstly, with the development of desalination membranes and, secondly, with desalination by means of ion exchange. During the year a further two agreements were entered into for research on the development of membrane support systems and on the desalination of mine waters.

Development of membranes and membrane support systems for reverse osmosis and ultrafiltration

The development of local expertise for manufacturing membranes for reverse osmosis and ultrafiltration and support systems for these membranes, especially with a view to the desalination of effluents, is seen by the Commission as an important aspect of its research programme on desalination. As a result the Commission is financing two projects in this regard at the Institute for Polymer Sciences of the University of Stellenbosch.



An example of an electrodialysis unit which will be used in the research on the desalination of underground mine waters.

During the year the research had a serious setback when the building in which the research was being done was razed to the ground by fire. As a new building has already been erected and the equipment replaced, the research will continue normally during 1983.

Desalination by means of ion exchange

This research is a continuation of previous research projects on the reclamation of water by means of ion exchange and will conclude research on this subject so that a complete information package will be available for the full-scale application of the results.

Research project on the desalination of underground mine waters

Owing to the fact that underground mine water is generally highly saline and that the disposal of relatively large volumes of this water places a heavy burden on the water environment, the Commission has entered into an agreement with the Chamber of Mines on a partnership basis for research to be done on the desalination of mine waters. Pilot-scale equipment has been obtained for the investigations and research will commence during 1983.

List of research projects on desalination

- Research on and development of polymeric membranes and supplemental coatings for reverse osmosis and ultrafiltration (Existing project: Contract with the University of Stellenbosch — Institute for Polymer Sciences).

- Research on the technological development of continuous counter-current ion exchange for the reclamation of water of potable quality from secondary effluents. (Existing project: Contract with the University of Cape Town — Department of Chemical Engineering).

- Research on and development of membrane support systems for reverse osmosis and ultrafiltration (New project: Contract with the University of Stellenbosch — Institute for Polymer Science, and the CSIR — National Institute for Water Research).

- Research on the desalination of mine water (New project — Contract with the Chamber of Mines).

Chapter 8

Research on urban and industrial water consumption

Total urban and industrial water consumption is rising steadily and water savings in these sectors could contribute significantly to the Republic's water balance. With this fact in mind, the Commission has already initiated several research projects in connection with water economy of which a few have already been completed. Although several other projects being financed by the Commission also aim at the economic utilisation of water, this chapter reports on two projects directly involved with water economy, *viz* water economy at power generating stations and in water distribution systems.

Water economy at power generating stations

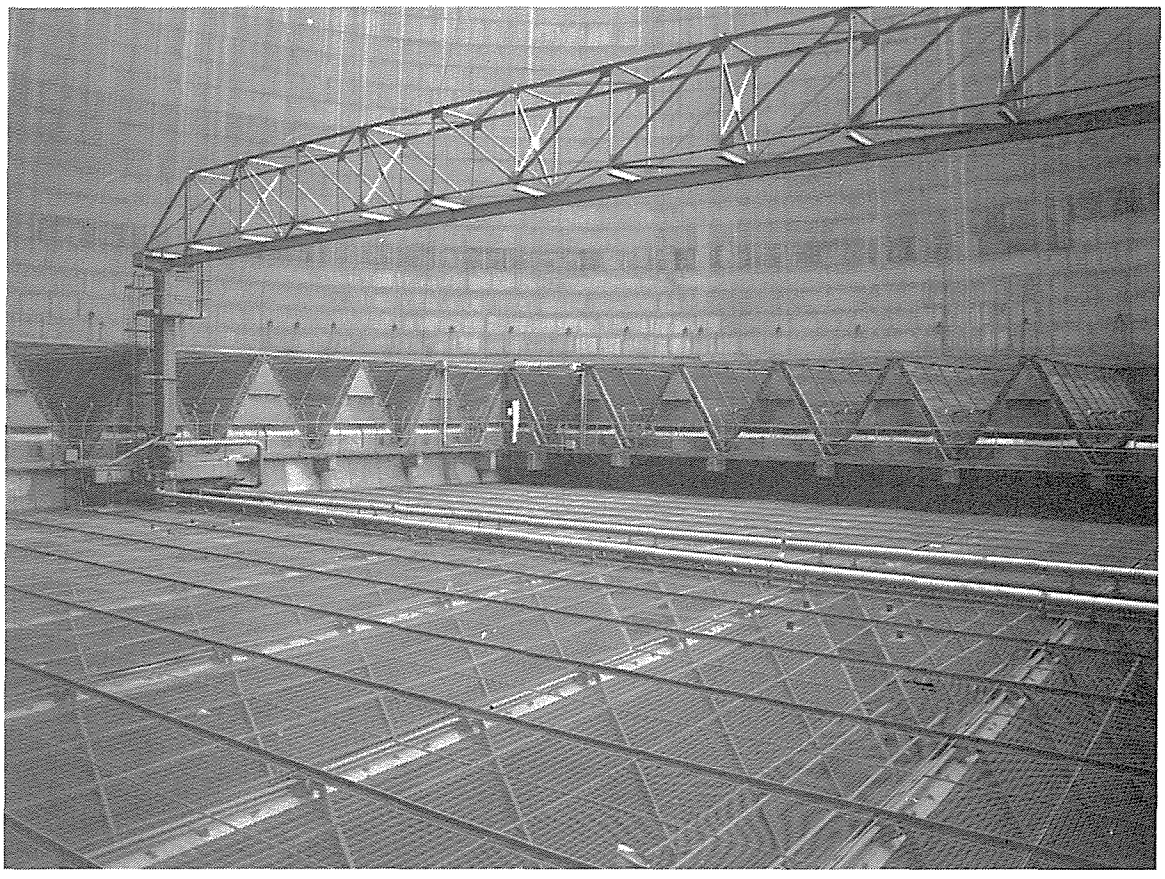
It is estimated that approximately two-thirds of the water used by industry in South Africa (excluding mining) is required for cooling purposes, especially at power generating stations. However, large volumes of water are lost during the wet cooling process, and if in future wet cooling could be replaced by a dry cooling process at power generating stations, considerable water economies may result.

Dry cooling differs from wet cooling in that water flows through cooling elements and is therefore air-cooled without evaporation taking place. Although dry cooling effects considerable water savings, it suffers from two disadvantages. Firstly, the capital cost for a dry cooling unit greatly exceeds that of wet cooling. Secondly, dry cooling is somewhat less efficient, necessitating the use of more coal for the same amount of energy supply than in the case of wet cooling. Dry cooling systems therefore should operate as efficiently as possible. Two of the most important causes of decreased efficiency with regard to dry cooling are temperature inversions and wind, and investigations for determining the extent of the problems and the solution to these have been identified as priority areas of research.

Research on the optimisation of systems for dry cooling is being done in terms of a tripartite agreement with ESCOM and the CSIR (Atmospheric Sciences Division, and the Corrosion Research Division). Emphasis is being placed on the effect of local atmospheric conditions on the performance of dry cooling units and on corrosion of cooling elements.

Water economy in urban areas

The project on water economy measures is being undertaken in terms of a tripartite agreement between the Commission, the CSIR (National Building Research Institute) and the SABS. The main objective of this project is to obtain significant water economies by means of the design and use of water supply fittings and to formulate regulations allowing uniform control to be exercised over urban water consumption.



Cooling elements in one of the dry cooling towers at Escom's Grootvlei Power Station. The Commission supports research on the optimization of dry cooling systems at power stations which will result in meaningful water savings.

During the year a research scientist of the National Building Research Institute visited Israel, Europe and the USA in order to study the latest technological developments in the field of domestic water economy.

It is clear that any campaign to promote water economy measures in the domestic sector will require the full cooperation of the water user. This means the programmes will have to be aimed specifically at combating water wastage.

The research has progressed well and good cooperation has been enjoyed from manufacturers with regard to the development and testing of new designs for fittings.

List of research projects on urban and industrial water consumption

- Research on the optimisation of dry and dry-wet cooling systems at power stations in South Africa. (Existing project: Contract with ESCOM and the CSIR — Atmospheric Sciences Division, and Corrosion Research Division).

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

Chapter 9

Research in irrigation

The agricultural sector is responsible for approximately 70% of the annual water consumption in the Republic and if the national socio-economic development is to be sustained it is imperative that irrigation water be used as effectively as possible. This implies striving for optimal crop production per unit volume of irrigation water which necessitates continued and purposeful irrigation research. In this regard and for some years now the Commission has been making an important financial contribution.

Priorities of irrigation research

The major share of irrigation research in South Africa is undertaken by the Department of Agriculture and the Commission works in close collaboration with the Department, especially in respect of the identification of shortcomings and priorities in irrigation research. The latter is one of the main responsibilities of the Coordinating Committee for Irrigation Research (CCIR) which operates under the control of the Department of Agriculture and comprises representatives of the Department of Environment Affairs, Department of Cooperation and Development and the Commission. In meeting this responsibility the CCIR has decided to arrange workshops and during the year under review the first of two dealing with agronomic and soil aspects of irrigation was held. The aim is for the eventual compilation of master plans for irrigation research.

During the year the Commission supported ten irrigation research projects. These projects cover all aspects of irrigation, namely agronomy, soil science, agrometeorology and engineering, and are aimed at removing the obstacles barring optimal water consumption in agriculture.

Completed irrigation research projects

During the year three research projects financed by the Commission were completed. The final reports of two of these projects have already been accepted by the Commission and the results released, while the third final report is to be considered by the Commission during 1983.

The project undertaken by the Department of Soil Science of the University of Fort Hare and which dealt with profile available water capacities of soils, produced the following reports:

- **The determination of the profile available water capacities of soils,** by M Hensley and JM de Jager.

  The results of this project, aimed at the optimal utilisation of irrigation water, showed that the profile available water capacity (PAWC) constitutes a valid parameter which could be advantageously applied in irrigation management. The method for determining PAWC is based on the plant as indicator and can be applied by relatively unskilled staff. Two preliminary mathematical models have been developed for the prediction of the PAWC. However, research on refining these models is continuing.

- **Determination of soil properties related to irrigation and drainage,** by DA Russell.

  Factors that influence the movement of water on an irrigation bed have been investigated, as well as factors that affect the infiltration of water under dynamic conditions. The two-dimensional behaviour of irrigation beds and the use thereof in the design of irrigation beds has therefore been investigated. This led to improved guidelines for the design of irrigation beds.

The second project which was completed, was undertaken by the Civil Engineering Department of the University of Stellenbosch and dealt with different methods of irrigation on steep lands. The following report has been accepted and released by the Commission:

- **Die ontwikkeling van doeltreffende besproeiingsmetodes vir toepassing op skuinsgronde,** by WPJ Wessels.

  In addition to the performance of four irrigation methods, *viz.* microjets, microfurrows, drip irrigation and conventional sprinkler irrigation on experimental steep land plots, the investigation also included automatic control of irrigation water in the water mains. From the results it appeared that each of the systems may be so managed that satisfactory results will be obtained under these circumstances, provided that sufficient information on soil moisture conditions and on factors related to the weather is available.

The reports mentioned above were distributed as widely as possible to interested organizations and persons in order to promote and encourage the practical application of the results.

New research projects with regard to irrigation

During the year three research agreements were concluded and the relevant research has already commenced.

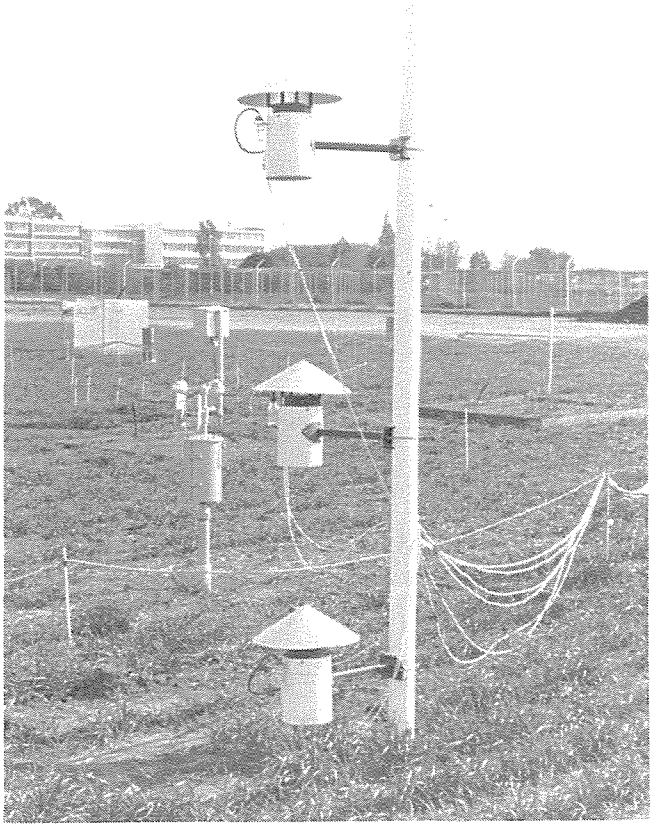
- **Continuation of research on an irrigation scheduling service for wheat in the Free State region.**

  An earlier project undertaken by the Department of Agrometeorology of the University of the Orange Free State was completed towards the end of the year and had as its objective the mathematical modelling of the soil/plant/atmosphere system. This model can be used for irrigation scheduling since it provides information on the daily water consumption of wheat and the state of the water in the soil. Further testing and refining of the model on a larger scale is required in order to round off the model for irrigation scheduling by wheat producers. This will be done during the follow-up project.

- **Development of procedures for selecting irrigation methods and designing irrigation systems**

  A firm of consulting agricultural engineers, Murray, Biesenbach and Badenhorst, has been contracted for a project in connection with the development of an extensive procedure for selecting an irrigation method and for designing irrigation systems. In selecting the most suitable irrigation method such factors as water consumption efficiency, energy and labour will be taken into consideration. In designing the relevant system all the characteristics of the system will be provided for in order to optimise the design.

Equipment used in the research project on the wheat irrigation scheduling service in the Orange Free State.



This caravan housing sophisticated data acquisition and computer equipment is being used in the research project on evapotranspiration and water use.

- **A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa.**

  The objective of this research project is to do an analysis of probable soil moisture deficits and their occurrence for various combinations of soils, land use and cultivation practices on the basis of homogeneous regions. This information will enable planners to optimise water supply. The project will be undertaken by the Department of Agricultural Engineering of the University of Natal.

List of research projects on irrigation

- 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. (Existing project: Contract with the University of the Orange Free State — Department of Agronomy/Horticulture).

- The efficiency of water extraction from fine sandy irrigation soils by different root systems. (Existing project: Contract with the University of the Orange Free State — Department of Soil Science).

- Research on the scheduling of irrigation of wheat in the irrigation areas of the Orange Free State. (Existing project: Contract with the university of the Orange Free State — Department of Agrometeorology).

- Evapotranspiration and water use studies by means of weighing lysimeters: Evapotranspiration as a function of soil, plant and atmospheric factors. (Existing project: Contract with the Department of Agriculture — Soil and Irrigation Research Institute).

- Water requirements of certain agronomic and vegetable crops. (Existing project: Contract with the University of Pretoria — Department of Plant Production).

- Development of the required apparatus and programmes for the monitoring and management of irrigation systems (Existing project: Contract with the University of Stellenbosch — Department of Civil Engineering, Chair in Irrigation Engineering).

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

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

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

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

Chapter 10

Research on surface hydrology

The major objective of the hydrological (and geohydrological) studies supported by the Commission is to provide the information and techniques that constitute the basis of water resource analysis, planning and management in South Africa. The current surface water research programme covers the following three interrelated aspects:

- regional hydrology which seeks to determine the temporal and spatial distribution of surface water resources;
- the development of empirical techniques to aid the water resource engineer in planning and management; and
- process studies that are designed both to improve the empirical techniques and facilitate the prediction of the effects of changes in land-use and management on the water resources.

Completion of projects

Five research contracts terminated during the year.

Research on water resources

This project was carried out by the Hydrological Research Unit (HRU) of the University of the Witwatersrand. The main thrust was on an appraisal of South Africa's water resources and the results provided guidelines whereby hydrologists can generate the streamflow history, predict stream behaviour and analyse the interplay of complex water supply and demand systems.

Research on flood occurrences

The final report for this project, which was also carried out by the HRU, takes the form of 11 interim reports that have been released during the term of the project. The main results include the development of programmes for flood forecasting, reservoir routing and flood gate operation.

An agrohydrological study of Natal

This project was carried out by the Department of Agricultural Engineering at the University of Natal. An assessment of Natal's water resources pertaining to the agricultural sector was provided with the objective of promoting a higher efficiency in the use of water. The main emphasis was on irrigation modelling, rainfall erosivity studies, compiling of rainfall and temperature maps and the development of agrohydrological indices for Natal. The results will be published in the form of an *Agrohydrological and climatological atlas of Natal* which will be available for distribution in 1983.

A national data bank of digitized rainfall records

The other research projects that terminated during the year were both associated with the development of a national data bank of autographic raingauge records. The data bank has been developed by the Weather Bureau with an additional input in the form of digitized rainfall records (from Natal initially), by the Department of Agricultural Engineering of the University of Natal. The available data will largely contribute to research efforts on depth/duration/frequency relationships for South African rainfall.

A digitizer which is being used in the research on the digitization of autographic rainfall data.

New projects on hydrology

During the year two new hydrology projects were started.

The first was by way of a contract with the University of Natal in terms of which their Department of Agricultural Engineering will undertake research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa. The objective of the research project is to revise the existing mean annual precipitation map series (which is based on data only up to 1960) by using the latest available data and techniques. This will allow the re-evaluation of the spatial and temporal distribution of mean annual precipitation, homogeneous precipitation regions and other statistics such as variability and mean monthly precipitation.

The second project concerns urban hydrology and drainage and will be carried out by the Water Systems Research Programme, Department of Civil Engineering of the University of the Witwatersrand.

This research is intended to produce guidelines for hydrologists and engineers concerned with designing drainage systems and estimating floods in urban and small catchments.

Visiting scientists

Two projects benefited from the services of two overseas scientists who also acted in an advisory capacity to the Commission.

Prof. E Seyhan from the Free University in Amsterdam, Netherlands worked on the Zululand University project entitled *Hydrological research in Zululand* where he helped develop pilot studies for the estimation of runoff. He also helped with the work on the mapping of soil moisture using infra-red areal photography.

Prof. JK Mitchell of the University of Illinois, United States of America was involved with research on the project *Hydrological investigation of rural catchments in Natal with specific reference to flood events* where he worked mainly on distributed rainfall/runoff modelling and sediment yield.

Hydrological instrumentation workshop

A workshop on hydrological instrumentation which was arranged by the Commission, was held during June 1982. Here manufacturers had the opportunity

A weir at N'tabamhlope employed in the hydrological research in Natal.

to display their equipment and get to know more about the South African hydrological community.

The objective of the workshop was achieved by improving technical communication which led to better cooperation between the manufacturers or agents of equipment on the one hand and the users, being hydrologists, on the other. This in turn should lead to the production of more reliable instrumentation which is more suited to the range of environmental conditions experienced by the hydrologists in South Africa.

List of research projects on surface hydrology

- Research on water resources. (Existing project: Contract with the University of the Witwatersrand — Hydrological Research Unit).
- Research on flood occurrences (Existing project: Contract with the University of the Witwatersrand — Hydrological Research Unit).
- Hydrological investigation of rural catchments in Natal with specific reference to flood events. (Existing project: Contract with the University of Natal — Department of Agricultural Engineering).
- An agrohydrological study of Natal. (Existing project: Contract with the University of Natal — Department of Agricultural Engineering).
- Hydrological research in Zululand. (Existing project: Contract with the University of Zululand — Department of Geography).
- Research on continuous streamflow modelling of South African rivers. (Existing project: Contract with the University of Natal — Department of Civil Engineering).
- The development of a data bank of autographic raingauge records in South Africa. (Existing project: Contract with the University of Natal — Department of Agricultural Engineering).
- Hydrological research in the Ecca and Wilderness catchments. (Existing project: Contract with Rhodes University — Department of Geography).
- Digitizing of autographic rainfall data. (Existing project: Contract with the Department of Transport — Weather Bureau).
- Research on drought occurrences. (Existing project: 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. (New project: Contract with the University of Natal — Department of Agricultural Engineering).
- Research on urban hydrology and drainage (New project: Contract with the University of the Witwatersrand — Department of Civil Engineering, Water Systems Research Programme).

Chapter 11

Research on rainfall stimulation

In view of South Africa's limited water resources and the predicted water shortage soon after the turn of the century, it is essential that all possible alternative sources of water be investigated timeously. One of the alternatives that may have great potential is rainfall stimulation, but much research is required before the feasibility of area-wide rainfall stimulation can be assessed.

In the early stages of research on rainfall stimulation in South Africa, it is necessary to address, inter alia, the following type of questions:

- What conditions in a cloud system qualify it as being suitable for treatment (seeding)?
- How often do suitable clouds occur?
- At what stage in the development of a suitable cloud system should it be treated?
- Where in the cloud system should treatment be applied and how much treatment should be applied?
- What agent should be used for treatment?

In view of these considerations basic research is necessary in connection with cloud physics including cloud dynamics and the mechanisms of precipitation. The characteristics of clouds tend to change from one area to another and consequently it is necessary to examine the clouds at selected sites in South Africa. Once answers to the above questions have been found for a particular area, it is possible to decide whether or not conditions are sufficiently favourable to proceed with the development of an hypothesis about rainfall stimulation that can be tested in a carefully planned experiment. Should such an experiment provide positive results, the final stage would involve the application of the technology for practical purposes on an area-wide basis.

The Commission has for several years been involved in research on rainfall stimulation in the Bethlehem area and in the Nelspruit area.

The Bethlehem project

This rainfall stimulation research project is being conducted at Bethlehem by the Weather Bureau of the Department of Transport. The objective of the project is to investigate the feasibility of increasing the rainfall by cloud seeding. In conjunction with this project, the Directorate of Water Affairs of the Department of Environment Affairs has a research programme in the same area that is aimed at determining the effects of artificial changes in rainfall on stream runoff.

The Bethlehem project was visited during the year by Dr G Foote and Dr B Silverman from the United States who are both prominent scientists associated with the major weather modification programmes overseas. Both Dr Foote and Dr Silverman stayed long enough to take part in operations and their advice and enthusiasm have been of great benefit to the project.

A group of overseas consultants visited South Africa in June 1982 in connection with research on rainfall stimulation.

The Nelspruit project

The agreement between the Commission and the Laeveldse Koöperasie Beperk for rainfall stimulation research in the Nelspruit area terminated during 1981 and the final report by a group of specialist consultants from the USA has been submitted to the Commission. In view of the possible impact that the report may have on future weather modification in South Africa, it was decided to submit the report to various overseas consultants for independent scientific evaluation. The consultants visited South Africa in June 1982 to discuss the report with the authors and made detailed recommendations as to the objectives and scope of future research in the Nelspruit area. The data and information obtained during the first contract will provide a valuable base for future work that may well lead to the design of a fully scientifically based experiment.

List of research projects on rainfall stimulation

- Research on the artificial stimulation of rainfall at Bethlehem. (Existing project: Contract with the Department of Transport — Weather Bureau).
- Research on weather modification at Nelspruit. (New project: Contract with a firm of consulting meteorologists, Simpson Weather Associates, USA.)

Chapter 12

The transfer of information and technology

The world is experiencing an information explosion and enormous efforts are being directed daily at the generation of more and more information. In contrast to this there is often a serious lack of effort at the utilisation and application in practice of the information and technology developed. In this respect the Commission has a specific responsibility which is spelled out in the Water Research Act, *viz* to 'accumulate, assimilate and disseminate knowledge in regard to the results of such research and the application thereof, and promote development work for the purposes of such application'. In order to comply with this, the Commission has developed certain avenues. Some are directed more at information transfer, others at technology transfer, i.e. the application of results.

In its programme of information and technology transfer, the Commission basically employs:

Partnership research

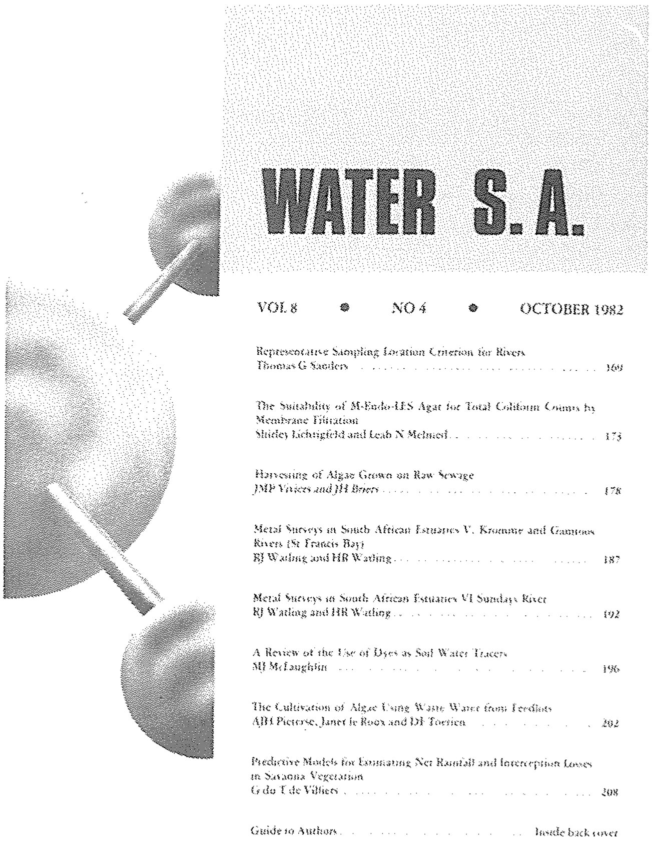
Partnership research is high on the list of priorities at the Commission and is regarded as the most effective method for successful technology transfer. The partnership principle is incorporated, as far as possible, in research contracts, which means that the potential user of the results becomes involved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

The South African Water Information Centre

The South African Water Information Centre is operated as an independent unit on behalf of the Commission, and under contract, by the CSIR and provides various information services in the water and related fields. By using a team of qualified indexers approximately 500 scientific and technical journals are read on a regular basis and articles dealing with water are selected and indexed for inclusion in the computerised bibliographic data base *Waterlit* developed by the Centre. Apart from the journals mentioned above, reports, books, patents, theses and conference proceedings are also indexed. The data base already contains some 60 000 items and more than 1 000 items are added monthly.

The Centre currently operates approximately 200 SDI (selective dissemination of information) profiles and does some 60 retrospective information searches on *Waterlit* monthly. In order of utilisation of *Waterlit,* the most frequent users are: universities, the CSIR, the Department of Environment Affairs, municipalities, engineering consultants and industries.

Since September 1981 *Waterlit,* in terms of an agreement with System Development Corporation



WATER S.A.

VOL 8 • NO 4 • OCTOBER 1982

Heffing op ingelyste besproeiingsgrond:

DIE WNK EN DIE BOER

Duisende besproeiingsboere in die Republiek van Suid-Afrika betaal jaarliks 'n heffing aan die Waternavorsingsfonds ten opsigte van water wat vir besproeiing op ingelyste grond gebruik is.

Dié Fonds word gebruik om die werksaamhede van die Waternavorsingskommissie (WNK) te finansier, wat ten taak het om navorsing oor die gebruik van water vir landbou-, nywerheids- of stedelike doeleindes te koördineer, te bevorder, aan te moedig of te laat onderneem. Die heffing op besproeiingswater is egter nie die enigste bron van inkomste van die Fonds nie: heffings op waterverbruik vir stedelike, nywerheids- en huishoudelike doeleindes lewer verreweg die grootste bydrae, soos elders in dié bulletin geïllustreer word.

Hierdie spesiale uitgawe van *SA Waterbulletin* (nuusbrief van die WNK) word aangebied met die vertroue dat onduidelikhede wat mag bestaan oor die aanwending van die fondse daardeur uit die weg geruim sal word, en dat die belangrikheid van navorsing vir die beter benutting van besproeiingswater weer eens duidelik na vore sal kom. Enige verdere navrae kan gerig word aan die Voorsitter, WNK, Posbus 824, Pretoria 0001.

(SDC) in the 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 servies on *Waterlit*.

The Centre also provides a current awareness and document service.

Over the years, the Centre has played an extremely important role in water research and in the activities of the water community in South Africa. It has a national character with its own identity and operates under its own name, thereby providing a centralised point of access for all persons and organisations using information sources and services in connection with water.

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 April 1975 and the journal appears quarterly.

There are approximately 2 200 subscribers of whom approximately 800 reside abroad.

Water SA enjoys world-wide coverage and is included in 16 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; Water Research Centre Information; Aqualine; Abstracts Journal (Institute of Scientific Information of the USSR Academy of Science); and Soils and Fertilizers (including Irrigation and Drainage Abstracts).

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 highlighted in the bulletin.

During the year under review the bulletin's firmly established columns such as "technology transfer" and "new equipment and processes" again received an excellent response and many enquiries were dealt with, some from as far afield as West Germany.

The publication of special editions of *SA Waterbulletin* commenced during the year. These editions will appear from time to time and deal with a specific subject or aspect of the Commission's activities, and are aimed at the transfer of information to groups with special interests. During the year under review approximately 20 000 copies of a special bulletin on irrigation research entitled *Die WNK en die boer* were distributed. This bulletin contained information on the way in which the levy paid annually to the water research fund by irrigation farmers is administered by the Commission, as well as information on the results of and reports on the Commission's irrigation research.

Manuals and reports

At the conclusion of a project, and in some cases whilst research is still underway, results are evaluated in respect of possible application and depending on the nature of the results a decision is taken on the publication, dissemination and application thereof. It may be that the final report has been compiled in such a way that it may selectively be distributed in that format. A decision may also be taken to package the results in the form of a manual in order to enhance the application possibilities. Interim reports and results are handled in the same way.

State of the art reports and proceedings

In planning for water research in new fields, it is often necessary to prepare state of the art reports. This is sometimes done by specialist consultants, or the responsibility is delegated to a study group. The nature of the report will determine whether it will be published or not.

From time to time the Commission arranges symposia, the proceedings of which may be published.

List of publications of the Commission

The 1981 annual report contained a list of publications (articles, papers and published reports) which emanated from research supported wholly or in part by the Commission since its inception. That list is, however, incomplete and a supplementary list is therefore being published as an Appendix to this annual report.

The Appendix also contains a complete list of publications released during 1982.

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. For a considerable period of time there has been a need for regular feedback of information to local authorities and this column is aimed at keeping local authorities abreast of activities and research being done on their behalf.

Conferences, seminars, work sessions and demonstrations

From time to time the Commission, on its own or in cooperation with other organizations, 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.

During the year considerable attention was paid to open days/demonstrations and three such functions were arranged for the practical demonstration of developed technology.

The utilization of overseas expertise

The Commission is of the opinion that the utilization of overseas expertise and knowledge, where such knowledge is locally unavailable, will benefit the country as a whole, and various methods have been developed to achieve this. Overseas specialists are used as consultants in cooperation with local specialists and consultants to view specific problems and make recommendations for research and the application of existing knowledge.

The Commission from time to time sends study groups overseas in order to obtain knowledge in a specific problem area. This is seen as an important strategy for transferring proven overseas technology and practice to South Africa and preventing duplication of work locally.

In general the Commission endeavours to strengthen and expand overseas contacts by entering into agreements for the exchange of information, by taking up membership of appropriate overseas and international organizations and by subscribing to services and media which concentrate on the publication of important developments in research and technology.

Chapter 13

Financial Statements

The Statement of Income and Expenditure and the Balance Sheet have been 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 1982 to 31 December 1982.

The Commission derives its income from rates and charges on water usage and on scheduled irrigation land. The tariffs for the 1982 financial year were 0,25 c/m^3 for water supplied for urban, industrial or domestic use, and 40 c/ha of land scheduled for irrigation.

WATER RESEARCH COMMISSION

STATEMENT 1

BALANCE SHEET AS AT 31 DECEMBER 1982

1981	Liabilities	1982		1981	Assets		1982	
R		R	R	R		R	R	R
	Sundry creditors —				*Capital assets —			
37 196	Revenue paid in advance		63 452,38	5 000	Land (Cost)		5 000,00	
	Fund account —				Motor vehicles	7 728,92		
7 165 753	Balance at 31/12/81	7 165 752,71			*Less:* Depreciation	1 918,87		
	Plus: Excess of income over expenditure 1982	199 150,60		7 729			5 810,05	
			7 364 903,31		Office equipment	80 678,48		
					Less: Depreciation	3 209,19		
				55 782			77 469,29	
					Office furniture	30 640,59		
					Less: Depreciation	1 485,19		
				28 689			29 155,40	
								117 434,74
					Investments		4 896 657,15	
					Plus: Accrued interest, 1/10/82 to 31/12/82		158 660,50	
				4 694 470				5 055 317,65
					Current assets —			
					Sundry Debtors —			
					Outstanding revenue:			
					Prior to 1982	17 016,71		
					1982	826 071,63		
				716 029			843 088,34	
				1 440 563	Project advances (Statement 3)	1 227 304,30		
				2 580	Subsistence and transport advances	19 107,26		
				62 669	Motor financing	81 211,02		
				200	Deposits	200,00		
							1 327 822,58	
				150	Cash on hand		150,00	
				189 088	Cash in bank		84 542,38	
								2 255 603,30
R7 202 949			R7 428 355,69	R7 202 949				R7 428 355,69

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

Pretoria, 24 March 1983

(Sgd.) M.R. HENZEN
Chairman

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.

Office of the Auditor-General,

Pretoria, 7 April 1983

(Sgd.) H. J. van Eck

Acting Auditor-General.

WATER RESEARCH COMMISSION

STATEMENT 2

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR 1 JANUARY 1982 TOT 31 DECEMBER 1982

1981	Expenditure		1982
R			R
760 553	Salaries and allowances		1 063 345,11
20 850	Subsistence		35 862,66
6 435	Motor transport		4 483,62
89 069	General transport		135 852,76
1 950	Commission members' allowances		3 200,00
6 598	Postal and telegraph services		10 726,63
10 113	Telephone services		16 197,22
9 829	Printing and stationery		19 301,09
1 372	Advertisements		3 293,16
52 589	Publications and information		92 036,02
—	Technology and information transfer		12 836,12
7 504	Lease and maintenance of office equipment		11 141,62
7 355	Entertainment		19 941,10
29 159	Office rental		35 873,28
237	Maintenance of and alterations to offices		3 738,56
3 288	Electricity		3 785,23
319	Maintenance and lease of furniture		37,80
500	Typing services		400,00
2 924	Insurance and licenses		4 461,55
43 030	Collection fees		58 673,72
1 209	Audit fees		1 131,00
121	Legal costs		1 937,00
15 152	Registrations and subscriptions		14 125,04
2 836	Miscellaneous petty expenses		5 609,89
6 533	Depreciation		6 613,25
2 453 498	Research projects (Statement 3)		4 053 242,16
	Contracting of researchers and expertise:		
		R	
140 219	Weather modification at Bethlehem	195 907,79	
51 459	Evapotranspiration and water use studies by means of weighing lysimeters	55 781,64	
53 526	Digitizing of autographic raingauge data	75 281,49	
			326 970,92
152 500	Research and other grants		162 400,00
217 512	Specialist and consultation services		191 743,47
1 452	Repayment of interest on rates and changes in arrear		—
919 832	Excess of income over expenditure		199 150,60

1981	Income			1982	
R		R		R	R
	Rates:				
	Government irrigation schemes with canal systems:				
	Received			35 187,15	
	Plus: Outstanding 1982			51 427,28	
82 287					86 614,43
6 839	Government irrigation schemes without canal systems:				—
	Irrigation Board Schemes:				
	Received			70 682,23	
	Plus: Outstanding 1982			2 046,78	
26 522					72 729,01
	Charges:				
	Metered water from Government schemes:				
	Received			3 532 448,18	
	Plus: Outstanding 1982			710 734,59	
3 287 534					4 243 182,77
	Municipalities:				
	Received	1 302 306,12			
	Less: adjustment in respect of previous years	84,07			
				1 302 222,05	
	Plus: Outstanding 1982			11 110,04	
949 919					1 313 332,09

STATEMENT 2 *(continued)*

1981	Expenditure *(continued)*	1982	1981	Income *(continued)*		1982	
			R		R	R	R
				SWA:			
				Received		14 898,49	
				Plus: Outstanding 1982		50 752,94	
			76 942				65 651,43
				Unallocated rates and			
			181 088	charges			92 186,01
				Interest on rates and charges			
			1 198	in arrear			1 629,75
				Interest on investments:			
				Received		452 186,80	
				Accrued		158 660,50	
			451 467				610 847,30
			—	Research contributions			5 000,00
			5 727	Sundry income			6 937,79
R5 069 523		R6 498 110,58	R5 069 523				R6 498 110,58

WATER RESEARCH COMMISSION

STATEMENT 3

STATEMENT OF PROJECT EXPENDITURE AND ADVANCES FOR THE YEAR 1982

Project	Expenditure		Total advances outstanding as at 31/12/82
	1981	1982	
	R	R	R
Development of research on the reclamation of water at the Athlone Sewage Works, Cape Town	3 480	—	—
Technological development of water reclamation on the basis of the Windhoek plant	21 464	23 904,00	—
Reclamation, storage and abstraction of purified sewage effluent in the Cape Peninsula	22 557	11 302,11	922,06
Hydrological investigation of small catchments in the Mtunzini district	18 822	—	—
An investigation on the optimal utilization of water in the Eerste River in sandbeds or by other means	14 179	(690,03)[x]	—
South African Water Information Centre	151 864	189 700,01	(47 055,47)*
The development and evaluation of techniques for the determination of the exploitation potential of ground water resources in the Southern Free State and Northern Cape	189 558	11 791,79	—
Research on flood damage — Institute for Social and Economic Research	1 527	—	—
Research on the microbiological quality and health aspects of water for reuse	264 161	173 096,81	(161 666,76)*
Research on the soil factors effecting the optimal utilization of irrigation water in National States	—	8 550,73	9 407,12
Research on water requirements of certain agronomic and vegetable crops	—	3 200,00	—
Research on the purification and reuse of effluents from the hides and skins curing, fellmongery and tanning industries	125 752	54 865,00	10 373,70
Research on and development of desalination of sea water by reverse osmosis on the pilot plant at Swakopmund	4 059	—	—
Research and development of membrane support systems and modules	51 519	802,00	—
Water management and effluent treatment in the Textile Industry	58 915	84 013,62	—
Research on the development of effective irrigation methods for application on steep lands, with special reference to micro-methods	—	54 482,16	3 298,75
Research on flood occurrences	—	21 680,53	—
Research on water resources	—	130 279,49	—
Water pollution and effluent reclamation in the Pretoria-Witwatersrand-Vereeniging-Sasolburg Complex	46 770	3 200,94	20 413,31
Research on the scheduling of irrigation of wheat in the irrigation area of the Orange Free State	23 474	—	17 012,45
Research on rainfall stimulation at Nelspruit	43 281	—	—
Research on the development and application of aspects of equilibrium chemistry and precipitation kinetics to water stability problems encountered in water reclamation	16 088	8 572,59	7 203,96
The removal of nitrogen and phosphate from biofilter effluents	38 140	43 484,25	(6 947,07)*
Hydrological research in the Ecca and Wilderness catchments	55 614	64 031,99	(744,20)*
Research on optimization of dry and dry-wet cooling systems at power stations in South Africa	163 942	100 043,00	(55 572,00)*
Research on optimization of the modified activated sludge process for nutrient removal (Johannesburg City Council)	12 360	8 396,50	36 609,12
Research on the optimization of the modified activated sludge process for nutrient removal (NIWR)	108 712	19 868,00	—
Hydrological investigation of rural catchments in Natal with specific reference to flood events	53 402	59 886,89	74 901,29
An Agrohydrological study of Natal	4 172	7 345,63	—

The development of a data bank of autographic raingauge records in South Africa	18 628	26 375,27	14 224,00
Hydrological research in Zululand	60 028	32 032,39	21 477,01
The efficiency of water extraction from fine sandy irrigation soils by different root systems	33 257	15 571,73	(471,73)*
Technological development of ion exchange for the desalination and tertiary treatment of effluents: Planning, design, construction and operation of a 100 kl/day pilot plant and evaluation of its performance	144 522	—	—
Research on economy measures for water distribution systems in urban areas	136 382	157 672,44	(6 897,62)*
Research on water reclamation and pollution control: Operation of Stander Water Reclamation Plant by the City Council of Pretoria, the implementation of surveillance programmes relevant to health aspects and the application of catchment quality control	—	85 188,58	—
Epidemiological studies pertaining to the reclamation and reuse of purified sewage effluent in the Cape Peninsula	—	80 522,17	58 750,87
The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality	136 066	248 055,04	223 992,40
Optimization of the modified activated sludge process for nutrient removal (University of Cape Town)	—	105 865,13	78 472,01
Water management and effluent treatment in the textile industry: Pilot plant treatment of cotton/synthetic fibre dyehouse effluents with water reuse	99 294	94 810,77	96 600,00
Research on water management and effluent treatment in the textile industry: Wool scouring effluent treatment	114 398	80 626,60	101 000,00
Research on continuous streamflow modelling of South African rivers	16 445	23 447,11	22 708,25
The treatment and disposal of sewage sludge: The stabilisation of sludge by means of photosynthetic bacteria	12 734	16 844,27	(973,56)*
The treatment and disposal of municipal sludges: Sludge dewatering and the treatment of sludge liquors	—	5 385,10	1 702,00
The treatment and disposal of municipal sludges: Sludge disposal to sea	30 000	24 200,00	8 076,00
Research on water requirements of certain agronomic and vegetable crops	—	62 290,52	60 309,48
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	14 484	114 686,38	32 295,72
The treatment and disposal of municipal sludges: Pasteurisation and thermophilic anaerobic digestion of sludge	—	8 609,93	5 890,07
The treatment and disposal of municipal sludges: Autothemic aerobic digestion of sludge	5 278	—	32 859,75
The treatment and disposal of municipal sludges: The characterisation of sludge	15 500	19 227,00	373,00
Research on biochemical processes which result in phosphate and nitrogen removal in the modified activated sludge process	—	12 025,68	15 974,32
Research on drought occurrences	—	79 435,22	(4 235,22)*
Pilot plant studies in connection with the adsorption capactiy of regenerated activated carbon	12 499	—	—
Research on the technological development of continuous counter current ion exchange for the reclamation of water of potable quality from secondary effluents	—	85 267,87	35 861,62
An investigation into the water and effluent management problems in the fishing industry: Shortcomings in dry offloading systems for unloading fishing vessels	40 118	7 817,85	—
Research on and development of polymeric membranes and supplemental coatings for reverse osmosis and ultra filtration	—	—	131 800,00
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	48 680	60 292,77	—
An investigation into the water and effluent management problems in the fishing industry: Effluent handling at fish processing factories	21 373	64 525,57	—
Research on the profile available water capacities of soils	—	—	79 000,00
Eutrophication research on the Hartbeespoort Dam	—	58 795,00	6 505,00
Research on integrated studies of the generation of runoff, solutes and sediment in tributary catchments of the Great Fish River	—	101 774,88	34 425,12
The treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge, prototype study	—	24 511,00	7 389,00

Development of the required apparatus and programmes for the monitoring and management of irrigation systems	—	94 012,77	20 237,23
Investigations into the use of physical-chemical techniques for treatment and management of industrial effluents with high organic content Preliminary investigation to define problem areas	—	45 168,67	—
Investigation into the water management and effluent treatment in the processing of (i) pulp and paper (ii) metals (iii) fementation products (iv) pharmaceutical products	—	—	54 000,00
Research on and development of membrane support systems for reverse osmosis and ultrafiltration	—	40 450,95	16 899,05
Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant	—	—	11 758,51
Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa	—	—	22 500,00
Research on weather modification (C.I.C.)	—	769 048,96	42 962,29
Research on weather modification at Nelspruit (S.W.A.)	—	21,00	100 400,00
Research on the applicability of groundwater models as an aid to the study and evaluation of South Africa aquifers	—	96 347,90	8 411,10
Research on urban hydrology and drainage	—	—	60 000,00
Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems	—	58 002,65	4 747,35
Research on an irrigation scheduling service for the Free State region	—	4 750,14	34 249,86
A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa	—	—	5 250,00
Research on the characterization, evaluation and regeneration of activated carbon for water reclamation and water purification	—	150 319,00	(150 319,00)*
Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization	—	4 035 84	44 364,16
Research on the reclamation of secondary sewage effluent by reverse osmosis	—	13 420,00	(13 420,00)*
	R2 453 498	R4 053 242,16	R1 227 304,30

*Excess expenditure over advances for projects.

ˣAmendment to expenditure of previous years.

WATER RESEARCH COMMISSION
STATEMENT 4

BUDGET 1983

	R	R
ESTIMATED INCOME		
Rates and charges in terms of Section 11 of the Water Research Act		7 437 000
Interest on investment		200 000
		7 637 000
Appropriation from accumulated funds		1 770 000
TOTAL ESTIMATED INCOME		9 407 000
ESTIMATED EXPENDITURE		
Administrative expenses:		
Salaries and allowances	1 239 000	
Subsistence and travelling expenses	191 000	
Postal, telegraph and telephone	31 000	
Printing, stationery, advertisements and publications	145 000	
General expenditure	196 000	
		1 802 000
RESEARCH PROJECTS		
Approved Projects		
Technological development of water reclamation on the basis of the Windhoek plant	12 000	
South African Water Information Centre	243 300	
Research on the microbiological quality and health aspects of water for reuse	35 800	
Research on the development and application of aspects of equilibrium chemistry and precipitation kinetics to water stability problems encountered in water reclamation	6 600	
Hydrological research in the Ecca and Wilderness catchments	74 400	
Research on the optimization of the modified activated sludge process for nutrient removal (Johannesburg City Council)	50 000	
Hydrological investigation of rural catchments in Natal with specific reference to flood events	89 000	
Hydrological research in Zululand	54 800	
The efficiency of water extraction from fine sandy irrigation soils by different root systems	5 100	
Research on economy measures for water distribution systems in urban areas	151 000	
Epidemiological studies pertaining to the reclamation and reuse of purified sewage effluent in the Cape Peninsula	76 000	
The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality	178 000	
The optimization and evaluation of the full scale treatment of spent wine residue	25 000	
Optimization of the modified activated sludge process for nutrient removal (University of Cape Town)	83 000	
Research on water management and effluent treatment in the textile industry: Wool scouring effluent treatment	86 000	
Research on continuous streamflow modelling of South African rivers	13 000	
The treatment and disposal of municipal sludges: The stabilisation of sludge by means of photosynthetic bacteria	8 500	
The treatment and disposal of municipal sludges: Sludge dewatering and the treatment of sludge liquors	4 100	
The treatment and disposal of municipal sludges: Sludge disposal to sea	32 800	
Research on the water requirements of certain agronomic and vegetable crops	63 300	
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	22 500	
The treatment and disposal of municipal sludges: Pasteurisation and thermophilic anaerobic digestion of sludge	24 500	
The treatment and disposal of municipal sludges: Autothermic aerobic digestion of sludge	22 000	
The treatment and disposal of municipal sludges: The characterization of sludge	25 000	
Research on biochemical processes which result in phosphate and nitrogen removal in the modified activated sludge process	14 000	
Research on drought occurrences	48 000	
Research on and development of polymeric membranes and supplemental coatings for reverse osmosis and ultra filtration	94 500	
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	34 000	
An investigation into the water and effluent management problems in the fishing industry: Effluent handling at fish processing factories	42 000	
Research on the profile available water capacities of soils	68 000	
Eutrophication research in the Hartbeespoort Dam	82 000	
Research on integrated studies of the generation of runoff solutes and sediment in tributary catchments of the Great Fish River	66 300	
The treatment and disposal of municipal sludges: Forced aeration composting of sewage sludge, prototype study	27 000	
Development of the required apparatus and programmes for the monitoring and management of irrigation systems	108 900	

Evaluation of the technical performance of a full scale textile sizing and desizing effluent treatment plant	31 000	
Research on and development of membrane support systems for reverse osmosis and ultra filtration	97 200	
Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant	19 500	
Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa	47600	
Research on the applicability of groundwater models as an aid to the study and evaluation of South African aquifers	117 050	
Research on sludge bulking in the activated sludge process	18 000	
Research on urban hydrology and drainage	80 000	
Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems	124 500	
Research on an irrigation scheduling service for the Free State region	28 000	
A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa	11 250	
Research on the characterization, evaluation and regeneration of activated carbon for water reclamation and water purification	9 500	
Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization	66 000	
Research on the autoanalysis of sulphate and alkalinity in water	10 700	
Research on the desalination of mine waters (RCC)	14 000	
Research on the desalination of mine waters (Process Systems (Pty) Ltd)	6 000	
Research on the reclamation of secondary sewage effluent by reverse osmosis	32 300	
Research on the desalination of mine waters (U.C.T.)	8 000	
Evaluation of electrodialysis reversal for the desalination of effluents and brackish water	20 000	
	2 711 000	
Proposed projects	2 794 200	
Possible projects	1 230 200	
		6 735 400
Contracting of researchers and expertise		369 600
Research and other grants		220 000
Specialist and Consultation Services		280 000
TOTAL ESTIMATED EXPENDITURE		R9 407 000

APPENDIX

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

This Appendix contains, firstly, a list of publications released in 1982 and, secondly, a complementary list to that which appeared in the 1981 annual report (and which was incomplete).

Requests for publications should be directed, as far as possible, to the authors themselves.

Publications for 1982

Articles and Papers

BENNIE, A.T.P. (1982) Effek van verskillende metodes van diep bewerking op mieliegroei. 'n Referaat gelewer tydens die 1982-kongres van die SA Vereniging vir Gewasproduksie.

BOTHA, F.J.P. en BENNIE, A.T.P. (1982) Die invloed van grondbewerking op die waterverbruiksdoeltreffendheid van mielies onder besproeiing. Handeling: Kongres van die Gewasproduksie Vereniging van SA.

BOURNE, D.E. and WATERMEYER, G.S. (1982) Proposed potable reuse — An epidemiological study in Cape town. Water Reuse Symposium II. Proceedings **3** 2195-2199 Washington D.C. 1982.

BUCHAN, L. (1982) Possible biological mechanisms of phosphorus removal. Paper presented at the IAWPRC Seminar, Pretoria.

BUCKLEY, C.A. and GROVES, G.R. (1982) Treatment of desizing effluents for recovery and reuse of polymer sizes — Pilot-plant performance and economics. Proceedings of Symposium on New Technologies for Cotton, Textile Institute/SAWTRI, 26-28 July, 483-504.

BUCKLEY, C.A., TOWNSEND, R.B. and GROVES, G.R. (1982) Performance of an ultrafiltration pilot-plant for the closed loop recycling of textile desizing effluents. International Association of Water Pollution Research, 11th Conference, Cape Town, 29th March – 2nd April.

CARR, A.D. (1982) Desalination and tertiary treatment of wastewater using ion exchange. Water Reuse Symposium II, Washington D.C.

CHUTTER, F.M. A Model of the orthophosphate load/phytoplankton relationship in South African impoundments. Paper presented at the Annual Congress of the Limnological Society of Southern Africa, Pretoria, July 1982.

CLAYTON, A.J., VAN VUUREN, L.R.J. and ROUX, B. (1982) Development of water reclamation technology in South Africa. Paper presented at the 11th IAWPR Conference, Cape Town, March 1982.

COCHRANE, K.L. Preliminary observations on the nature and distribution of the fish population in Hartbeespoort Dam. Paper presented at the Annual Congress of the Limnological Society of Southern Africa, Pretoria, July 1982.

DE KLERK, J.v.R. en HUMAN, J.J. (1982) Verwantskap tussen nettofotosintese, huidmondjiesluiting en blaarwaterpotensiaal. 'n Referaat tydens die 1982-kongres van die SA Vereniging vir Gewasproduksie.

EKAMA, G.A., SIEBRITZ, I.P. and MARAIS, G.v.R. (1982) Considerations in the process design of nutrient removal activated sludge processes. Presented at the IAWPR post-conference seminar on phosphate removal, Pretoria.

FLEMMER, R.L.C., BUCKLEY, C.A. and GROVES, G.R. (1982) An analysis of the performance of a spiral-wound ultrafiltration membrane with a turbulence-promoting net. *Desalination,* **41**(1), 25-33.

GÖRGENS, A.H.M. and HUGHES, D.A. (1982) An analysis of medium and long-duration extreme rainfalls in the Southern Cape coastal lakes region for the purposes of flood hydrograph generation. *Water SA,* **8**(1), 16-22.

GÖRGENS, A.H.M. and HUGHES, D.A. (1982) A synthesis of streamflow information relating to the semi-arid Karoo Biome of South Africa. *S. Afr. Jnl. Sci.* **78**(2) 58-68.

HAYES, D.W.J., COOPER, D.R., SHUTTLEWORTH, S.G. and SLABBERT, N.P. (1982) Purification of simulated wet blue wastewater by activated sludge treatment. Leather Industries Research Institute. Research Bulletin No. 836.

HENDRY, B.A. (1982) Continuous countercurrent ion exchange for desalination and tertiary treatment of effluents and other brackish waters. IAWPR 11th International Conference, Cape Town.

HENDRY, B.A. (1982) Methods of reducing consumption of sulphuric acid in regeneration of strong cation exchanges in water desalination. Conference on Mass Transfer and Kinetics of Ion Exchange, NATO Advisory Studies Institute, Italy, May 1982.

HEYNIKE, J.J.C. and McCULLOCH, S.F. (1982) The economic impact on an urban and industrial complex of mineral pollution in the water supply — a case study. Paper presented at 11th IAWPR Conference, Cape Town, March 1982.

HUGHES, D.A. (1982) The relationship between mean annual rainfall and physiographic variables applied to a coastal region of Southern Africa. *South African Geog. Journ.* **64**(1), 41-50.

KELBE, BRIAN EDWARD M-L (1982) Factors contributing to the convection over northeastern South Africa and Swaziland. PhD dissertation, University of Virginia and Simpson Weather Associates Tech. Rept., 261 pp.

LYNCH, S.D. (1982) Grondwatermodellering en parameteridentifikasie van die Sishen-akwifeer. M.Sc.-tesis, UOVS, Bloemfontein.

MAAREN, H. and SCHULTZ, C. (1982) The Bethlehem rainguage recorders and network. Paper presented at the Hydrological Instrumentation Workshop held at Pretoria, 14 and 15 June.

MALAN, G.J. (1982) Measurement of the peak rates of water demand for an apartment block and the testing of two types of domestic water meters. Paper presented at the CIB-W.62 Seminar Lostorf, Switzerland August/September (1982).

MALAN, G.J. and SIMPSON, G.C. (1982) Flush valve: WC performance and water conservation. Published in Supplement to *Planning and Building Development, April 1982 and Municipal Engineer,* March/April 1982, pp. 25-37.

MARAIS, G.v.R., LOEWENTHAL, R.E. and SIEBRITS, I.P. (1982) Review: Observations supporting phosphate removal by biological excess uptake. Presented at IAWPR post-conference seminar on phosphate removal, Pretoria.

MULDER, G.J. (1982) The contribution of groundwater and subsurface flow to the stormflow hydrograph as indicated by the results of a rainfall-runoff plot. Paper presented at: Groundwater '82, Groundwater division of the Geological Society of South Africa, 11 pp.

NICHOLLS, H.A. (1982) Application of the Ekama-Marais activated sludge model to large plants. IAWPR Conference, Cape Town, 1982.

ODENDAAL, P.E. (1982) Involving practitioners in research — a key to successful technology transfer. Paper presented at the 11th International Conference of the IAWPR, Cape Town, 29 March – 2 April 1982. *Wat. Sci. Tech. 14* 4D1-4D8.

OOSTERHUIS, D.M. and WALKER, S. (1982) Field use of thermocouple psychrometers for determining plant water potential: Application in plant water studies in wheat. Paper presented at the 1982 Congress of the SA Society for Crop Production.

OOSTERHUIS, D.M. and WALKER, S. (1982) Field measurement of leaf water potential components using thermocouple psychrometers. II. Applications in plant water relation studies in wheat. *Proc. Crop. Prod. Soc. South Africa.* Vol. II.

OOSTERHUIS, D.M. and WALKER, S. (1982) Influence of evaporation from the cut edge of excised leaf samples taken for water potential determinations using thermocouple psychrometers (abs.) *Plant Physiol. Suppl.* **69**(5):12.

OOSTERHUIS, D.M., WALKER, S. and SAVAGE, M.J. (1982) Field comparison of leaf *in situ* and screen-caged thermocouple psychrometers, and pressure chamber measurements of soybean water potential. *Agron. Abstracts,* Annual Meetings, Anaheim, California.

PIETERSE, M.J. (1982) Packaging of information — part and parcel of successful technology transfer. Paper presented at the 11th International Conference of the IAWPR, Cape Town 29 March – 2 April 1982. *Wat. Sci. Tech.* **14** 4E1-4E10.

PIETERSE, M.J. (1982) Die koördinering van waternavorsing in Suid-Afrika. Lesing gelewer by die Kernontwikkelingskorporasie van Suid-Afrika, 4 November.

PITMAN, A.R., VENTER, S.L.V. and NICHOLLS, H.A. (1982) Practical experience with biological phosphorus removal plants in Johannesburg. Paper presented at the IAWPR Seminar, Pretoria.

ROBARTS, R.D. (1982) Primary production of Hartbeespoort Dam. Paper presented to 1st Group on Aquatic Primary Production, Konstantz, West Germany.

ROBARTS, R.D., ASHTON, P.J. and THORNTON, J.A., TAUSSIG, H.J. and SEPHTON, L.M. (1982) Overturn in a hypertrophic warm monomictic impoundment (Hartbeespoort Dam, South Africa) *Hydrobiologica.*

SCHMIDT, E.J. (1982) Improved estimates of peak flow rates using modified SCS lag equations. 142 pp. Thesis for Degree of M.Sc. Eng. (Dept. Agric. Eng., Univ. Natal).

SCHULZE, R.E. (1982) Generalizing the use of the SCS stormflow model by soil moisture budgeting. Paper presented at the International Symposium on Hydrological Basins and their Use in Water Resources Planning, Berne, Switzerland.

SCHULZE, R.E. (1982) Mapping mean monthly temperature distributions for Natal by trend surface analysis. *S.A. Journal of Science* **78** 246-248.

SCHULZE, R.E. (1982) Natal's maximum water requirements for irrigation in an average year. *Arena* **5** 27-28.

SCHULZE, R.E. (1982) The significance of soil in hydrological modelling. Paper presented at conference 'Soil Science in Natal', June, 1982.

SCHULZE, R.E. (1982) The SCS Model: present and proposed use in Southern Africa. Paper presented at SARCCUS Meeting, July 1982.

SCHUTTE, C.F. (1982) Water recycling for domestic and agricultural applications: State of the Art. Paper presented at IAWPR Conference, Cape Town, April.

SIEBRITZ, I.P., EKAMA, G.A. and MARAIS, G.v.R. (1982) A parametric model for biological excess phosphorus removal. Presented at IAWPR post-Conference seminar on phosphate removal, Pretoria.

SIMPSON, G.C. (1982) Revising the cistern inlet valve. *Municipal Engineer* November/December 18, 19.

SMITHEN, A.A. and SCHULZE, R.E. (1982) The spatial distribution in Southern Africa of rainfall erosivity for use in the Universal Soil Loss Equation. *Water SA* **8** 74-78.

SPAMER, M.J.M., DE BRUYN, L.P. en HUMAN, J.J. (1982) Invloed van stremmingstoestande in die verskillende groeistadia op die onttrekkingspatroon van water uit die grondprofiel deur koring onder besproeiing. 'n Referaat gelewer tydens die 1982-kongres van die SA Vereniging vir Gewasproduksie.

STEYN, M.R. (1982) *Waterlit,* gerekenariseerde inligting vir visboere. Referaat gelewer by simposium oor akwakultuur, gereël deur die Transvaalse Landbou-unie, Mei.

TOERIEN, D.F., CLOETE, T.E., DU TOIT, P.J. and BOTES, P.J. (1982) Stabilizing high-strength wastes with photosynthetic bacteria. *Water SA* **8** 92-96.

TREFFRY-GOATLEY, K., BUCKLEY, C.A. and GROVES, G.R. (1982) Closed loop treatment and recycle of cotton/synthetic fibre dyehouse effluents. Proceedings of Symposium on New Technologies for Cotton; Textile Institute SAWTRI, 26-28 July, 439-456.

TWINCH, A.J. Hartbeespoort Dam sediments: their phosphorus status and distribution. Paper presented at the Annual Congress of the Limnological Society of Southern Africa, Pretoria, July 1982.

VAN HAANDEL, A.C., DOLD, P.L., and MARAIS, G.v.R. (1982) Optimization of nitrogen removal in the single sludge activated sludge process. *Wat. Sci. Tech* **14** 443.

WALKER, S. and OOSTERHUIS, D.M. (1982) Field measurement of leaf water potential components using thermocouple psychrometers. I Techniques. *Proc. Crop Prod. Soc. South Africa,* Vol II.

Reports Released

ADAMS, J., TOWNSEND, R.B. and BUCKLEY, C.A. (1981) Treatment of printing effluent for closed loop recycling. Report D17, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

ARKLEY, M.J. and MARAIS, G.v.R. (1982) The effect of the anoxic zone on sludge production and settleability in the activated sludge process. Research Report W38. University of Cape Town.

BOTHA, J.F., BAKKES, G.N., WEIDEMAN, J.A.C. en HODGSON, F.D.I. (1982) The development and evaluation of techniques for the determination of the ground-water potential in the Southern Orange Free State and Northern Cape. Vol. 6 Mathematical Developments and Numerical Simulations — Institute for Ground-water Studies — University of the Orange Free State.

BUCKLEY, C.A., TOWNSEND, R.B., SOUTHWORTH, B. and GROVES, G.R. (1982) The Treatment of textile desizing effluents by ultrafiltration — Final Report. Report UF10, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

BURGER, C.A.J., HODGSON, F.D.I. en VAN DER LINDE, P.J. (1982) Die ontwikkeling en evaluering van tegnieke vir die bepaling van die ontginningspotensiaal van grondwaterbronne in die Suid-Vrystaat en in Noord-Kaapland. Vol. 2 Hidrouliese Eienskappe van Akwifere in die Suid-Vrystaat. Instituut vir Grondwaterstudies — Universiteit van die Oranje-Vrystaat.

BURGERS, M.S. (1982) Besproeiingsprogrammering met behulp van panverdamping by koring, aartappels en stambone. Deel van die finale verslag oor die navorsingsprojek deur die Department Plantproduksie van die Universiteit van Pretoria in samewerking met die Waternavorsingskommissie.

CONSTANTINIDES, C.A. and STEPHENSON, D. (1982) Dimensionless hydrographs using kinematic theory. Report 5/1982, Water Systems Research Programme, University of the Witwatersrand.

DE JAGER, J.M., VAN ZYL, W.H., BRISTOW, K.L. en VAN ROOYEN, A. (1982) Besproeiingskedulering van koring in die besproeiingsgebied van die Vrystaatstreek. Finale verslag aan die Waternavorsingskommissie.

DOLD, P.L., BUHR, H.O. and MARAIS, G.v.R. (1982) Design and control of equalization tanks, in 2 volumes. Research Report W 42. University of Cape Town.

GÖRGENS, A.H.M. and HUGHES, D.A. (1982) Hydrology of the Karoo Biome. Chapter 6: *Synthesis for the Karoo Biome,* Roux, P.W. and Pieterse, J.H. (Editors), National Scientific Programmes Report, CSIR, Pretoria.

HENSLEY, M. and DE JAGER, J.M. (1982) The determination of the profile available water capacities of soils. Final report by the Department of Soil Science of the University of Fort Hare to the Water Research Commission.

HODGSON, F.D.I. (1982) Die ontwikkeling en evaluering van tegnieke vir die bepaling van die ontginningspotensiaal van grondwaterbronne in die Suid-Vrystaat en in Noord-Kaapland. Volume 1 Opsommende verslag — Instituut vir Grondwaterstudies — Universiteit van die Oranje-Vrystaat.

HUGHES, D.A. (1982) Conceptual catchment model parameter transfer studies using monthly data from the Southern Cape Coastal Lakes region. Report 1/82, Hydrological Research unit, Geography Department, Rhodes University.

HUGHES, D.A. and GÖRGENS, A.H.M. (1982) Hydrology of the Buffalo River catchment. Chapter 4: *Water quality in the Buffalo River A synthesis,* R. Hart (Editor), Rhodes University, Grahamstown, pp. 37-62.

MACMILLAN, C.D. and GROVES, G.R. (1982) Results of the operation of a pilot-plant for the treatment and reuse of wool scouring effluents — desuinting/scouring system. Report W14/2, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

MACMILLAN, C.D. and GROVES, G.R. (1982) Results of the operation of a pilot-plant for the treatment and reuse of wool scouring effluents — ultrafiltration system. Report W14/3, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

MACMILLAN, C.D. and GROVES, G.R. (1982) Results of the evaporation of desuinting effluents from wool scouring. Report W15, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

RUSSEL, D.A. (1982) Determination of soil properties related to irrigation and drainage. Part of the final report on the research project by the Department of Soil Science of the University of Fort Hare in collaboration with the Water Research Commission.

SCHROEDER, W.D., DOLD, P.L. and MARAIS, G.v.R. (1982) The CO D/VSS ratio of the volatile solids in the activated sludge process Research Report W45. University of Cape Town.

SCHULZE, R.E. (1982) Adapting the SCS stormflow equation for application to specific events by soil moisture budgeting. Univ. Natal, Dept. Agric. Eng., ACRU Report No. 15, 62 pp.

SCHULZE, R.E. and DENT, M.C. (1982) Hydrological design information for water resources development from small dams in the Highflats area. Univ. Natal, Dept. Agric. Eng., ACRU Report No. 13, 47 pp.

SCHULZE, R.E. and DENT, M.C. (1982) Development of a data file of autographic rainguage records in southern Africa. Univ. Natal, Pietermaritzburg, Department of Agric. Engineering, ACRU Report No. 16, 32 pp.

SIMPKINS, M.N.J.P. and GERBER, A. (1982) Technical guide on biological nutrient removal: The Phoredox Process. Water Research Commission.

SMITH, D.J.G., VILJOEN, M.F. and SPIES, P.H. (1982) Guidelines for assessing flood damage in South Africa. Water Research Commission.

STEPHENSON, D. (1982) Peak flows from small catchments using kinematic hydrology. Report 4/1982, Water Systems Research Programme, University of the Witwatersrand.

TREFFRY-GOATLEY, K., BUCKLEY, C.A. and GROVES, G.R. (1982) Results of the operation of a pilot-plant for the treatment and reuse of cotton/synthetic fibre dyehouse effluents. Report D20/2, Pollution Research Group, Department of Chemical Engineering, University of Natal, Durban.

VAN DER MERWE, J., VAN ROYEN, L., HODGSON, F.D.I. en POTGIETER, G.J.A. (1982) Die ontwikkeling en evaluering van tegnieke vir die bepaling van die ontginningspotensiaal van grondwaterbronne in die Suid-Vrystaat en in Noord-Kaapland. Vol. 3 Grondwaterondersoeke in Noord-Vrystaat en Noord-Kaapland. Instituut vir Grondwaterstudies — Universiteit van die Oranje-Vrystaat.

VAN DER WESTHUIZEN, C. and HODGSON, F.D.I. (1982) Development and evaluation of techniques for determining the exploitation potential of groundwater resources in the Southern Free State and Northern Cape. Vol. 4 Geohydrological Aspects of the Vryburg Compartment, Northern Cape Province. Institute for Ground-water Studies — University of the Orange Free State.

VAN TONDER, G.J. and HODGSON, F.D.I. (1982) Development and evaluation of techniques for determining the exploitation potential of groundwater resources in the southern Free State and Northern Cape. Vol. 5 Statistics and Data Analysis. Institute for Ground-water Studies — University of the Orange Free State.

VOS, J.A. (1982) Die bepaling van vloedskades binne stedelike nedersettings na aanleiding van die 1975-oorstromings in die Vaalrivier asook riglyne vir die vermindering van vloedskades. Instituut vir Sosiale en Ekonomiese Navorsing, Universiteit van die OVS, Bloemfontein.

WATER RESEARCH COMMISSION (1982) A guide for the planning design and implementation of a water reclamation scheme. Water Research Commission, Pretoria.

WESSELS, W.P.J. (1982) Die ontwikkeling van doeltreffende besproeiingsmetodes vir toepassing op skuins gronde. Finale verslag deur die Department Siviele Ingenieurswese van die Universiteit van Stellenbosch aan die Waternavorsingskommissie.

Complementary list to the 1981 Annual Report

Articles and Papers

1973

BRATBY, J. and MARAIS, G.v.R. (1973) Dissolved air flotation. *Proc. Filtration Society.* Conference on What's New in Liquid Solid Separation. London.

1974

BRATBY, J. and MARAIS, G.v.R. (1974) Dissolved air flotation. *Filtration and Separation* **11**, 614.

1975

BRATBY, J. and MARAIS, G.v.R. (1975) Saturator performance in dissolved-air (pressure) flotation. *Water Research* **9**, 929.

BRATBY, J. and MARAIS, G.v.R. (1975) Dissolved-air (pressure) flotation — An evaluation of interrelationships between process variables and their optimization for design. *Water SA* **1**(2)57.

HENZEN, M.R. (1975) Use of sandy aquifers for storage and reclamation of purified sewage — Paper presented at the Israel/South African Symposium on Recycling of Wastewater for Agricultural and Industrial Uses. Herzlea, Israel, 24-29 November.

1976

BRATBY, J. and MARAIS, G.v.R. (1976) A guide to the design of dissolved air (pressure) flotation in activated sludge systems. *Water SA* **2**(2)86.

1977

BRATBY, J. and MARAIS, G.v.R. (1977) Flotation — Chapter 5 in book entitled *'Solid-Liquid Separation Equipment Scale-up',* Ed. D Purchas, Uplands Press, England.

BRATBY, J. and MARAIS, G.v.R. (1977) Dissolved-air flotation in activated sludge. *Prog. Wat. Tech.* **9** 311.

BRATBY, J. and MARAIS, G.v.R. (1977) Thickening of brown water sludges by dissolved-air flotation. *Water SA* **3** (4)202.

EKAMA, G.A. and MARAIS, G.v.R. (1977) The activated sludge process, Part 2 — Dynamic behaviour. *Water SA* **3** (1)17.

MARAIS, G.v.R. and EKAMA, G.A. (1977) The activated sludge process, Part 1 — Steady state behaviour. *Water SA* **2** (4)163.

1978

EKAMA, G. and MARAIS, G.v.R. (1978) Adsorption in the activated sludge process. *Water SA* **4**(1)39.

1979

EKAMA, G.A and MARAIS, G.v.R. (1979) Dynamic behaviour of the activated sludge process. *J. Wat. Poll. Cont. Fed* **51** 534.

EKAMA, G.A., VAN HAANDEL, A.C. and MARAIS, G.v.R. (1979) The present status of research in nitrogen removal: A model for the modified activated sludge process. Proc. Symp. on Nutrient Removal from Municipal Effluents. Published by the Water Research Commission, Pretoria.

1980

ALEXANDER, W.V., EKAMA, G.A. and MARAIS, G.v.R. (1980) The activated sludge process Part 1 — application of the general kinetic model to the contact stabilization process. *Water Research* **14** 1737.

DOLD, P.L., EKAMA, G.A. and MARAIS, G.v.R. (1980) A general model for the activated sludge process. *Prog. Wat. Tech.* **12** Tor 47.

FRONT COVER:

From top to bottom: 1. Sludge disposal to sea. 2. Weir in Breede River. 3. Fruit processing. 4. Prototype water reclamation plant, Cape Flats.