

# **RESEARCH IMPACT ASSESSMENT:**

## **LESSONS TO BE LEARNED FROM THE COST-BENEFIT ANALYSES OF SELECTED WRC RESEARCH PROJECTS**

Prepared for the

Water Research Commission

by

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## 1. PROFILE AND MISSION OF WRC

The Water Research Commission (WRC) was established in 1971 (the Water Research Act, Act No 34 of 1971) following a period of water shortage. It was deemed to be of national importance to generate new knowledge and to promote the country's water research purposefully, owing to the view held that water would be one of South Africa's most limiting resources in the 21st century.

The WRC has over the years positioned itself to achieve its primary objective, which is to serve the nation as a dynamic hub for water-centred knowledge, innovation and intellectual capital as well as to provide leadership for research and development (R&D) through the support of knowledge creation, transfer and application.

### Funding

The Water Research Act provides for the establishment of a Water Research Fund, which derives income from levies on water consumption. The Department of Water Affairs and Forestry collects the funds for the WRC, on a commission basis.

Through its networking-based activities, and by aligning itself with national priorities and presidential imperatives, the WRC aims to engage stakeholders and partners in solving water-related problems that are crucial to South Africa's sustainable development and economic growth, while assisting in positioning the country on the African Continent through the WRC's involvement in the New partnership for Africa's Development (NEPAD).

The present strategic direction of the WRC focuses on:

- Water Resource Management
- Water-linked Ecosystems
- Water Use and Waste Management
- Water Utilisation in Agriculture
- Water-Centred knowledge

In order to achieve its objectives in the key strategic areas (KSAs), the WRC performs the following functions:

- Promoting co-ordination, co-operation and communication in the area of water research and development
- Establishing water research needs and priorities
- Stimulating and funding water research according to priority
- Promoting effective transfer of information and technology
- Enhancing knowledge and capacity-building within the water sector

### Core Business Process of Funding

#### - Preamble

The WRC strives to function effectively, and to be of high relevance to South Africa by addressing national priorities and the water sector's needs. With recent changes in governance processes, the requirements of the Public Finance Management Act (PFMA), and the new strategic direction and the re-structuring of the WRC, the Board of the WRC has strongly emphasised the need for the improvement of the current process of selection of research projects and programmes. This need coincides with the decision of the Board to revise the procedure for approval of research funding i.e. to change from a process that directly addresses individual research projects (requiring Board approval at project level) to a more holistic and strategic approach, where Board approval of research funding is based on strategic business plans at organisational and key strategic area (KSA) levels. The strategic change in approach requires a process of selection that increases the level of confidence of both the Board and the wider stakeholder community. This process should provide for:

- Effectiveness and relevance
- Technical rigour

- Transparency and openness (equity and re-dress)
- Efficacy.

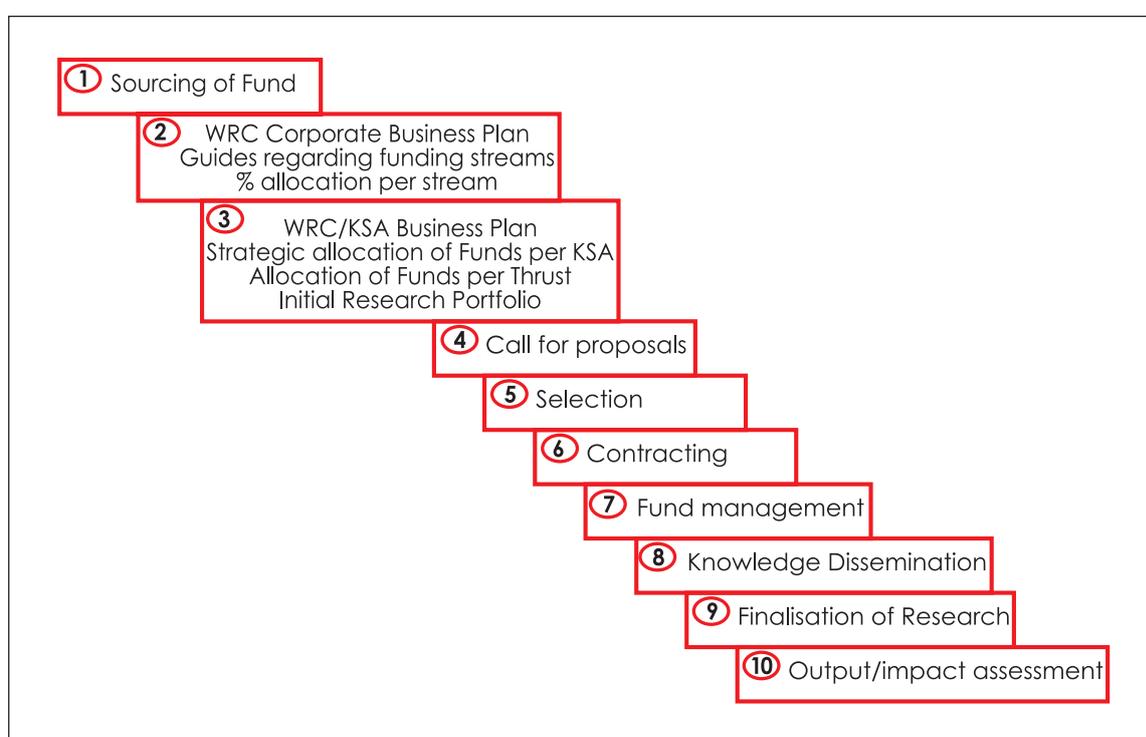
In addition to the changes in the process of selection, changes in funding mechanisms, size and type of research projects are also addressed, both with the aim of supporting and facilitating the above.

## - Introduction

The WRC investment in building water-centred knowledge focuses on:

- The development/creation of new knowledge (investment in research);
- The building of a sustainable and transformed knowledge-base and the development of the nation's intellectual capital (capacity/competence development);
- The implementation of knowledge dissemination initiatives;
- The strategic support of knowledge application, innovation and commercialisation of relevant knowledge with high intellectual property value.

The Board approved a new approach/process of allocation of funds for the creation, dissemination and transfer of water-centred knowledge based on the implementation of a business planning process and the development of strategic research portfolio(s) – see diagram below.

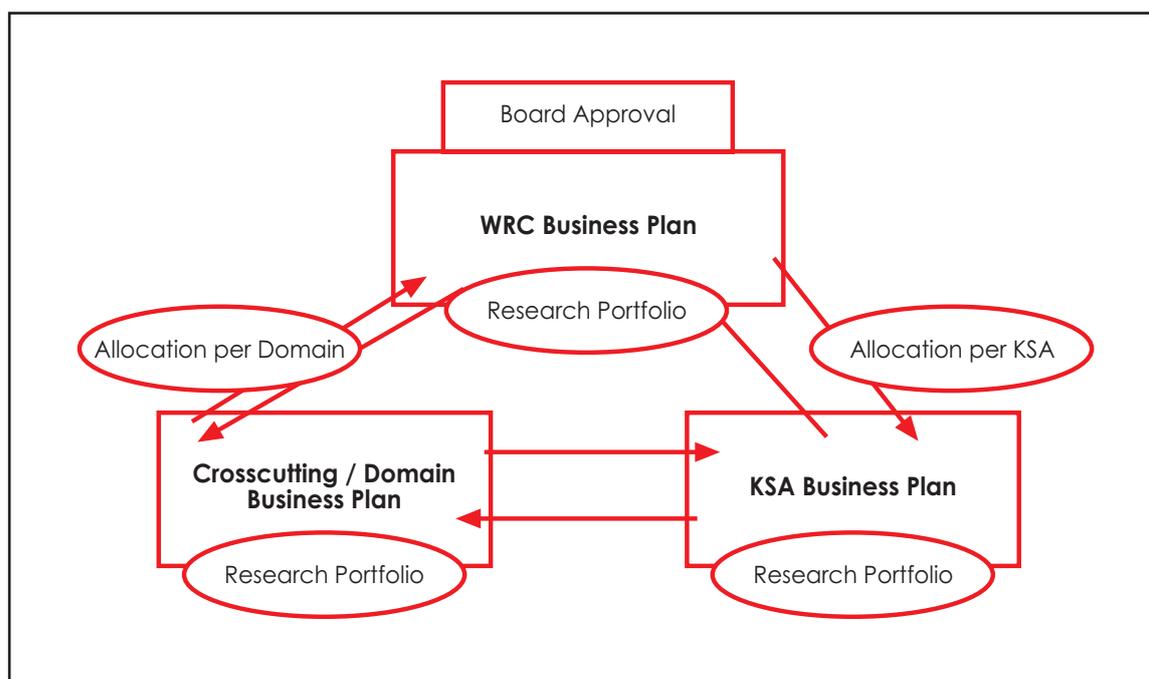


A number of sub-processes have been addressed as part of the organisational as well as KSAs' and crosscutting domains' business plans and applicable Key Performance Areas (KPA's). These include the issues pertaining to sources of fund (i.e diversification of income and leverage), fund management and finalisation of research (both addressed under improvement of internal processes and IT tools). The sub-process of output/impact assessment has also been addressed in the business plans. Each KSA and crosscutting domain indicates relevant achievements to date against stated objectives (and KPA's). Further attention will be given to the development of a frame for assessment of outputs/impact during this financial year.

## - The WRC's new approach to funding - using a strategic research portfolio approach

The current move to KSAs allows for a strategic, focused and integrated approach to funding. Each KSA provides an integrating framework for investment and is based on a portfolio of identified key, water-related research needs. A KSA forms the basis for a portfolio of key thrusts, where each thrust is based on a portfolio of programmes. Programmes could be addressed as a primary call for

'investment' or be built around a portfolio of projects. In addition to the KSAs, the four crosscutting domains (i.e. health, environment, economy and society-related issues) will provide further links between KSAs and will support key national priorities. The links between the business plan and the research portfolio of each KSA/crosscutting domain are presented below. The research portfolios of most of the crosscutting domains form an integral part of the various KSA portfolios. The research portfolios of the KSAs reflect the needs of the crosscutting domains that directly relate to the KSAs, e.g. research projects on food security and water issues will be addressed in the KSA: Water Utilisation in Agriculture. However, in certain domains, specific needs for investment may be identified for projects/programmes directly linked to the domain rather than to any specific KSA. The decision regarding funding allocation for each of the KSAs' research portfolios as well as for the specific needs of each of the crosscutting domains is made on the basis of the business plans of the KSA or the domain. These form the basis for approval by the Board.



## - Funding Mechanisms (Streams)

Based on its business plan, each KSA (and in certain cases a crosscutting domain) calls for research proposals using different mechanisms or funding streams. The research portfolios should allow for short-, medium- to long-term programmes/projects, consortia-based funding as well as solicited and non-solicited research (clear, pre-defined terms of reference will form the basis for solicited research; the call for non-solicited research will aim at sourcing highly innovative research proposals using a strategic framework). The ratio (mix) of different funding streams may be different for each of the KSAs and may also change with time in accordance to the specific strategic needs of the specific KSA.

It is envisaged that the WRC's research portfolio will have funds allocated to research in the following categories:

- Solicited projects
- Non-solicited projects
- Consultancies (solicited or non-solicited)

### Solicited Research

The purpose of soliciting research is to proactively and strategically direct research and development into the areas of greatest need or where the greatest potential impact can be achieved. Solicited research will, by and large, take the form of relatively large projects or programmes which address medium to long-term needs, and with budgets in the range of R1 to 2 million per year over a maximum of three years. In the case of such large projects or programmes, there will be a definite preference for the research to be undertaken by consortia rather than individual organisations.

Solicited research may be non-targeted, i.e any organisation or consortium of organisations that

considers itself qualified will have an equal opportunity to submit a bid to undertake the research. However, it is conceivable that some solicited research projects may be targeted, i.e assigned to specific research providers who may have exclusive skills to undertake the necessary research.

Although most of the solicited research will, in the long run, address large projects or programmes, some targeted, solicited research projects may be regarded as consultancies with a funding limit of R200 000, especially if there is an element of urgency. In addition, it is envisaged that funds will be allocated for strategic research or research on research. This special form of strategic research is necessary for establishing the current status and direction of research and the associated competency base addressed (or to be addressed) by a KSA or a crosscutting domain.

### Non-solicited Research

Non-solicited research proposals provide the opportunity of accommodating, within the preferred focus or thrust areas recognized by the business plan, promising and relevant research based on innovative thinking and with the potential to yield valuable results. Proposed projects in this category will typically have budgets ranging from R400 000 to R1 million per annum over a period of one to three years. They will mostly be undertaken by a single organization, although the participation of collaborating organizations cannot be excluded.

### Consultancies

Consultancies refer to short-term investigations (6-12 months maximum) that are crucial, urgent or exploit windows of opportunity, and which have total budgets not exceeding R200 000. Proposals for consultancies will be evaluated by the relevant research manager for recommendation to the KSA team or the crosscutting forum for final approval by the KSA Director or the Deputy CEO.

## **- Call for Proposals**

The WRC's investment in R&D will be mainly through solicited and non-solicited research projects or programmes. In both 'streams', calls for proposals will be issued annually (annual funding cycle). While calls for proposals will differ between the two categories (i.e. solicited and non-solicited), in both instances they will be supported by clear guides for either proposal writing or clear terms of reference (ToR). Consultancies will cater for the initiation of either short-term or seed/pilot investigations, and will allow for fund allocation within the frame of the strategic portfolio, but outside of the annual cycle of fund allocation for projects/programmes.

Calls for proposals for solicited research will be accompanied by clear ToRs, to which proposers of research will be required to closely adhere. The ToRs will align the research with the WRC's (KSA's) strategic objectives and will be clear and specific. The WRC will seek the support and advice of strategic reference groups (where applicable) for the identification of solicited research (for further details please see Annexure A). Calls for proposals for non-solicited research will indicate that proposals should conform closely to published guidelines with regard to preferred focus areas as identified in KSA and crosscutting domain business plans, and a standard WRC layout for research proposals. It is suggested that in future funding cycles, the WRC will include a call for 'concept proposals' for non-solicited research that will improve the efficacy of the selection process.

## **- Selection of Proposals**

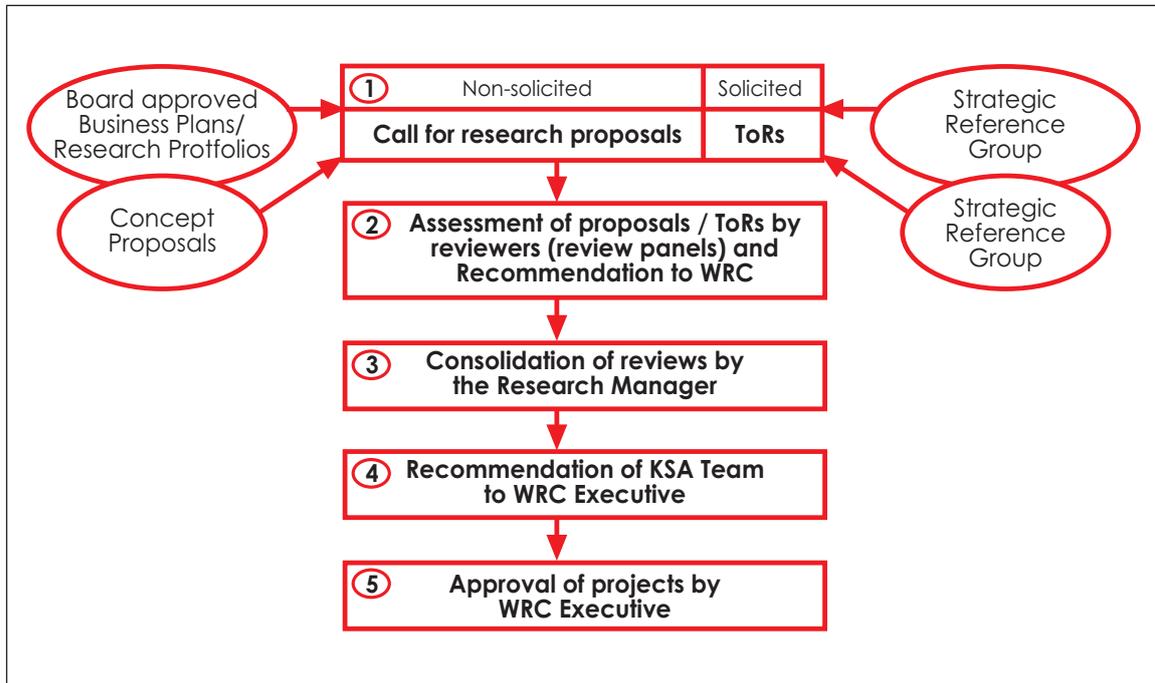
The selection of research proposals is a crucial step towards ensuring both high quality research and cost-effective research products and outcomes. The selection process should allow for:

- Effectiveness and relevance
- Technical rigour
- Transparency and openness (equity and re-dress)
- Efficacy.

The process will be based on the application of key selection criteria and the use of peer review (i.e a review panel that includes technical (scientific) experts and practitioners). Both solicited and non-solicited funding will be assisted by review panels. Members of the review panel may provide their individual review to the WRC and the consolidation of the various reviews, and the final decision of

approval of a research project, will be addressed by the WRC (see flow diagram addressing the process).

**- Selection of Research Projects/Programmes**



**Criteria for selection**

The criteria for selection for both solicited and non-solicited research are basically similar, and aim to ensure that research proposals (or ToRs) are closely aligned with research strategies identified in the KSA and/or the crosscutting domain business plans. These criteria also indicate the WRC expectations and requirements with regard to strategic initiatives such as capacity development, equity and redress, knowledge dissemination, innovation, commercialisation (where applicable) and leveraging of resources (see below). However, selection criteria for solicited research projects are largely embodied in the ToRs (i.e. the strategic relevance, already addressed through the choice of ToRs). The selection process will emphasise applicability and quality (within the framework of the ToR). All essential information required for assessing/evaluating a proposal (or a ToR) will have been requested in the call for proposals or the ToRs (see Annexure A). It should also be noted that, with regard to non-solicited research, initial selection will be done on 'concept proposals' (in future funding cycles, not the current cycle) that will be assessed mainly against relevance and credibility, while the full proposal will be re-evaluated against all the criteria as set below.

The criteria will address the following:

- Relevance (to the needs of society and to the WRC's strategic research objectives. Please note that, in the case of solicited research, this is already addressed by the ToRs as described above)
- Scientific/technical credibility
- Potential contribution to capacity building
- Leveraging of resources
- Anticipated value for money
- Track records of research team and project leader and lead organisation (where applicable)
- Make-up of the research team with regard to equity and redress.

It is envisaged that a scale of merit will be attached to each assessment criterion. The idea is to include a five-point scale, and an appropriate weight for each of the criteria, as a basis for a final merit score. Please note that research managers and the WRC Executive (KSAs' Directors, DCEO, CEO) will use this score as a guide rather than an absolute ranking criterion during final deliberation and decision-making.

The selection (evaluation) of solicited and non-solicited proposals/ToRs are presented above (process flow diagram). Essentially, the selection is based on assessments of (a) how highly the various proposals/ToRs score in meeting the selection criteria and (b) the competencies of the research team or consortium and their ability to deliver. Initial assessment is carried out by a panel of external, expert reviewers (see Annexure A). Based on these assessments, research managers prepare recommendations for further evaluation at either KSA-team or crosscutting domain forum level. Final assessments, and subsequent decisions, are performed by the WRC Executive (Directors, DCEO, CEO), based on recommendations emanating from the KSA team or the crosscutting domain forum. In the case of non-solicited research, it is envisaged that the process would include initial selection by the research manager with the aim of eliminating unacceptable proposals (this will also apply to concept proposals in future years).

## - Summary

The sub-processes addressing the call for and the selection of proposals for the different funding 'streams' have been described above. Based on the recommendation by the RPS committee, and upon approval by the Board, the WRC will consolidate the given approach into clear and focused guideline documents, which will cater for the call for proposals and for selection criteria.

The Board should take into account that the changes in approach, as presented above, align with the new strategic decision (approved by the Board) where business plans and strategic research portfolios form the basis for the allocation of funds. The call for proposals or ToRs for specific projects are 'products' of these plans. In addition, this change in approach coincides with changes in the delegation of power and authority (addressed under separate headings) and changes in fund management, size and number of projects, and a new approach to knowledge dissemination. The new selection process allows for increased relevance, by using the business plans and research portfolios as the basis for the development of ToRs and the call for non-solicited research. The use of strategic advisory groups supporting the selection of ToRs, and the use of review panels and a peer review approach will provide for technical and scientific rigour. The composition of the panels of reviewers and strategic advisors will address the issues of equity and re-dress and improve openness in conducting both strategic and project reviews. The use of individual reviewers and the increase of project size, together with the decrease in the number of research projects, will contribute to increased efficacy and a reduction in cost, without compromising the effectiveness (or will even support an increase in effectiveness) of the process of selection. The introduction of concept proposals will also improve the effectiveness and efficacy of the process. It is envisaged that within a period of three years, the process of selection will become increasingly cost effective and, coinciding with other interventions (e.g. increasing project size and reducing the number of projects; a reduction of about 50% in the current number is expected within three years), will provide a substantial reduction in the cost of the selection process and the overall administrative cost of fund management (by at least 20% of current cost).

## Technology Transfer

The implementation of positive research findings is the WRC's ultimate objective. For this reason, the WRC follows a wide range of strategies to promote the dissemination and application of research findings.

The WRC has over the years achieved the mobilisation and development of research expertise over a wide range of disciplines and organisations. To a greater or lesser extent, the WRC has successfully addressed the key issues.

However, the question remains to what extent the research expenditure by the WRC was economically beneficial and will be so in the future.

## 2. BACKGROUND AND PURPOSE OF STUDY

The WRC is part of the broader public sector and has a claim to public funds. It is thus necessary for the Commission to spend its funds in such a manner that this reflects the preferences of society, and that the expenditure is cost-effective. Although the benefits culminating from research projects are

very difficult to quantify on an exact basis, it is still necessary that a comprehensive evaluation is made of the direct and indirect benefits that flow from such projects.

On the one hand, the social impact can be measured, based on the magnitude of the improvement in the quality of living of the relevant people affected by the research. The provision of high quality water at affordable prices is an example of such a measurement.

On the other hand, the costs of the research also have to be taken into account. All in all, the evaluation has to take cognizance of the effectiveness as well as the efficiency of the outcome of the research.

In order to further enhance its effectiveness, the WRC initiated a study project to analyse the impact of its research. The aims of this study were the following:

1. Quantitative Analysis i.e. determining the economic contribution of selected WRC Research projects;
2. Salient features of the impact of the selected WRC research projects; and
3. Synthesis of positive and negative factors (See objective 2) enabling the WRC to identify appropriate WRC projects in the future. This should enhance and optimize the effectiveness and efficiency of research funded by the WRC.

A sample, consisting of six research projects, was selected and evaluated by means of Cost-Benefit Analysis (CBA). These projects were the following:

- ACRU Model Development
- Hydrosalinity System Models
- Surface Water Resources of South Africa
- Biological Nutrient Removal
- Dry Cooling in Power Generation
- Combined Services Model

### **Cost-Benefit Analysis**

The Cost-Benefit Analysis (CBA) method provides a logical framework by means of which projects can be evaluated, thus serving as an aid in the decision making process. In layman's terms, the principle of a CBA can be described as the comparison of costs and benefits that emanate from a particular project. A factor that complicates the technique is the capitalization of costs and benefits to present values.

Costs and benefits that are immediately incurred are judged differently by the community from costs and benefits that materialize over a future period of time. Usually, a community would prefer receiving a benefit today rather than reaping benefits in the future, whilst deferred costs are more attractive than immediate payments. Consequently, the current money value of costs and benefits over time can not simply be added together. The time preference of the community has to be taken into account through the use of a weighting process. This weighting by the community is done with the assistance of a rate that reflects the true value of a cost or benefit over time. This rate is known as the social discount rate. To a large extent, this principle can also be compared (in an inverse sense) to the long-term interest rate on fixed investments. This rate signifies the willingness of investors to forego current spending in favour of more favourable returns in the future. For this reason, the proposed social discount rate for use in a particular CBA will always be compared with, for example, the interest rate on long-term Government securities

The first sensible step in conducting a CBA for a particular project is to indulge in the so-called scenario settings i.e. identifying those economic sectors and communities that will be affected (also referred to as the stakeholders). These sectors may be either positively or negatively impacted by the activities related to each of the various scenarios.

Thus, the CBA conducted for each of the identified projects incorporates the description and analyses of both the benefits and cost streams of each project, as well as assigning monetary values to them. These costs and benefits were calculated for each year over the lifespan of each project, and discounted to present values by the use of the social discount rate.

In addition, the CBA for each project was, in the first instance, undertaken at market prices. Market prices are the perceived prices at which products and services are traded, irrespective of interferences in the market. However, in circumstances where market prices of products and services do not clearly reflect their real scarcity value or economic contribution, they were adjusted accordingly. These adjusted prices are called shadow prices.

These present values will be used to calculate various assessment criteria, which will assist in the evaluation of each of the probable scenarios. These criteria are:

- Net Present Values (NPV)

According to this method the difference between the benefits and costs (the net benefit) in the specified year is discounted to the present by using the social discount rate. The discounted sum of all these net benefits over the (economic) project life is defined as the net present value (NPV), where:

$$NPV = \sum b_j / (1 + i)^j - \sum c_j / (1 + i)^j.$$

The criterion for the acceptance of a project is that the net present value must be positive; i.e. funds will be voted for a project only if the analysis produces a positive net present value. Where a choice has to be made between mutually exclusive projects, the project with the highest net present value will be chosen since it maximizes the net benefit to the community.

- The Economic Rate of Return (ERR)

The economic rate of return (ERR) is the discount rate at which the present values of cost and benefits are equal. It is therefore the value of the discount rate  $r$ , which satisfies the following equation:

$$\sum b_j / (1 + r)^j - \sum c_j / (1 + r)^j = 0.$$

Only projects with an economic rate of return higher than the social discount rate, (which forms a lower limit) will be considered for funding.

- The Discounted Benefit-Cost Ratio (BCR)

The discounted benefit-cost ratio (BCR) is the ratio of the present value of the benefits relative to the present value of the costs, i.e.

$$BCR = \{ \sum b_j / (1 + i)^j \} / \{ \sum c_j / (1 + i)^j \}$$

A project will only be considered for funding if the benefit-cost ratio is greater than 1.

There exists doubt in the literature about how costs and benefits should be dealt with. In practice, it is probably more common not to compute the benefit-cost ratio using gross costs and gross benefits, but rather to compare the present worth of the net benefit with the present worth of capital costs. There are, however, some institutions that include some operating and maintenance costs as part of the costs with which the net benefit should be compared. As far as this study is concerned, only costs of a capital nature (assets and equipment with a life of more than a year) form part of the costs with which the net benefit should be compared.

In the next section, the economic contributions of the abovementioned six research projects will be discussed in terms of the CBA methodology. It should be noted that the CBA analyses of the six projects were conducted during 2000/2001.

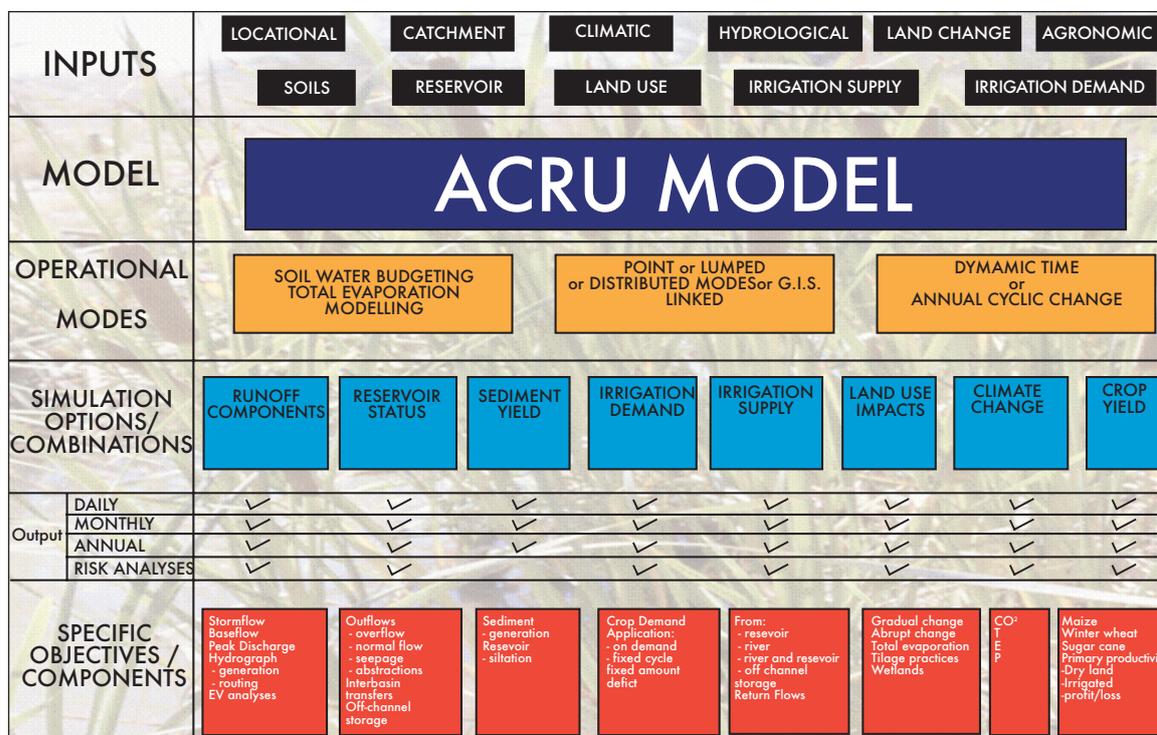
### 3. ECONOMIC CONTRIBUTION OF SIX SELECTED WRC RESEARCH PROJECTS

The following six projects were selected to represent the wide spectrum of WRC research activities:

- ACRU Model Development
- Hydrosalinity System Models
- Surface Water Resources of South Africa
- Biological Nutrient Removal

- Dry Cooling in Power Generation
- Combined Services

In the following discussion the economic contribution of each project will be analysed individually. It should be emphasized that, in view of the fact that the benefits are in most cases much higher than the costs of the research and its application, NPVs will be used as the CBA decision criteria.



## ACRU Model Development

### Background

The impact of increased human activities on South Africa's water resources is one of the major issues in the South African water resources utilization process. South Africa's history is full of anecdotal examples of rivers having dried up as a result of overgrazing, building of dams, planting of trees, irrigation, etc.

With funding from the WRC, the Department of Agricultural Engineering at the University of Natal started to research the catchment hydrology, i.e., the water balance of land areas in 1980. The concept of rainfall-runoff modelling was expanded to explicitly take into account specific land-use decisions, and to predict the impact of these decisions on water resources. This applies to both water quantity as well as quality. One of the products of this research was the so-called ACRU-model.

The output of the relevant research is thus a tool which is tailor made for South African conditions and is available for present day water management. The model provides simulated data on a great number of agricultural water management situations including crop yield predictions, optimal irrigation water supply schemes, and the effect of afforestation on water runoffs, etc.

To measure the benefits of the ACRU model, two applications were selected, namely the sugar industry and forestry.

### Sugar

The sugar industry was selected because of recent studies undertaken to predict seasonal crop yields. In the case of sugar, the savings experienced by the sugarmill and the industry are measured as a result

of the introduction of this model.

Forecasts of crop yields are important to the millers in the industry to facilitate optimum planning for the milling season. On average, the milling season varies between 8 and 10 months due to the fact that, because the maximum capacity of a mill is predetermined, the duration of operating time is then determined by the crop yield in the mill supply area.

The sucrose content of sugarcane deteriorates later in the cutting season, i.e. into the spring and summer of the next season. This factor also has cost implications for the mill and the sugarcane farmer. Accurate crop yield forecasts are therefore of great importance to the sugar mills in order to determine the cutting season and also in managing costs.

In order to assess the economic benefits of forecasting, consideration was firstly given to the costs associated with inaccurate yield forecasts derived from the different methods, including the use of the observed median. The costs associated with the different methods were compared to those of the observed median, which formed the basis for comparisons.

The costs of underestimating a crop are higher than overestimating. An underestimation implies that a mill must operate later into the wet season in order to complete the crushing of a crop. This latter period is, as mentioned above, unfavourable for milling.

The economic benefits of the different yield forecasting methods can be assessed against their costs of implementation in order to estimate the net economic benefit of the methods.

The discounted benefit for the sugar dryland area is then R27,07 million.

This calculation is probably an undercalculation because of the application possibilities of ACRU in irrigated cane areas, and its application in other neighbouring countries. The reason that irrigated lands were excluded is that the studies are not yet completed to calculate the relevant savings.



## Forestry

The forestry industry was selected because of the hydrological impacts of afforestation.

In the case of forestry, the benefits of the ACRU model are inherent in the identification of more appropriate soil conditions, which ultimately lead to higher forestry yields.

The rotational period of a plantation varies from 10 years in the case of gum, and up to 30 years in the case of pine. Over this period, it is important that the most favourable annual increment takes place. The annual increment depends on rainfall, topography, temperature, soil types, depth of soil and plant material. ACRU is used to identify the geographical areas that will deliver the best growth.

The forestry industry is regulated by a licensing system, managed by the Department of Water Affairs and Forestry (DWAF). For any new license to be issued, and in the case of replanting, a hydrological assessment has to be undertaken and, for this, the ACRU is used. Simultaneously, the industry uses ACRU to identify the areas where the best yield potential exists.

For the purposes of this study, it was decided to do an analysis of a pine plantation in the Eastern Cape. With only a relatively small area of 9 000 ha being available annually for new plantings, it is important that the most suitable areas are planted each time.

The mean annual increment for pine is 14,47 m<sup>3</sup>/ha which, according to the Forestry Economic Services, converts to a profit of R245,53 per hectare per annum. If the higher potential areas are identified and planted, the industry expects to achieve an improvement of at least 5 % in average increment to 15,19 m<sup>3</sup>/ha according to Mondi Eastern Cape.

The following table indicates what happens to profit if the mean annual increment increases from 14,47 m<sup>3</sup>/ha to 15,19 m<sup>3</sup>/ha.

	South African Average	5 % Increase
Mean Annual Increment	14,47 m <sup>3</sup> /ha	15,19 m <sup>3</sup> /ha
Profit	R245.53/ha	R303.53/ha

The increase of 23,6 % in profit per ha (i.e. R58.00) is interpreted as the benefit resulting from using ACRU. The total benefit per annum for the 9 000 ha planted should be R522 000. The average rotation age for South African Pine Plantations is 26 years, and the NPV is, therefore, calculated over this period with a once off cost for applying ACRU and a planting of 9 000 ha/annum for the next 26 years.

## Results

The results of the application of the ACRU model for sugar and forestry are as follows:

1999 economic prices	Present Value 8 %, R millions
<b>A. COST</b>	
Cost of WRC research projects	-R16,90
<b>B. BENEFITS</b>	
<b>B1. APPLICATION IN SUGAR INDUSTRY</b>	
Cost of setting up ACRU	-R0,55
Cost of maintaining ACRU	-R5,41
Savings from improved forecasting	R33,02
Sub-Total	R27,06
<b>B2. APPLICATION IN FORESTRY – NEW PLANTING (PINE)</b>	
Cost of setting up ACRU	-R2,67
Savings from improved forecasting	R93,47
<b>TOTAL BENEFITS</b>	R117,86
<b>NET PRESENT VALUE (NPV)</b>	R100,96

## Concluding Remarks

Although the relevant research started in 1980 and the ACRU model was first available from ± 1985, it was only in 2000 that the model's capabilities were fully understood and its application began to gain momentum.

As projections indicate that, by 2030, South Africa will start experiencing severe water shortages, the benefits derived from using the ACRU model to facilitate proper strategic water planning, should grow dramatically.

Although the costs associated in developing the model are relatively high, the benefits outweigh those costs a number of times.



## HYDROSALINITY SYSTEM MODELS

### Background

South African Water Engineers are considered world wide to be at the forefront when it comes to optimising the water yield and quality of complex inter-catchment water transfer schemes. The showpiece of these schemes is the Vaal system model. This model is inter alia being used to predict how long the present water supply in the system can be expected to last under different future rainfall scenarios; when to release water from the Sterkfontein Dam; etc. It is also used to manage Vaal Dam releases so that the salinity in the Vaal Barrage remains within acceptable limits.

The present systems model has its roots in a suite of mathematical hydrosalinity models that were developed for the WRC by the

Hydrological Research Unit (HRU) of the University of the Witwatersrand, and the consultants Stewart Sviridov and Oliver (SSO).

In 1975, the WRC initiated a study of the PWV complex with special reference to existing and potential problems of water supply, waste water management and pollution control. Salinisation was singled out as a problem requiring urgent attention, with the objective being to develop a set of numerical models that could be used to simulate the fluctuation of salinity at key points in the system, and to provide a means of comparing various proposals for ameliorating undesirable future salinity conditions. The project output, was a suite of models, delivered in 1980/81, which simulate the PWV water supply system.

This suite of hydro-salinity system models, together with newer revisions, has found application in numerous Department of Water Affairs and Forestry (DWAF) studies on both the Vaal River and other major river catchments. Studies carried out, using these models, identified a major flaw in the front runner alternative to the Lesotho Highlands Water Project. In this instance, simulated model results showed that the rival Orange-Vaal Weirs Scheme (a novel concept that would have involved transferring Orange River water to the Gauteng area by reversing the flow of the Vaal River) would have resulted in a build up of salinity in the Vaal River to unacceptably high levels. The ensuing costs to consumers would have been twice as high as the total engineering cost over the life of the

scheme (i.e. in the order of R14 billion in today's money). The model thus played a major role in eliminating an otherwise attractive scheme that, if implemented, could have seriously damaged the RSA economy.

Another notable achievement arising from using this suite of models was the identification and subsequent implementation of the PWV salinity blending scheme, which is estimated to hold a present value economic benefit for Gauteng water users running to about R5 billion.

The suite of mathematical hydrosalinity models comprise the following models:

- Flood Plain;
- Rainfall-runoff
- Washoff;
- Tributary Routing;
- Barrage; and
- Feedback

It is important for the South African economy that the correct blending of Vaal River water is viewed as a critical issue. The advantage of using the hydrosalinity models is to optimize the water releases in order to achieve the correct balance. The aim of the CBA was therefore to compare the cost of the WRC's funded research to develop these models, compared with the benefits accruing from this research by optimizing the fine balance of water releases.

The costs for the research of the Hydrosalinity System Models consisted of two items. Firstly, there is the direct cost of the research and, secondly, the administrative cost incurred by the WRC to administer the research. The total of these research costs amounted to R4,52 million at 2000 prices.

As the activities of collection and processing of the relevant data are regarded by the Department of Water Affairs and Forestry (DWAF) and the Rand Water Board (RWB) as part of past and ongoing monitoring processes, no provision was made for operating costs in the CBA.

The project team considered various options for calculating the economic values of the benefits resulting from the application of the hydrosalinity models. In view of various limitations and other factors it was decided to use a conservative approach.

As explained above, there is a cost to the economy when too much or too little water is released in the Vaal Barrage. In view of the massive cost of releasing too little water, the project team was of the opinion that there would probably never be a point where too little water is released. However, it could easily happen that too much water is released. Accordingly, the CBA approach used was to measure the cost to the economy if too much water is released, and what the advantage would be of applying the hydrosalinity models in optimizing the quantity of released water by not releasing too much.

According to various sources, 0,3 % of the water demand in the so-called PWV area is required to achieve the relevant blending standard. In discussions with DWAF, an upward error factor of 30 % was raised in such water releases, without the benefit of the models. A shadow price of R2,00 per m<sup>3</sup> (the corresponding water cost from the Lesotho Highland Scheme) was then applied over a period of 20 years. It is emphasized that the 30 % error factor for the value of water used should be regarded as the bare minimum.

## Results

The CBA shows that the NPV of this research project is R12,3 million which covers the relevant research costs nearly three times.

1999 economic prices	Present Value 8 %, R millions
<b>A. COST</b>	
Cost of WRC research projects	-4,5
<b>B. BENEFITS</b>	
Savings in excess water release	16,8
<b>NET PRESENT VALUE (NPV)</b>	12,3

## SURFACE WATER RESOURCES OF SOUTH AFRICA

### Background

It is difficult to imagine how water resources development in South Africa would have taken place if it had not been for the pioneering studies of the Hydrological Research Unit (HRU), University of the Witwatersrand. In 1982, these studies led to a six-volume report, presenting guidelines for estimating water resources in South Africa. Hydrologists and planners relied heavily on these guidelines for water resource analysis, planning and management. No single study has made such an enormous impact on broad water resources planning in South Africa as these surface water resources assessments.

The first WRC funded studies that contributed to the report were initiated in the early 1970s. The most prominent and long lasting development was probably the well-known Pitman model, which, to date, has become the de facto planning model for most of South Africa's bulk water development.

After a series of workshops in 1985, the present updated survey known as Surface Water Resources 1990 was planned. In a five-year project, a consortium of engineers consisting of Knight Piésold (Pty) Ltd., Stewart Scott (CE) Inc, and SRK (CE) Inc, under the leadership of Prof DC Midgley, reassessed South Africa's water resources.

In 1995, a series of reports, consisting of one user manual, six volumes of data, and six books of maps was produced, accompanied by a CD containing all of the data and 23 GIS coverages. A start has also been made on making the data available via the World Wide Web. Judging by the rate at which these products are being requested by consultants and other interested parties, their impact will be as far-reaching as that of the original set of reports.

The aim in analysing the Surface Water Resources project was, therefore, to compare the cost of the WRC's funded research with the benefits accruing from this research. It was accepted that most of the benefits would be realised in assisting the planning process. The benefits would result from improved accuracy, as well as cost savings which planners of water related projects would experience by using the outputs of the project.

The costs for the research of the Surface Water Resources project consisted of two elements. Firstly, there is the direct cost of the research and, secondly, there is the administrative cost incurred by the WRC to administer the research i.e. a total of R5,7 million.

The main advantage of this research is the time saved by professionals in using the research results instead of doing primary research to obtain the same data and information. To determine the difference in time usage, a number of case studies were analysed to determine an average time factor. Discussions were held with officials of civil engineering firms to identify suitable case studies for analysis. It appears from the case studies and others that, if the relevant information and data were not available, it would have cost anything between 4 and 6 times more to undertake such studies- and would obviously have taken a much longer period to complete. In other words, this would result in a longer period for the relevant information to have come to the "market" so to speak.

A survey was conducted amongst four engineering firms to determine the extent of the usage of WR 90 and the budgets involved. After consultation, it emerged that 80 hours per project could be accepted as the average time spent on hydrology analysis of a project. Each firm performed an average of 16 projects per year, with 80 hours per project being used (at R400 per hour) to calculate the usage costs by the four firms.

It was then estimated that the four firms had not more than a 40 % market share between them.

∴ The annual savings due to the availability of the relevant information being:

= R5,12 million.

## Results

The CBA shows that the NPV of this research project is R28,7 million which covers the research cost many times. The detailed results are as follows:

1999 economic prices	Present Value 8 %, R millions
<b>A. COST</b>	
Cost of WRC research projects	-R5,70
<b>B. BENEFITS</b>	
Savings in planning time	R34,36
<b>NET PRESENT VALUE (NPV)</b>	R28,7

## BIOLOGICAL NUTRIENT REMOVAL (BNR)

### Background

The development of the capability to remove nutrients (N and P) from municipal waste waters became critically important when the rivers draining the industrial and commercial centres in the Gauteng area became highly eutrophic. The WRC considered this a priority research area for an extended period. Although the WRC has funded research in both chemical and biological nutrient removal, the emphasis has been on biological nutrient removal, as chemical removal contributes to salinisation of receiving waters.

Research into biological nutrient and phosphate removal was first supported by the WRC in 1973, very soon after Dr JL Barnard first found that phosphorous could be removed biologically. Since that time, research was funded at various institutions, initially with the CSIR, and subsequently with the Department of Civil Engineering of the University of Cape Town and the Johannesburg City Council playing leading roles in both the development of the process and its understanding. This research led to the development of a number of different process configurations. Some 57 of the new generation activated sludge plants are operating in the country.

This work has led to a number of publications, of which one of the more notable is the Theory and Design of Nutrient Removal Activated Sludge Processes for which there has been widespread international demand.

As a result of their research work, researchers from the University of Cape Town have formed part of the team that developed the Activated Sludge Models No 1 and 2 of the IAWQ (International Association on Water Quality) for nutrient removal, which has become the internationally accepted model for biological nutrient removal.

In recognition of the fact that there are many plants in the area covered by the special phosphate standard that cannot remove phosphate biologically, the WRC funded research leading to the publication of the Guidelines for chemical phosphate removal of municipal waste waters. This has

helped to optimise the use of the chemicals in the process.

In 1984, the WRC published a report titled "Theory, design and operation of nutrient removal activated sludge processes." In this report a number of technical aspects are discussed in detail. The funding by the WRC of BNR research contributed significantly to realising the BNR process in practice.

For purposes of the CBA, it was necessary to differentiate between the two processes, namely, the historical chemical method, and the new BNR method for the treatment of waste water. Both processes can result in water of a similar quality. However, the chemical method entails the addition of chemicals. On the other hand, the BNR process which was developed mainly by means of the WRC-funded research, is more capital intensive. Consequently, it was the objective of this CBA study to compare the capital and operational costs of the two processes. In addition, possible (additional) benefits of the BNR process were also taken into account.

The aim of the CBA was, therefore, to test the hypothesis that the BNR method is in the first place more cost-effective than the chemical process - even though it is more capital intensive. Secondly, the question was whether such a positive difference between the cost ratios of the two technologies (which constitutes the benefits of the BNR project) is more than the cost of the relevant WRC research. However, the argument might be preferred that it was not only the WRC's contribution which made the BNR process technically viable. Such argument was also taken into account in the CBA methodology.

Discussions were also held with other operators of BNR plants in Gauteng and civil engineers who specialise in designing these plants. However, the non-availability of accurate cost data complicated the comparative studies.

As a result of these discussions, it was therefore decided to develop a scenario in which a BNR plant could be compared with a chemical plant of the same capacity by means of a CBA approach. For this purpose, a plant capacity of 10 million litres of water per day was selected which, according to the relevant engineering firm, would be appropriate for this study.

The cost element in the CBA is defined as the cost of the WRC research relating to the BNR process. For purposes of the CBA analysis, a total research cost of R463 000 at 1999 prices was taken into account. On the other hand, the benefits of this project are defined as the difference between the costs of the chemical process, and those of the BNR process, to achieve the same result regarding the relative quality of purified water.

The CBA analysis took into account the total BNR capacity of the additional 375 BNR plants that were constructed since 1984. It was estimated (no accurate figures were available) that the 375 plants have a total daily capacity of 6 562,5 million litres of water.

It is accepted that this total capacity of 6 562,5 million litres of water is not 100% directly as a result of the relevant BNR research which was handled by the WRC. However, on the one hand, one can use a conservative assumption that at least 25 % of the total capacity is in fact a direct result of the relevant WRC research. In such a case, the benefits of R81,5 million are considerably higher than the research cost (R463 000 at 1999 prices) incurred by the WRC. On the other hand, if one accepts that 50 % of the total BNR capacity is a direct result of the relevant WRC research, the benefits are even higher i.e. R163 million.

## Results

The CBA shows that the NPV of this research project is R162,5 million, which covers the research cost many times. The detailed results are as follows:

1999 economic prices	Present Value 8 %, R millions
<b>A. COST</b>	
Cost of WRC research projects	-0,5
<b>B. BENEFITS</b>	
Replacement of chemical by BNR process	163,0
<b>NET PRESENT VALUE (NPV)</b>	162,5

From the results, it can be concluded that the introduction of the BNR process, replacing the chemical process, is highly advantageous for South Africa and its population.



## DRY COOLING IN POWER GENERATION

### Background

Dry cooling in power generation can save enormous quantities of water. However, it is more capital intensive than wet cooling, and the power generation process also becomes less efficient. The optimisation of dry-cooling technology can, therefore, affect major cost deductions. Pursuing this objective, the WRC has been funding research on dry cooling for many years. Research so far has found application in the world's largest air-cooled condensers (Matimba and Majuba) and dry-cooling towers (Kendal). As each of these is more than an order of magnitude larger than any other station abroad, Eskom is clearly the international leader in the field.

To enable Eskom to improve the efficiency of such large systems, the WRC commissioned the Department of Mechanical Engineering, University of Stellenbosch, to develop computer programs to evaluate the performance of dry-cooling systems. The results of previous research by the University, the CSIR and Eskom, as well as practical field measurements, are incorporated in these programs.

Programs for evaluating the thermal performance of dry- and wet-cooling towers have been tested and applied successfully by Eskom. Programs for evaluating the performance of direct air-cooled condensers are also being used by Eskom to monitor the performance of existing systems and to devise possible modifications for improved performance.

The aim of the CBA is, therefore, to compare the cost of the WRC's research with the benefits accruing from the research. However, the argument may be proffered that it was not only the WRC's contribution that made the dry cooling process technically and financially viable. This argument was taken into account in the methodology.

The following comparisons were made, namely:

- (i) Direct dry-cooling with indirect dry-cooling
- (ii) Direct dry-cooling with wet-cooling.

The total cost of the relevant research was taken as R13,4 million at 1998 prices.

The overall objective of the research funded by the WRC was to optimize dry-cooling units at power stations in an effort to save water.

Although the analysis of the improvement of dry-cooling as a result of the research was the main emphasis of the CBA analysis, it is also of great importance to analyse the efficiency of dry-cooling relative to wet-cooling. The efficiency was measured in terms of the saving of water, as well as overall financial viability.

### Water Saving

The introduction of dry cooling has resulted in large water savings by Eskom in its coal-based power stations, as shown below.

	Water saved/ annually Ml	Monetary saving per annum	
		Financial Analysis	Economic Analysis
Eskom total	93 000 Ml	R186 million	-
Water scarce region (Matimba)	41 000 Ml	R82 million	R170 million

Price of water: R2/kl.

Due to a scarcity of water in the Northern Province, it is more appropriate to use the economic price of water to calculate the value of water savings. If the economic price of water is used i.e. R4.16/kl, the water savings per year amount to R170 million.

### Overall Financial Efficiency

In analysing the success of the WRC's funded research, various comparisons were made namely:

- (i) Direct dry-cooling with indirect dry-cooling
- (ii) Direct dry-cooling with wet-cooling.

In comparing direct dry-cooling with indirect dry-cooling (after including the WRC research cost) the following results in favour of direct dry-cooling were found.

NPV Economic Prices: R952,2 million

In comparing direct dry-cooling with wet-cooling in a water scarce region, the following results (after including the WRC research cost) favour direct dry-cooling method.

NPV: R527,7 million

## Results

The detailed results of the CBA for the various scenarios are as follows:

1999 economic prices	Indirect versus Direct Dry Cooling Present R millions	Dry vs. Wet Cooling Present Value 8 %, R millions
<b>COST</b> - Cost of WRC Research Projects	-R14,4	-R14,4
<b>BENEFITS</b> - Difference between A. Indirect Dry Cooling & B. Direct Dry Cooling	R1 013,8	R558,3
<b>NET PRESENT VALUE</b>	R999,4	R543,9

Note: Calculations are based on Matimba powerstation.

From the above analysis, it is evident that the benefits derived from the relevant research financed by the WRC are much higher than the cost. Huge water savings, with accompanying monetary savings, were achieved.

The CBA analysis also shows that the direct dry-cooling units are specifically viable in water scarce regions.

As in the case of the introduction of any new technology, the benefits cannot be totally contributed to only one portion of research. However, if only a fraction of the accrued benefits is due to the WRC research this still covers the cost many times over.



## THE COMBINED SERVICES MODEL (CSM)

### Background

One of the aims of the WRC's involvement in the water affairs of the country is to promote the supply of clean drinking water to everyone. This caused the WRC to become involved in the following project in 1992: Water and Sanitation in Urban areas: Financial and Institutional Review in partnership with the Development Bank of Southern Africa.

At the start of the project it was only envisaged to develop a water supply model. This was later adapted for sanitation services with the assistance of the Durban Corporation. The model used for water supply and sanitation was also extended to include roads, stormwater drainage, electricity and solid waste management.

This assignment resulted in the creation of a number of spreadsheets that were, however, not fully integrated and not easy to use. On the other hand, this modelling system provided useful information in support of decision making.

Recognizing that there was a very real need for a user-friendly model that would assist with long term infrastructure investment planning, the DBSA proposed a co-funding arrangement with the WRC to produce a Combined Services Model. The Palmer Development Group was commissioned to undertake the work during 1996.

The outcome of this project was that the CSM, a sophisticated computer-based model, was developed as a predictive model of the expenditures and cash flows associated with the provision of municipal infrastructure services for residential consumers. The main advantage of the model is that it contributes to the provision of appropriate services that are also more in line with what consumers can afford.

To assess the viability of a planned infrastructure, the combined services model:

- (i) Calculates the capital and operating costs and borrowing requirements associated with the investment programme, in both nominal and real terms; and
- (ii) Assesses affordability of the programme to households and the local authorities.

The WRC funded part of the relevant research to the extent of R427 000. The objective of this study was to determine if the economic and social benefits that originated from this research, outweigh its actual cost.

The aim of the CBA was therefore firstly, to test the hypothesis that, by using the Combined Services Model, the local authority would save money in the planning process. Secondly, that by using the Combined Services Model, the local authority would save the ratepayers money due to the fact that the ratepayers receive a service that is commensurate with their needs and ability to pay.

It is important to note that the benefits that were calculated for the ratepayers and for the local authorities, could not be added together. These benefits are mutually exclusive, and either one or the other could be accepted as the benefits emanating from the application of the CSM model.

### Local Authority Savings

Below are present values depicting differences in costs, if 72 local authorities either make use, or do not make use of the CSM as a planning tool.

## (1999 PRICES)

	<b>RAND</b>
Present value of costs without CSM	9 612 024
Present value of costs with CSM	1 072 874
Present value of CSM benefits	8 539 150

### Savings for Rate Payers

In calculating the benefit to ratepayers, the existing situation of local authorities was compared with the end result, after the implementation of the proposed strategy of using the CSM. It was assumed that only 10 % of local authorities make use of the CSM. The NPV of the savings was, therefore, R137,6 million.

The CSM was also nominated by the Development Bank of Southern Africa for a National Productivity Award which it eventually received. The model is actively promoted by the DBSA and they have also made use of the model in the planning process as a condition before any loans for infrastructure projects will be approved.

Research has also shown that nearly 100 local authorities have already made use of the model, with some authorities using it more than once. In addition, the CSM is also used by private consultants in the planning process.

The CBA results of the CSM are given in the following table:

<b>1999 economic prices</b>	<b>Local Authority Savings Present Value 8% R million</b>	<b>Savings for Rate Payers Present Value 8% R million</b>
<b>COST</b>		
- Cost of WRC Research projects	-0,4	-0,4
<b>BENEFITS</b>	8,5	137,6
- Net Present Value	8,1	137,2

The overall conclusion is that the benefits of the CSM easily exceed the money spent on the relevant research effort and, as a planning tool, it will continue to find application in the long run.

## 4. SUMMARY OF SALIENT FEATURES OF CBA ANALYSES

In this section, a number of the salient features of the impact of the selected WRC research projects have been analysed. This has been done in order to enhance the effectiveness and efficiency of future WRC research projects. In broad terms, the various socio-economic impacts of the six selected WRC projects, embedded in the CBA Analyses, can be summarised as follows:

## DIRECT AND INDIRECT CONTRIBUTIONS TO CERTAIN OBJECTIVES

Description of type impact	ACRU	Hydro salinity	Surface Water	BNR	Dry Cooling	Services Model
1. Improved Crop Yield (Food Security)	X					
2. Strategic Decision Making	X	X	X	X	X	X
3. Quality of Drinking Water		X		X		X
4. Water Savings		X		X	X	X
5. Saving of Professional Fees			X			X
6.Capital Saving				Negative	Negative	
7.Operational Cost Saving	X	X	X	X	X	X
8.Savings for Rate Payers						X

The contributions of WRC- research efforts to the following broad objectives will now be addressed:

- Economic viability of WRC research
- Water Resource Development and Water Conservation and Demand Management.
- Agricultural water usage versus other water users.
- Research as planning tools and the development of new technology.
- Impact on costs in terms of capital expenditure and operational expenditure.

It should be noted that the comparisons and conclusions drawn in this section could be skewed. Although the six selected projects are major WRC research projects, this sample is not fully representative of all such research. The conclusions should therefore be weighed up against other research parameters before basing any decisions thereon. By expanding on the methodology used and analysing more projects, the validity of the conclusions could be further improved.

### Economic Viability of WRC Research

Table 4.1 provides a summary of the six selected WRC projects in terms of economic Costs, Benefits and NPV embedded in the CBA-Analyses.

**TABLE 4.1: SUMMARY OF WRC RESEARCH COSTS, BENEFITS AND NPV FOR SIX SELECTED PROJECTS**

Project, 1999 economic prices	Present Value 8 %, R millions		
	Cost of WRC Research	Benefits	NPV
ACRU Model Development	16,9	117,9	101,0
Hydrosalinity System Models	4,5	16,8	12,3
Surface Water Resources of South Africa	5,7	34,4	28,7
Biological Nutrient Removal	0,5	163,0	162,5
Dry Cooling in Power Generation*	14,4	558,3	543,9
Combined Services Model	0,4	146,1	145,7
<b>TOTAL</b>	<b>42,4</b>	<b>1 036,5</b>	<b>994,1</b>

\* Only the CBA results of Dry versus Wet Cooling.

According to Table 4.1, the economic benefits originating from the six selected WRC projects are significant. The total present value of benefits in 1999 prices amount to more than R1 billion. The yield of the relevant research is very high if one takes into account that the total cost of this research was relatively low at a present value of R42 million. In fact the Benefit Cost ratio is nearly 25, which means that, for every rand of research input, a return of nearly R25 is to be achieved.

It could be argued that the six projects are of a high calibre, and are not representative of all of the projects funded by the WRC. Notwithstanding such argument, the benefits flowing from the relevant projects are more than ten times the annual total budget for the WRC.

### **Water Resource Development, Water Conservation and Demand Management**

In terms of current water policies in South Africa, one can differentiate between two main streams of policies. On the one hand, there are those policies that relate to Water Resource Development. These policies entail the development of new water resources by means of dams, canals, catchment transfer systems, etc. On the other hand, one can identify policies that relate directly to the more efficient use of existing water by means of Water Conservation and Demand Management.

Historically, the emphasis by DWAF has been placed on Water Resource Development. However, in recent years, this approach has shifted to Water Conservation and Demand Management. In the following Table 4.2, the six projects' monetary contributions (NPV) towards the above-mentioned objectives are presented.

**TABLE 4.2: IMPACT OF SIX SELECTED PROJECTS IN TERMS OF NPV ON WATER RESOURCE DEVELOPMENT AND WATER CONSERVATION AND DEMAND MANAGEMENT**

<b>Project 1999 economic prices</b>	<b>Water Resource Development NPV, R millions</b>	<b>Water Conservation and Demand Management NPV, R millions</b>
ACRU Model Development		101,0
Hydrosalinity System Models	12,3	
Surface Water Resources of South Africa	28,7	
Biological Nutrient Removal		162,5
Dry Cooling in Power Generation		543,9
Combined Services Model		145,7
<b>TOTAL</b>	<b>41,0</b>	<b>953,1</b>
<b>Percentage</b>	<b>4,1</b>	<b>95,9</b>

From the above exposition, it is evident that the net benefits (NPV) accruing from the six projects fall mainly (95,9 %) into the category of Water Conservation and Demand Management. In conclusion, it therefore seems that the results underpin the water authorities' approach towards placing emphases on Water Conservation and Demand Management. Ultimately, by promoting water conservation and demand management research and practices, the country's water resources will be conserved and prolonged.

### **Agricultural water usage vs. other water uses**

In evaluating the CBA results for the six chosen WRC projects, one can also refer to its sectoral demand implications.

In this section, the impact of the economic benefits that emanated from the WRC's research activities are divided between agriculture and other users. In this regard, note should be taken of the fact that water use in South Africa is still dominated by irrigation, representing about 54 % of the total water used in the country (much of which is not used very productively). Due to South Africa's current and

expected economic and social development needs, there is a tendency developing for water that is destined for irrigation purposes to be gradually made available for other uses. In Table 4.3, the six research projects under scrutiny are divided between those that would impact on the Agriculture and Forestry Industry's water usage, and those projects that are proposed to benefit other water users.

**TABLE 4.3: IMPACT OF SIX SELECTED PROJECTS IN TERMS OF NPV ON AGRICULTURAL WATER USAGE VERSUS OTHER WATER USES**

<b>Project, 1999 economic prices</b>	<b>Agricultural &amp; Forestry Use NPV, R millions</b>	<b>Other Uses NPV, R millions</b>
ACRU Model Development	101,0	
Hydrosalinity System Models	N/A	N/A
Surface Water Resources of South Africa	N/A	N/A
Biological Nutrient Removal	N/A	N/A
Dry Cooling in Power Generation		543,9
Combined Services Model		145,7
<b>TOTAL</b>	<b>101,0</b>	<b>689,6</b>
<b>Percentage</b>	<b>12.8</b>	<b>87.2</b>

The above table shows that the advantages (NPV) of three of the relevant projects accrue to other users, and that only 12.8 % of the benefits are agricultural use related. This also signifies the WRC's current strategic direction and research focus areas.

#### **Planning tools vs. new technology**

In addition to the above distinctions of the results of the six selected WRC research projects, one can also endeavour to determine the useability of such research results for policy planning purposes, and for direct commercial and operational purposes. These applications of the projects' research outputs are reflected in the Table 4.4:

**TABLE 4.4: APPLICATION OF SIX SELECTED PROJECTS AS A PLANNING TOOL OR AS NEW TECHNOLOGY IN TERMS OF NPV**

<b>Project, 1999 economic prices</b>	<b>Planning Tool NPV, R millions</b>	<b>New Technology NPV, R millions</b>
ACRU Model Development	101,0	
Hydrosalinity System Models	12,3	
Surface Water Resources of South Africa	28,7	
Biological Nutrient Removal		162,5
Dry Cooling in Power Generation		543,9
Combined Services Model	145,7	
<b>TOTAL</b>	<b>287,7</b>	<b>706,4</b>
<b>Percentage</b>	<b>29.0</b>	<b>71.0</b>

From the above table, it is evident that the major portion of the net benefits (NPV) emanating from the six projects should be attributed to the so-called new technology projects. However, it is important to note that the majority of the projects were devoted to improving policy planning in the water field.

### Capital and Operational Expenditure

Another aspect that deserves attention in the discussion of the application of the outcomes of the sample of the six projects, is the differentiation between savings in terms of capital expenditure (CAPEX) and operational expenditure (OPEX). Table 4.5 shows in which category each of these six projects finds application in terms of CAPEX and OPEX.

**TABLE 4.5: APPLICATION OF SIX SELECTED PROJECTS IN TERMS OF CAPEX AND OPEX**

<b>Project 1999 prices discounted at 8%</b>	<b>CAPEX NPV R millions</b>	<b>OPEX NPV R millions</b>	<b>Total NPV R millions</b>
ACRU Model Development		101,0	101,0
Hydrosalinity System Models		12,3	12,3
Surface Water Resources of South Africa,		28,7	28,7
Biological Nutrient Removal	(1 969,0)	2 131,5	162,5
Dry Cooling in Power Generation	(760,0)	1 303,9	543,9
Combined Services Model		145,7	145,7
<b>TOTAL</b>	<b>(2 729,0)</b>	<b>3 723,1</b>	<b>994,1</b>

Table 4.5 shows that, on a net basis, nearly one billion rands savings will be affected mainly due to lower operational expenditures. Even given that in two cases R 2,7 billion of capital investment was spent to effect the savings in operational expenditures.

## 5. LESSONS FOR FUTURE WRC RESEARCH

Being aware of the limitations of this study, such as the fact that the sample of six projects chosen for scrutiny should not be seen as necessarily representative of the WRC's work, and the well known limitations of CBAs, the researchers nevertheless felt confident that a number of important policy and planning directives can be gleaned from this study.

It is also important to bear in mind that the specific brief of the study was to: "..... determine the economic contribution of selected WRC research projects". A number of related salient features of the identified research projects' contribution to a number of objectives were also brought into discussion.

Other aspects of the WRC's institutional performance levels and efficiencies as a publicly funded research entity were not addressed. These include the evaluation of the technical soundness of the research processes and outputs, financial management efficiency, etc. Consequently, this study is of limited scope with regard to the use of CBA techniques to determine the contribution of WRC research projects to the overall economic and social well-being of the country.

Given the above point of departure, and the outcomes of the CBAs, the following policy and planning directives for future WRC research initiatives are proffered:

- The CBA provides unequivocal evidence that the WRC research outputs have made a significant contribution to improving the economic welfare of South Africa
- The growing importance of research projects dealing with water conservation and demand management is in line with the WRC's strategic focus and the government's development prerogatives

- Agriculture remains the largest water user and, therefore, requires that a substantial amount of resources still be devoted to research activities that would promote more efficient use of water for irrigation purposes. However, the CBA results also show that research for other users is of great significance because of the potentially higher returns that can be expected on such outlays.
- The CBA shows that research into new technologies and the transfer thereof to the operational level provides handsome dividends. On the other hand, research projects which assist in the better planning of water projects in all their facets also produces more than reasonable returns.
- The CBA results of the projects in question show that proportionally larger benefits can be obtained from research directed at reducing operational costs. This is despite the fact that, in some cases, such reductions go hand-in-hand with major capital expenditure.

## Concluding Remarks

As with all organisations, it is necessary from time to time to evaluate the performance of the WRC. This study was focused on the evaluation of the economic contribution of WRC research, which only covered one element of an array of criteria that will have to be applied to determine the overall efficiency of its operations in terms of the set objectives.

Using the CBA techniques applied to the six projects identified for this purpose, it was established with a reasonable amount of certainty that, in terms of NPV estimates, the WRC's research efforts have made significant contributions towards all its focus areas, including: technology transfer; knowledge empowerment; determination of research priorities and directing research into priority areas.

In conclusion, the CBA technique has vindicated itself as a reliable method to determine the economic efficiency and effectiveness of an organization in attaining a predetermined set of objectives with a limited amount of resources. This was again proved in the case of measuring the WRC's contribution to the country's economic and social upliftment.

This study has confirmed that research impact assessment should be done on a regular basis.

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