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REPUBLIC OF SOUTH AFRICA

CONTRACT NO. WP 10276

Development and Implementation of Irrigation Water Management Plans to Improve Water Use Efficiency in the Agricultural Sector

SCHOONSPRUIT GOVERNMENT WATER SCHEME MANAGEMENT PLAN

FINAL REPORT

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DIRECTORATE: WATER USE EFFICIENCY

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FINAL

DECEMBER 2012

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EXECUTIVE SUMMARY

Background

The Department of Water Affairs (DWA) through the Directorate: Water Use Efficiency commissioned a study to develop pilot Water Management Plans (WMPs) for fourteen (14) selected irrigation schemes as part of its assistance to the agriculture sector as well as to initiate a process whereby all irrigation schemes develop their own WMPs for implementation as required by the National Water Act (36 of 1998).

The study was informed by the fact that no progress had been made by the agricultural sector with respect to the development and implementation of WMPs for that sector. Furthermore the study was initiated to address the increasing water scarcity[1] in a number of Water Management Areas (WMAs).

One of the approaches in addressing the increasing water scarcity and competition for water is to ensure that existing water users utilise their existing water entitlement efficiently.

Project Objectives and approach taken

The primary objective of the study is the development and implementation of irrigation WMPs for 14 irrigation schemes to improve water use efficiency in the agricultural sector. However the focus of the study was at the irrigation scheme level with minimal work conducted to determine on-farm irrigation water use efficiency levels.

In order to achieve this objective, the following tasks have to be undertaken:

- Compilation of a situation assessment of the current water use and irrigation water use practices in the fourteen irrigation schemes;
- Determination of the irrigation water budget and establishing water use baseline for each irrigation scheme;
- Determination of the irrigation water management issues based on the situation assessment and water budgets prepared for each irrigation scheme;
- Identification of opportunities to improve water use efficiency in the agricultural sector;

[1] Water scarcity – this is an imbalance of supply and requirement under prevailing institutional arrangements indicating an excess of water requirements over available water at the required assurance of supply, especially if the remaining supply options are difficult or costly to tap. The current utilisation as a percentage of total available resources at the required assurance of supply can illustrate the scale of the problem and the latitude for policymakers

- Benchmarking of irrigation water use efficiency and setting irrigation water use efficiency targets for each scheme;
- Preparation of an irrigation water management plan for each irrigation scheme;
- Capacity building of the GWSs, IBs and WUAs to implement the identified opportunities to improve irrigation water use efficiency.

Overview of the Schoonspruit Government Water Scheme

The Schoonspruit Government Water Scheme was established in the early 1960's with the construction of the Schoonspruit weir and the Rietspruit Dam (which has a storage capacity of 7.3 million m^3) and later the Elandskuild dam, with a storage capacity of 1.2 million m^3.

Schedule of rateable area

The Schoonspruit Government Water Scheme has a total schedule of rateable area of 2 432.6 hectares, comprising of 507 ha in the Schoonspruit canal system, 648 ha supplied from the Elandskuil Dam canal system and 1 277.9 ha supplied from the Rietspruit Dam canal system.

The Schoonspruit Government Water Scheme has a total scheduled quota of 18.7 million m^3/a, at 7 700 m^3/ha/a.

The main types of crops irrigated in the Schoonspruit Government Water Scheme are mainly maize, wheat and vegetables which are the main crops under irrigation.

Conveyance and delivery infrastructure

Water to the water users in the Schoonspruit Government Water Scheme is delivered through a system of canal infrastructure comprising three main canals namely the Schoonspruit main canal, as well as the Rietspruit and Elandskuil canals. There are branch canals from these main canals which deliver water to the sluice gates at the irrigators' farms.

The total length of the canal infrastructure excluding drainage canals is approximately 114.3 km with all the canals concrete lined. This comprises of 27.4 km of concrete lined canal for the Schoonspruit canal system, 18.9 km for the Elandskuil canal system and 68 km of concrete lined canals for the Rietspruit canal system including branch canals.

The condition of the canals was found to be generally fair to very poor in some sections of the canal were some panels had moved due mainly to flooding and drainage problems.

Besides the canal infrastructure there are sluice gates and rectangular weirs to measure the volume of water taken by each water user in the canal.

Irrigation storage and regulation

The scheme is such that the Rietspruit and Elandskuil Dams are situated in the middle of the GWS and can provide the balancing and regulation of flow to downstream water users of the Schoonspruit GWS. The Dams have the effect of reducing the time it takes to deliver water to downstream water users while balancing any irrigation spills from upstream water users.

Findings of the situation assessments

A situation assessment of the Schoonspruit Government Scheme was conducted to determine the water management issues affecting the effective and efficient use of the available water to the scheme. The assessment was conducted at sub-scheme level, with the Schoonspruit Government Water Scheme divided into three sub-schemes, Schoonspruit sub- scheme, Elandskuil Dam canal sub-scheme and the Rietspruit canal sub-scheme.

Best Management Practice - Expected water losses

An evaluation of the expected water losses based on the existing canal infrastructure and assuming the infrastructure is maintained was conducted for the Schoonspruit canal system. The analysis indicated that the unavoidable water losses due to evaporation losses and seepage due to the expected hydraulic conductivity of lined canals is 3.03 million m^3/a, which translates into 7% of the total volume of water released into the Schoonspruit canal system.

There are expected to be operational inefficiencies due to the canal filling required after the dry periods, the metering errors even after calibration as well as problems in matching supplies and demands when applicants make changes to their requirements during the week. This was determined to be 10% of the total releases into the Schoonspruit canals respectively.

Based on the evaluation of the unavoidable water losses and the expected operational inefficiencies for the Schoonspruit Government Water Scheme, the water delivery Best Management Practice (BMP) should be based on the allowable water losses of approximately 17 % of the total inflow into the Schoonspruit irrigation canals.

Water balance assessment

A water balance assessment that was conducted for the Schoonspruit GWS irrigation sub-schemes indicated that the water losses in the all the sub- schemes exceeded the minimum expected seepage and evaporation losses. The average water loss based on the historic water use records was determined to be an average of 29% (see **Table 1** below) of the total water released into the Schoonspruit GWS.

Table 1: Water Losses in the Schoonspruit Government Water Scheme

Description	Unavoidable losses	BMP for operation & distribution	Avoidable losses	Total losses	% of total losses
Seepages	2.56			2.56	22%
Evaporation	0.46			0.46	4%
Filling losses		4.06	4.69	8.75	74%
Leakages					
Spills					
Operational Losses					
Over delivery to users					
Canal end returns					
Other					
Total	3.03	4.06	4.69	11.78	
% of total losses	26%	34%	40%	100%	
% of total volume released into system	7%	10%	12%	29%	

The equivalent depth of water released into the scheme per actual unit area irrigated was determined. In the Schoonspruit Government Scheme, the trend line indicates that it has been fairly constant at 1 900 mm per ha of water released from 2001 to 2008 water years for the scheme. However there was an improvement between the water years 2005 and 2007 in the diversion per unit of irrigated areas as illustrated in **Figure 1** below.

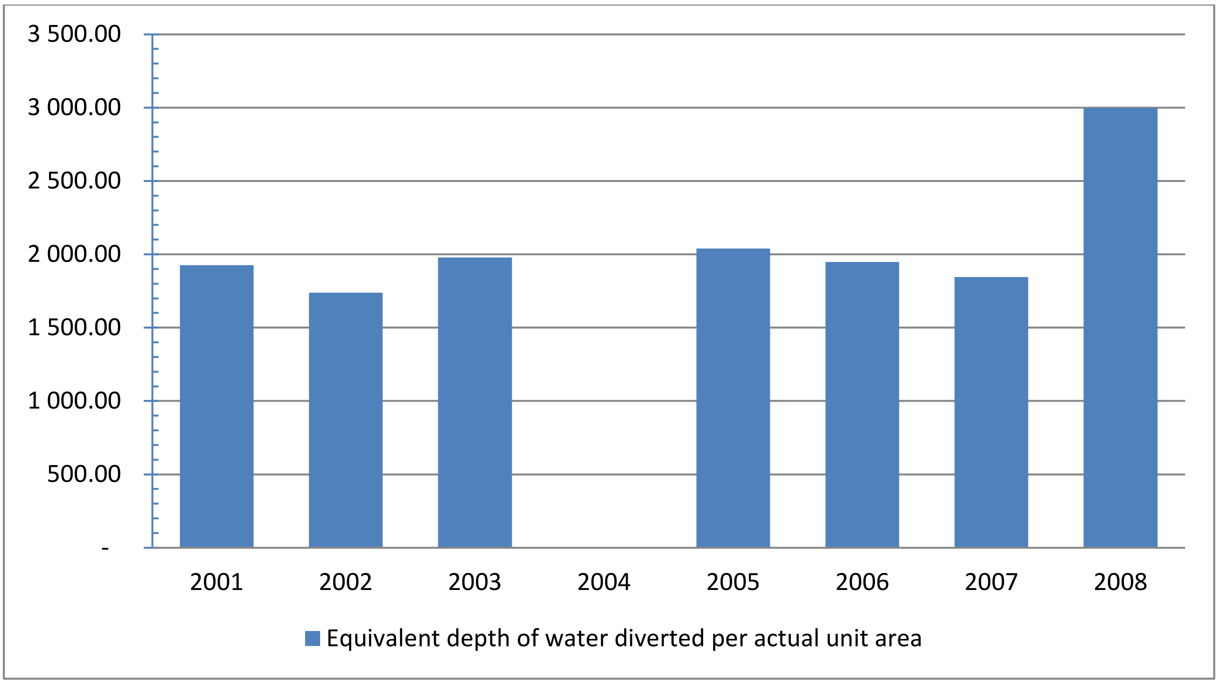

Figure 1: Irrigation water diversion expressed as an equivalent depth of water released per actual unit area irrigated for the Schoonspruit GWS canals

The slight decline in the irrigation diversions per unit of irrigated land is to an extent an indication that there are some improvements in irrigation water use efficiency during the period when the records were available.

However when the Rietspruit sub-scheme is analysed the trend line indicates that the irrigation conveyance efficiency has been increasing over the same period (see **Figure 2** below). This may be attributed to the fact that more water is being released into the canals than is necessary.

Any improvements for example in on-farm water use efficiency maybe likely to be offset with the increase in water losses. This conclusion has however only been reached with very limited data as no other historical data was available and will need to be verified in time.

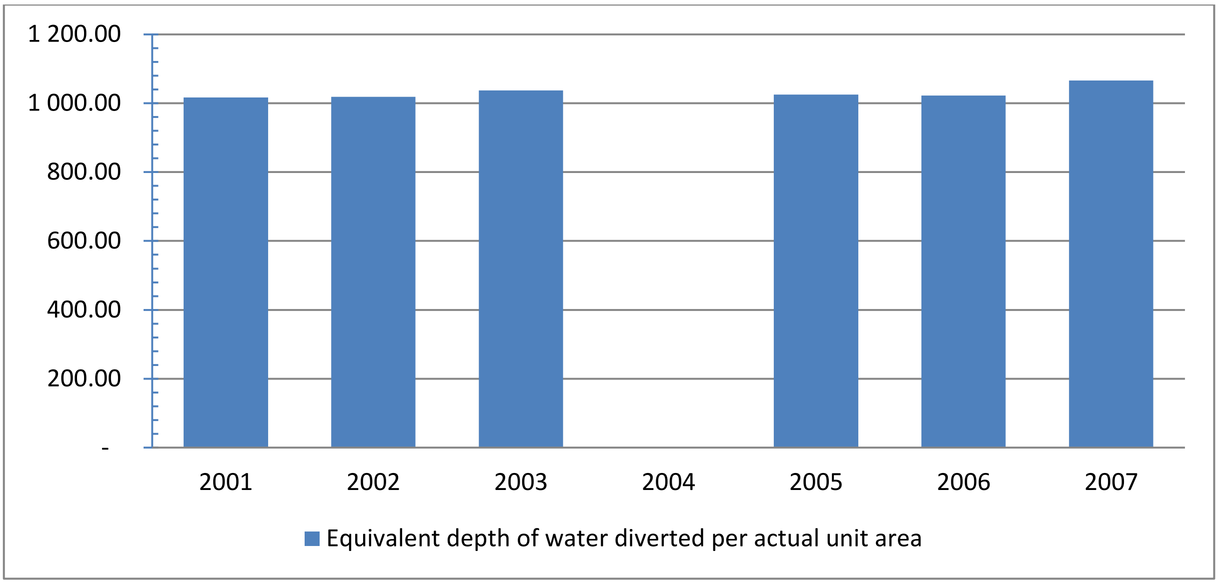

Figure 2: Irrigation water diversion expressed as an equivalent depth of water released per actual unit area irrigated for the Rietspruit canals

Water Management Issues

A number of water management issues affecting the effective and efficient use of water in the Schoonspruit Government Water Scheme were identified based on the water balance assessment, discussions with scheme managers and some field work that was conducted. The main water management issues identified include the following:

(i) There is a lack of measurement at some of the critical points in the scheme for a comprehensive water balance assessment to be conducted. These include the canal tail ends as well as flows into the downstream dams. The spills at the last two canal tail ends of the Elandskuil and Rietspruit canals are considered losses and can be avoided if regular flow measurements were taken. Therefore the current water balances are not accurate as they are based on estimates.

(ii) Although there are flow measurements, the accuracy of some of the measuring systems such as Rectangular weirs and lack of continuous flow monitoring to enable quick responses to operational problems have resulted in the low water use efficiency levels in the Schoonspruit Government Water Scheme.

(iii) There are significant algae and water grass problems in the canals. This is affecting the hydraulic capacity of the canals resulting in some cases in overtopping particularly the main Schoonspruit main canal.

(iv) The water administration system to manage water use is not being fully implemented for sub-scheme water budgets.

(v) The conditions of the canal infrastructure system were found to be poor. There are sections of the canal which will require complete renewal as some of the concrete panel sections have moved. This is attributed to soils conditions of the area. The DWA has already commenced with the refurbishment of these canal sections.

(vi) The capacity of the Schoonspruit GWS to conduct full maintenance of the canal infrastructure including refurbishment is limited while the current water charge by the DWA for the Return on Assets (ROA) does not appear to cover for the full cost of depreciation of the assets.

(vii) The current water rate structure does not have elements of incentive based pricing aspects. The fact that water users are charged a flat rate based on their scheduled quota does not provide an incentive to improve water use efficiency through managing demand.

Water Management Plan for the Schoonspruit Government Water Scheme

Establishment of water saving targets at sub-scheme level

The implementation of a Water Management Plan for the Schoonspruit Government Water Scheme to reduce water losses will imply reducing the water released per unit of the land area irrigated in the scheme. As is expected this will not affect the yields of the maize, wheat and vegetable crops being irrigated in the scheme area.

Therefore reducing the water released per unit of land area would mean an increase in productivity per unit of water which would be a clear indication of progress towards greater efficiency for the Schoonspruit Government Water Scheme assuming the scheduled quota of 7 700 m^3/ha/a remains constant.

A number of water management intervention measures were identified and a management plan developed to improve irrigation conveyance water use efficiency by reducing the avoidable water losses. The long term water savings targets for improving water use conveyance efficiency in the Schoonspruit Government Water Scheme is to save approximately 4.69 million m^3/a over a 10 year period (see **Table 2** below).

Table 2: Estimated water saving targets for the Schoonspruit Government Water Scheme

Description	System Inflow	Present Situation - Losses					Acceptable Water Losses		Target Water Savings		
		Unavoidable losses	BMP for distribution losses	Avoidable losses	Total losses	% of Total Volume Released	Annual Volume	% of Total Volume Released	Annual Volume	% of Total Volume Released	Intervention measure
Seepages		2.56			2.56	6.3%			0	0%	None
Evaporation		0.46			0.46	1.1%			0	0%	None
Filling losses										0%	
Over delivery to users										0%	
Leakages									1.78	4%	Refurbishment & resealing
Infrastructure condition											
Operational Losses			4.06	4.69	8.75	21.6%	7.08	17%	1.41	4%	Flow measurement & monitoring & WAS
											Recalibration of Rectangular weirs
Canal end returns									1.50	4%	Management of

Description	System Inflow	Present Situation - Losses					Acceptable Water Losses		Target Water Savings		
		Unavoidable losses	BMP for distribution losses	Avoidable losses	Total losses	% of Total Volume Released	Annual Volume	% of Total Volume Released	Annual Volume	% of Total Volume Released	Intervention measure
											Canal tail ends
											Management of Operational spills, eg removal of aquatic weeds
Other					0.00	0.0%				0%	
Total		3.03	4.06	4.69	11.77	29%	7.08	17%	4.69	12%	
Loss as a % of total losses		22%	28%	50%	100%						
Loss as a % of total volume released into system		8%	10%	18%	36%						
Total releases into Scheme	40.57										

*Canal tail-ends are estimated to be 2.756 million m^3/a in the Scheme. This amount is included in the total losses quoted in Table 2.

Identified water management measures to improve water use efficiency in the Schoonspruit Government Water Scheme

The priority water management measures to improve irrigation water use efficiency on the Schoonspruit Government Water Scheme include the following:

(1) Water measurements of the flow rates, duration and volume of flows at all the critical points which include the inflow and outflow at the balancing dams, the branch canals, as well as the canal tail ends, etc.
(2) Preparation of more detailed water balance assessments for the Schoonspruit Government Water scheme, as well as the sub-schemes to enable prioritisation of intervention measures on the sub-schemes where the conveyance efficiency levels are found to be very low.
(3) Implementation of a more complete water accounting system such as the WAS programme to enable irrigation monitoring and control of water use to reduce operational losses such as canal tail ends spills to be carried out as well as undertaken water balance assessment at scheme as well as sub-scheme level.
(4) Reducing the algae and water grass problems which are affecting the hydraulic capacity of the canal infrastructure resulting in flow measurement accuracy.
(5) Installation of automated monitoring or telemetry infrastructure to enable real time monitoring of irrigation water in the long term.
(6) Maintenance and refurbishment of the existing delivery canals as well as the siphons, in order to reduce leakage losses, improve flow rates and increase head at diversion points.
(7) Developing an incentive based water pricing structure to improve irrigation water use efficiency and reduce significant fluctuations in demand.

Conclusions and Recommendations

A water management plan for the Schoonspruit Government Water Scheme was developed to address the water losses taking place in the scheme and to improve irrigation water management of the scheme. The identified measures for implementation to reduce the water losses from the current 29% to 17% of the total inflow into the irrigation scheme include the following:

(i) *Installation of water measurement* - This measure has estimated water savings of 1.41 million m^3/a, at an average incremental cost of R0.03 per m^3. It is however easy to implement and should be considered a priority as all other measures are

dependent on availability of sufficient water measurements in the Schoonspruit Government Water Scheme.

(ii) *Control of canal tail end spills and Chemical management of aquatic weeds and algae growth in canals* - This measure has an estimated water savings of 1.5 million m^3/a, at an average incremental cost of R0.03 per m^3. It should be carried out at the same time as the first intervention measure.

(iii) *Water Accounting System* - This measure is aligned to the installation of water measurement and will provide the system necessary to identify areas where irrigation water management can be improved. The changes in operation of the canals and canal tail ends can result in water savings of approximately 1.41 million m^3/a if no water is allowed at the canal tail ends.

(iv) *Incentive based water pricing structure*- This measure has the lowest benefit with estimated water savings of 0.82 million m^3/a. The average incremental cost to implement this water management measure is likely to be very low as this will be done at national level.

(v) *Refurbishment & resealing* – this intervention measure has a high benefit with an estimated savings of 1.78 million m^3/a. The average incremental cost to implement this measure is likely to be very high.

In order to enable the implementation of the Water Management Plan (WMP) for the Schoonspruit River Irrigation Scheme it is imperative that Scheme Manager, Chief Water Control Officer and Water Control Officers are appointed by the DWA Regional Office for the optimal running of the Scheme.

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ABBREVIATIONS

AIC	Average Incremental Cost
BMP	Best Management Practice
DWA	Department: Water Affairs
ET	Evapo-Transpiration
EWR	Environmental Water Requirements
GIS	Geographic Information System
GWS	Government Water Scheme
IB	Irrigation Board
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MISD	Matching Irrigation Supply and Demand
O&M	Operation and Maintenance
RAT	Rapid Assessment Tool
RTU	Remote Telemetry Unit
SLA	Service Level Agreement
WARMS	Water Allocation Registration Management System
WAS	Water Administration System
WCD	Water Control Department
WC/WDM	Water Conservation and Water Demand Management
WCO	Water Control Officer

WMA	Water Management Area
WMP	Water Management Plans
WUA	Water User Association
WUEAR	Water Use Efficiency Accounting Report

GLOSSARY OF TERMS

Application efficiency The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent.

Applied water: Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries

Conduit: Any open or closed channel intended for the conveyance of water.

Conservation: Increasing the efficiency of energy use, water use, production, or distribution.

Consumptive use (evapo-transpiration) Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called: Crop requirement, crop irrigation requirement, and consumptive use requirement.

Conveyance loss: Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation and transpiration by plants growing in or near the channel.

Conveyance system efficiency: The ratio of the volume of water delivered to irrigators in proportion to the volume of water introduced into the conveyance system.

Cropping pattern: The acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops, and/or by cropping existing crops.

Crop water requirement: Crop consumptive use plus the water required to provide the leaching requirements.

Crop irrigation Quantity of water, exclusive of effective precipitation, that is needed

requirement:	for crop production.
Crop root zone:	The soil depth from which a mature crop extracts most of the water needed for evapo-transpiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in mm or m. This soil depth may be considered as the rooting depth of a subsequent crop, when accounting for soil moisture storage in efficiency calculations.
Deep percolation:	The movement of water by gravity downward through the soil profile beyond the root zone; this water is not used by plants.
Demand scheduling:	Method of irrigation scheduling whereby water is delivered to users as needed and which may vary in flow rate, frequency, and duration. Considered a flexible form of scheduling.
Distribution efficiency:	Measure of the uniformity of irrigation water distribution over a field.
Distribution loss:	See conveyance loss.
Distribution system:	System of ditches, or conduits and their appurtenances, which conveys irrigation water from the main canal to the farm units.
Diversion (water):	Removal of water from its natural channels for human use.
Diversion (structure):	Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream.
Drainage:	Process of removing surface or subsurface water from a soil or area.
Drainage system:	Collection of surface and/or subsurface drains, together with structures and pumps, used to remove surface or groundwater.
Drip (trickle) irrigation:	An irrigation method in which water is delivered to, or near, each plant in small-diameter plastic tubing. The water is then discharged at a rate less than the soil infiltration capacity through pores, perforations, or small emitters on the tubing. The tubing may be laid

	on the soil surface, be shallowly buried, or be supported above the surface (as on grape trellises).
Drought:	Climatic condition in which there is insufficient soil moisture available for normal vegetative growth.
Dry Period :-	A period during which there will be no water flowing in the canal system.
Evaporation:	Water vapour losses from water surfaces, sprinkler irrigation, and other related factors.
Evapo-transpiration:	The quantity of water transpired by plants or evaporated from adjacent soil surfaces in a specific time period. Usually expressed in depth of water per unit area.
Farm consumptive use:	Water consumptively used by an entire farm, excluding domestic use. See irrigation requirement, consumptive use, evapo-transpiration.
Farm distribution system:	Ditches, pipelines and appurtenant structures which constitute the means of conveying irrigation water from a farm turnout to the fields to be irrigated.
Farm loss (water):	Water delivered to a farm which is not made available to the crop to be irrigated.
Geographic Information System (GIS)	Spatial Information systems involving extensive satellite-guided mapping associated with computer database overlays
Irrigation schedule	This is the list prepared by the Board showing the sequence the Irrigators will lead and dependent on the scheduled area the time period that the Irrigator is entitled to receive water
On-farm:	Activities (especially growing crops and applying irrigation water) that occur within the legal boundaries of private property.
On-farm irrigation	The ratio of the volume of water used for consumptive use and

efficiency:	leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).
Operational losses:	Losses at the tail ends, sluices not opened or closed on time or opened to big and spills
Operational waste:	Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.
Pan evaporation:	Evaporative water losses from a standardized pan. Pan evaporation is sometimes used to estimate crop evapo-transpiration and assist in irrigation scheduling.
Parshall flume:	A calibrated channel-like device, based on the principle of critical flow, used to measure the flow of water in open conduits. Formerly termed the Improved Venturi Flume.
Percolation:	Downward movement of water through the soil profile or other porous media.
Reservoir:	Body of water, such as a natural or constructed lake, in which water is collected and stored for use.
Return flow:	That portion of the water diverted from a stream which finds its way back to the stream channel, either as surface or underground flow.
Return-flow system:	A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse. Sometimes called a "reuse system" or "recovery system".
Run-off	This is the water produced when irrigation water is applied to fields at rates and in amounts greater than can be infiltrated into the soil profile Tail end water i
Request Form :	A form on which an Irrigator requests the quantity of water he requires.
Tail end water	This is water at the endpoint of a canal

Telemetry	Involving a wireless means of data transfer
Water Note	A form issued by the Water Control Officer informing the Irrigator of the quantity of water he will be receiving.

1 INTRODUCTION

1.1 Background

Irrigation agriculture is the biggest water user in the South Africa, using approximately 62% of the current water use nationally. With the increasing competition between existing user sectors, the available water cannot meet the demand under current water use practices and operating conditions in all water use sectors. It is therefore imperative to ensure that available water supplies are used efficiently and effectively to avoid supply shortages and intermittent water supplies, which would have a major impact on the socio-economic growth and development of the country.

The savings that can potentially be made from implementing WC/WDM measures will delay in the need for the development of additional new water supplies, while ensuring that the natural environment is maintained or is not degraded further. The Department of Water Affairs (DWA) identified that, based on preliminary assessment of water losses in the agricultural sector, there was potential to implement measures to improve water use efficiency in the sector. The overall aim in reducing water losses and improving irrigation water use efficiency levels in the Water User Associations (GWSs)/Irrigation Boards (IBs) is that the limited available water can be optimally utilised to ensure a high economic return for the scheme area.

The study was commissioned because of the increasing water scarcity[2] in a number of Water Management Areas (WMAs). One of the approaches in addressing the increasing water scarcity and competition for water is to ensure that existing water users utilise their existing water entitlement efficiently. The Department of Water Affairs (DWA) Directorate: Water Use Efficiency, which has the mandate to ensure the efficient use of the water resources in the country by all water use sectors, identified that since the development of the pilot Water Management Plans (WMPs) for improving water use efficiency in irrigation agriculture, no progress had been made by the irrigation sector with respect to the development and implementation of WMPs for that sector.

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[2] Water scarcity – this is an imbalance of supply and requirement under prevailing institutional arrangements indicating an excess of water requirements over available water at the required assurance of supply, especially if the remaining supply options are difficult or costly to tap. The current utilisation as a percentage of total available resources at the required assurance of supply can illustrate the scale of the problem and the latitude for policymakers

In order to ensure the irrigation sector review their current water use efficiency levels and develop strategies to improve their water use efficiency, the DWA has identified a need to assist a number of irrigation schemes in developing their irrigation water management plans in order to primarily reduce their water losses. A secondary outcome can be seen as the enablement of irrigators to increase their on-farm irrigation efficiency.

Following the meetings with DWA Directorate: Water Use Efficiency, Schoonspruit GWS and the DWA Regional Offices, this report provides the following:

- Overview of the water allocation and irrigation water use situation of the Schoonspruit GWS and related institutional arrangement for irrigation water management
- Identification and assessment of the water management issues and management goals expected to address the irrigation water management issues identified.

1.2 Study Objectives

The primary objective of the study is the development and implementation of irrigation WMPs for 14 irrigation schemes (see **Figure 1.1** below) to improve water use efficiency in the agricultural sector. In order to achieve this objective, the following tasks have to be undertaken:

- Compilation of a situation assessment of the current water use and irrigation water use practices in the fourteen irrigation schemes;
- Determination of the irrigation water budget and establishing water use baseline for each irrigation scheme;
- Determination of the irrigation water management issues based on the situation assessment and water budgets prepared for each irrigation scheme;
- Identification of opportunities to improve water use efficiency in the agricultural sector;
- Benchmarking of irrigation water use efficiency and setting irrigation water use efficiency targets for each scheme;
- Preparation of an irrigation water management plan for each irrigation scheme;
- Capacity building of the Government Water Schemes (GWSs), Irrigation Boards (IBs) and Water User Associations (WUAs) to implement the identified opportunities to improve irrigation water use efficiency.

Figure 1.1: Location of the 14 irrigation schemes where WMPs have been developed

The development of WMPs for the selected Irrigation Schemes will not only provide a plan for reducing water losses and improve system efficiencies, but if the management plan is implemented and water losses and water demand is reduced, the benefits to the agricultural sector, customers and the catchments in general will include:

- Improved system efficiencies;
- Reduction in irrigation water return flows;
- Reduction in system operation and maintenance expenses;
- Potential cost savings due to deferral or downsizing of capital works;
- Benefits which are important but difficult to quantify such as reduced environmental impact resulting from delays in or deferment of construction of water sources and the maintenance of higher water levels in rivers and reservoirs.

1.3 Structure of the report

This report has been structured to first provide a perspective of the Schoonspruit Government Water Scheme as well as the potential for irrigated agriculture in the Schoonspruit GWS.

Chapter 1 provides the overall objective of assessing water conservation and demand management measures in the context of increasing competition between existing water users and the need for water for the environment.

Chapter 2 describes the catchment characteristics of the Schoonspruit catchment in which the Schoonspruit Government Water Scheme is situated.

Chapter 3 describes the history of the Schoonspruit Government Water Scheme and the scheduled quota. It also describes the catchment and the current land-use practices in the catchment. The chapter also describes the background to the scheme, the institutional arrangements.

Chapter 4 gives an overview of the inventory of the existing irrigation water management infrastructure which includes the size and capacity of the canals, the dams supplying the scheme; any balancing dams irrigation in the Schoonspruit Government Water Scheme as well as the flow measurements available in the scheme.

Chapter 5 describes the condition of the conveyance infrastructure. A framework for determining the condition assessment of the infrastructure is described while the condition of the various sections of the main canals and the branch canals are discussed based on discussions with scheme operators; surveys conducted during the various site visits, and any available information.

Chapter 6 of this report describes how the scheme is currently being operated to provide irrigation water to the irrigators. The scheme operating procedures including how the irrigators are supplied during drought periods is presented in this chapter.

Chapter 7 uses the information from the previous chapters to determine the irrigation water Best Management Practices for the irrigation schemes. This determines how much water losses would be expected if the scheme infrastructure is well maintained. Therefore the approach used to determine the expected seepage losses as well as the evaporation losses are described in the chapter of the management plan. It then describes the standards that can be adopted as appropriate for benchmarking of irrigation water use and management practices.

Chapter 8 describes the water balance assessment, as conducted, based on the water use and compared with expected irrigation efficiency levels for the different irrigation systems. This chapter also provides the performance benchmarking of the irrigation sector when compared with the expected standards.

Chapter 9 of this report describes the existing irrigation water management measures that the irrigation scheme is currently undertaking to improve irrigation water management efficient and reduce the water losses taking place in the irrigation scheme. is currently undertaking. These include flow measurement, availability of balancing dams, flow monitoring to reduce operational losses if any, canal maintenance during the dry periods; etc.

Chapter 10 then discusses the water management issues identified from the previous chapters. It then sets the management goals required to ensure any identified water management issues can be addressed.

Chapter 11 of the report provides an assessment of the identified water management measures that can be implemented to achieved the goals and objectives set in chapter 9. This is the strategic WC/WDM business plan for irrigation agriculture. The chapter also provides an estimate of the capital investment required to implement the strategy. It also provides the performance indicators for monitoring and controlling the implementation of the measures.

Chapter 12 presents the water management plan. This summarises all the water management issues, the irrigation water saving targets recommended to be achieved and the water management tasks to achieve the targets set to reduce water losses and improve irrigation water management efficiency of the scheme.

Chapter 13 provides a conclusion and recommendation for the irrigation sector.

2 CATCHMENT CHARACTERISTICS OF RIETSPRUIT AND VET RIVER CATCHMENT

2.1 Overview

The Schoonspruit Government Water Scheme is situated in the Ventersdorp Local Municipality. The nearest main town in the Schoonspruit Government Water Scheme is Ventersdorp located within the government water supply scheme area. **Figure 2.1** presents the locality map of the Schoonspruit Government Water Scheme area.

The Schoonspruit has its headwaters in the north east of Ventersdorp in the Ventersdorp Local Municipality. More than half of the water in the Schoonspruit River is from the dolomitic aquifers. A weir has been built to divert the Eye’s water into a canal on the right bank of the Schoonspruit River.

There are two storage dams in the Schoonspruit catchment, namely Elandskuil and Rietspruit Dams. The Elandskuil Dam is located in the Swartleegte River near the town of Ventersdorp. This is a very small dam and has a storage capacity of 1.2 million m^3. The dam was constructed to meet the irrigation water requirements of the lands on the right bank of the Schoonspruit Government Water Scheme.

The Rietspruit Dam is located in the Rietspruit which is a tributary of the Schoonspruit. The dam was built in 1977 to improve the security of supply to the irrigation. The storage capacity of the dam is 7.3 million m^3.

2.1.1 Climate and rainfall distribution

The climate and temperature variations of the Schoonspruit River catchment are closely related to elevation. The study area experiences extreme conditions during the summer months (DWAF: 1999). The characteristics of the catchment indicate that there is one climatic zone (see **Figure 2.2** below). The mean annual precipitation is between 550 mm and 600 mm. The low MAP indicates the need for irrigating the lands because of low rainfall in the Schoonspruit Government Water Scheme area.

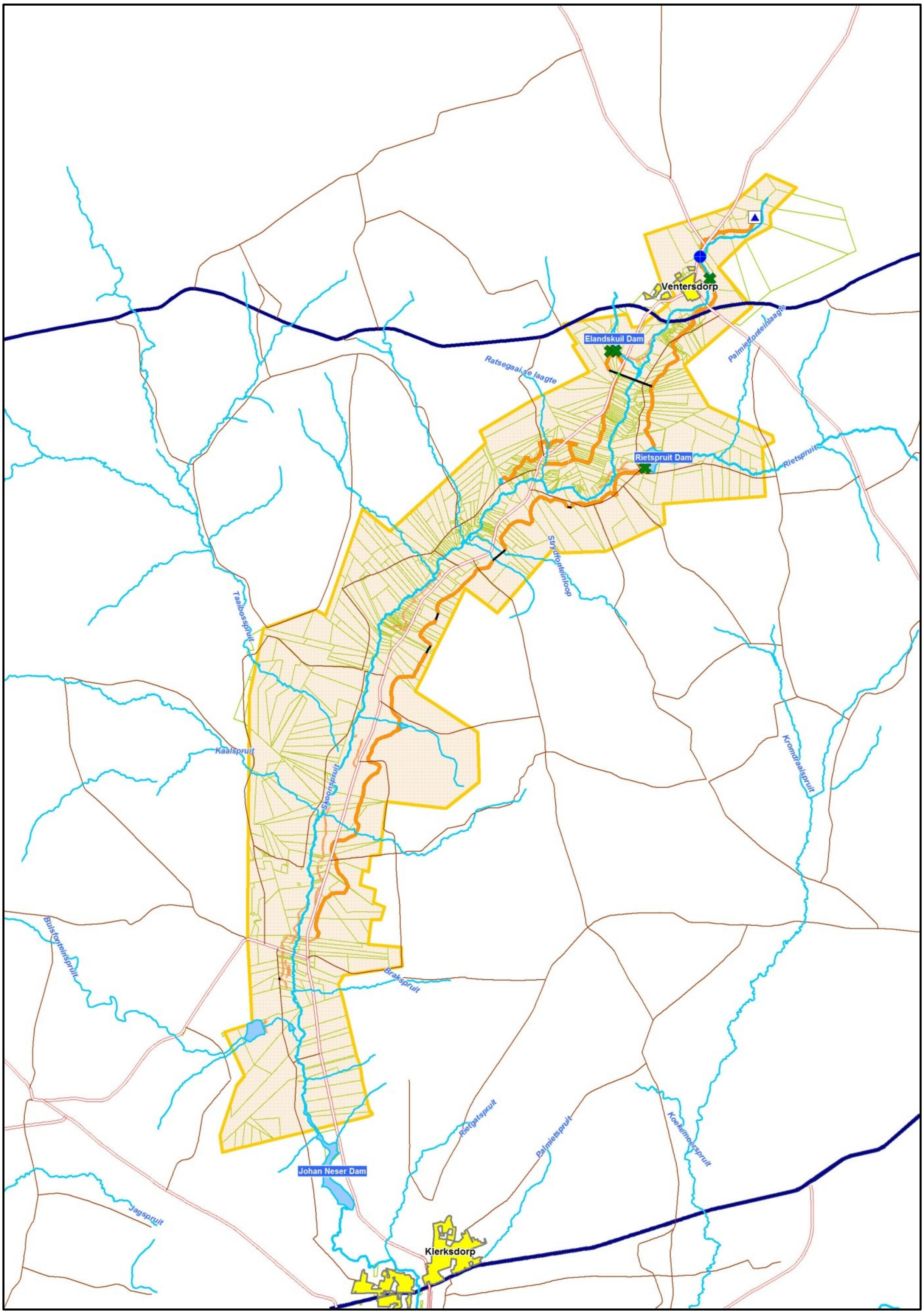

Figure 2.1: Overview of the Schoonspruit Government Water Scheme

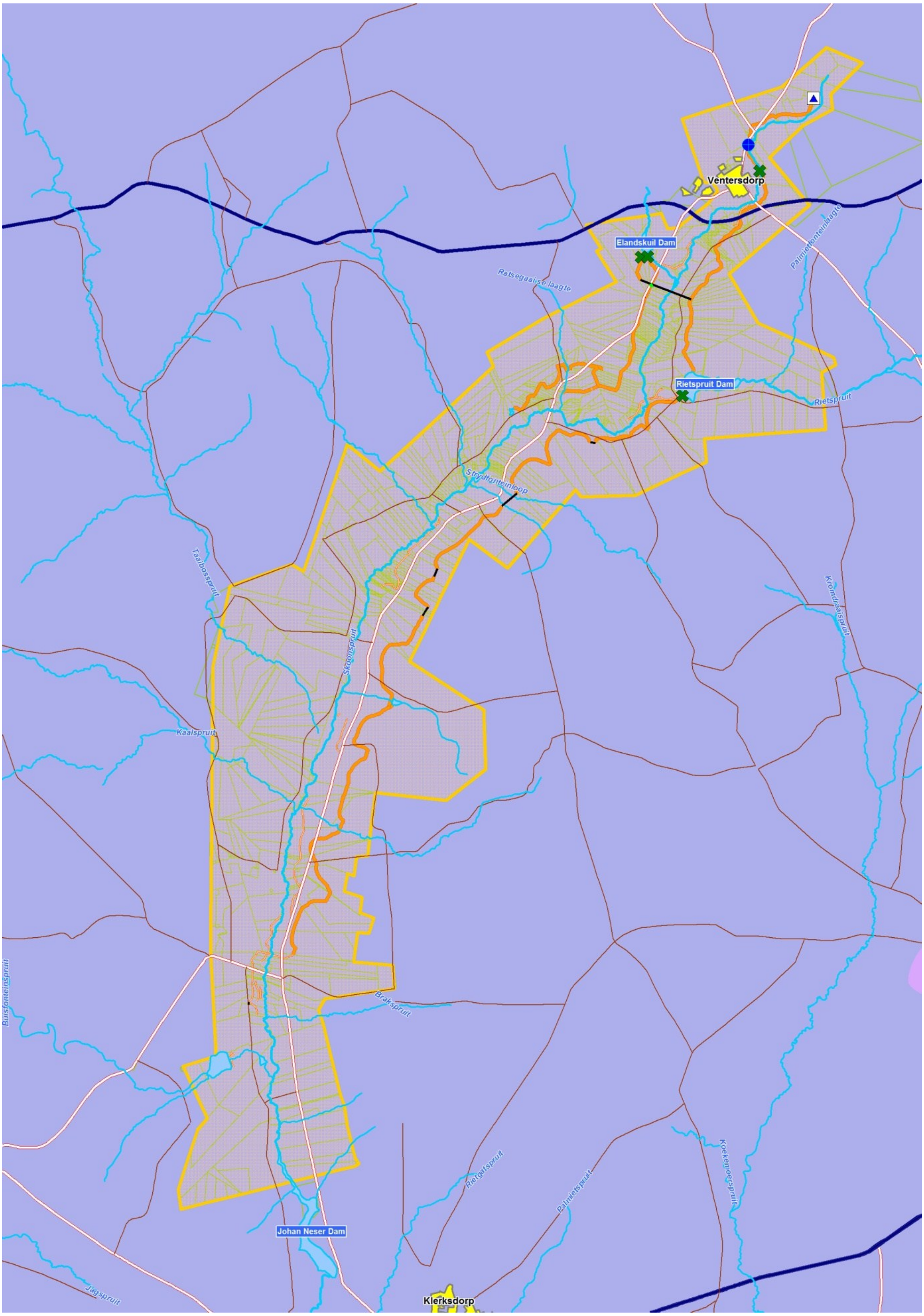

Figure 2.2: Precipitation Map of Schoonspruit GWS

The Rietspruit River catchment is divided into two evaporation zones. The headwaters of the Rietspruit River catchment and the left bank experience evaporation rates, estimated to range between 1700 mm to 1800 mm. The evaporation ranges between 1800 mm to 2000 mm on the right bank after the Rietspruit Dam as well as the left bank up to the end of the irrigation scheme,. The high evaporation rate has a direct correlation with the irrigation water use requirements.

2.1.2 Geology and soils of the catchment

The geology of the area supplied by Schoonspruit Government Water Scheme (GWS) has predominantly an assemblage of dolomitic aquifers in the upper catchments which is the source of the water supply into the Schoonspruit River.

As a result of the predominant geological strata as well as the climate, the soils of the Schoonspruit Government Water Scheme can be categorised as moderate to deep sandy loam soils on undulating plains. It is important to note that the sandy loam soils are ideal for irrigation because they possess a good balance between water holding capacity and drainage. The water holding capacity is high, estimated to range between 104 mm per m and 117 mm per m (J.L. Schoeman and M. van der Walt).

The average soil depth in the scheme area is 650 mm.

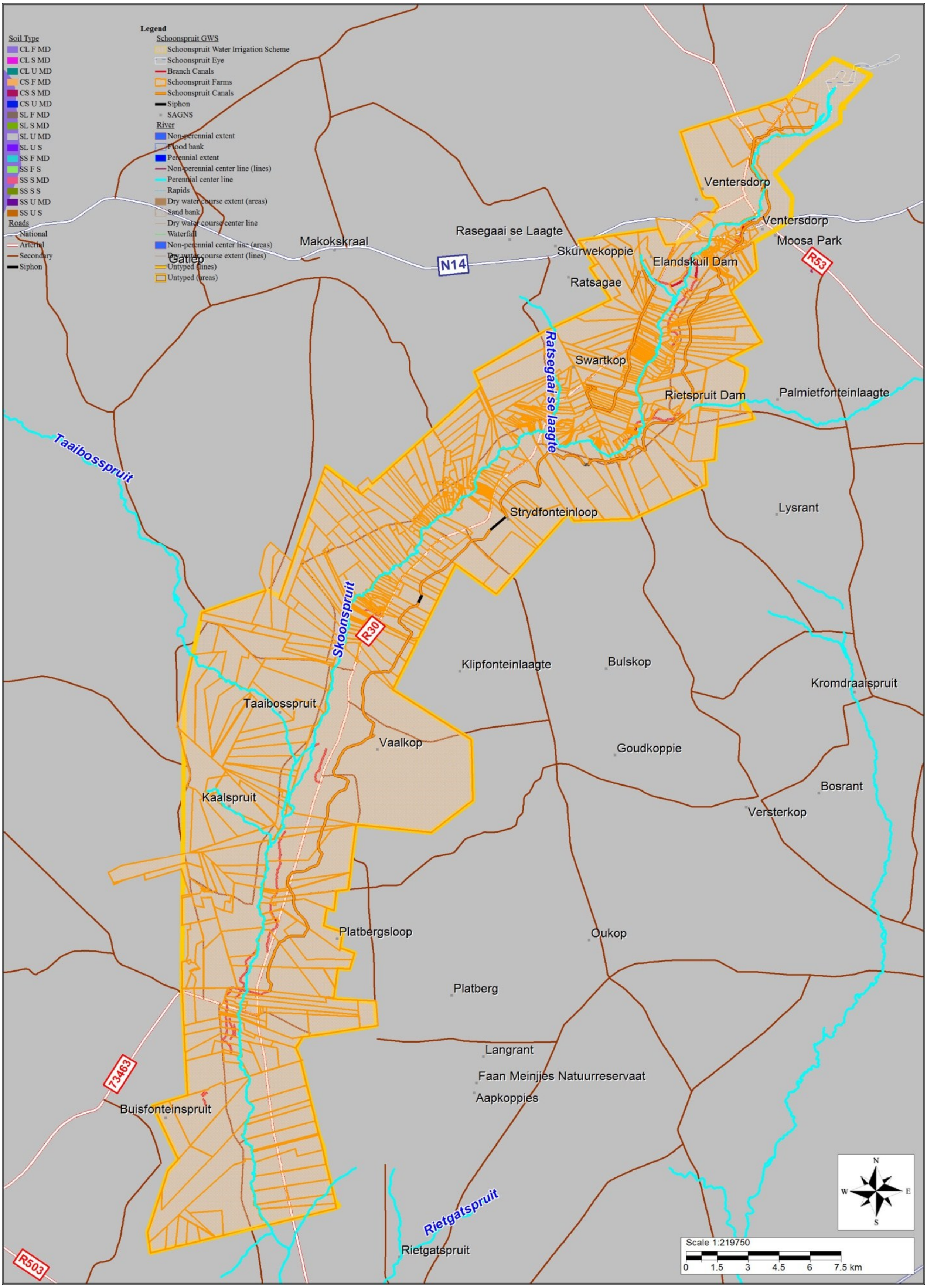

Figure 2.3: Schoonspruit Soil Map

3 OVERVIEW OF THE SCHOONSPRUIT GOVERNMENT WATER SCHEME

3.1 History of the Schoonspruit Government Water Scheme

Figure 3.1 below indicates the Schoonspruit Government Water Scheme. The scheme is located close to Ventersdorp and receives its water from the Ventersdorp Eye, Elandskuil Dam and Rietspruit Dam. A weir has been built to divert the Eye's water into a canal on the right bank of the Schoonspruit River. This canal conveys the water to the Ventersdorp Municipality and irrigation areas located further downstream along the canal system.

The canal then crosses the Schoonspruit River just downstream of the Kalk Dam, where there is a structure that can "reject" excess water from the canal into the Schoonspruit River, and also allows water to flow into a canal on the left bank of the Schoonspruit. This canal supplies irrigation water down to the Rietspruit Dam to approximately 507 ha of irrigation lands. The primary canal then supplements irrigation water from the Elandskuil Dam on the right bank via the Elandskuil pipeline to the Elandskuil Dam on the right bank of the Schoonspruit River. The right bank scheme supplies 648 ha of scheduled area.

The left bank primary canal then supplies excess water into the Rietspruit Dam which is located in the Rietspruit River, a tributary of the Schoonspruit River. The water from Rietspruit Dam irrigates 1 280 ha of scheduled area of the scheme.

3.2 Organisational arrangements

The Schoonspruit River Irrigation Scheme is a government water scheme (GWS) since establishment. The DWA, through its Infrastructure Branch is responsible for the operation and maintenance of the scheme. As part of the operation of the irrigation scheme, the Infrastructure Branch supplies water not only to the irrigators in the Schoonspruit River Government Water Scheme but also provides the water requirements for municipal water use through the canal infrastructure to the town of Ventersdorp.

The Schoonspruit River Government Water Scheme is managed by a Proto Catchment Management Agency Area Manager who is performs the dual role for the strategic oversight and day to day management of the scheme. There is no Scheme Manager for the Scheme.

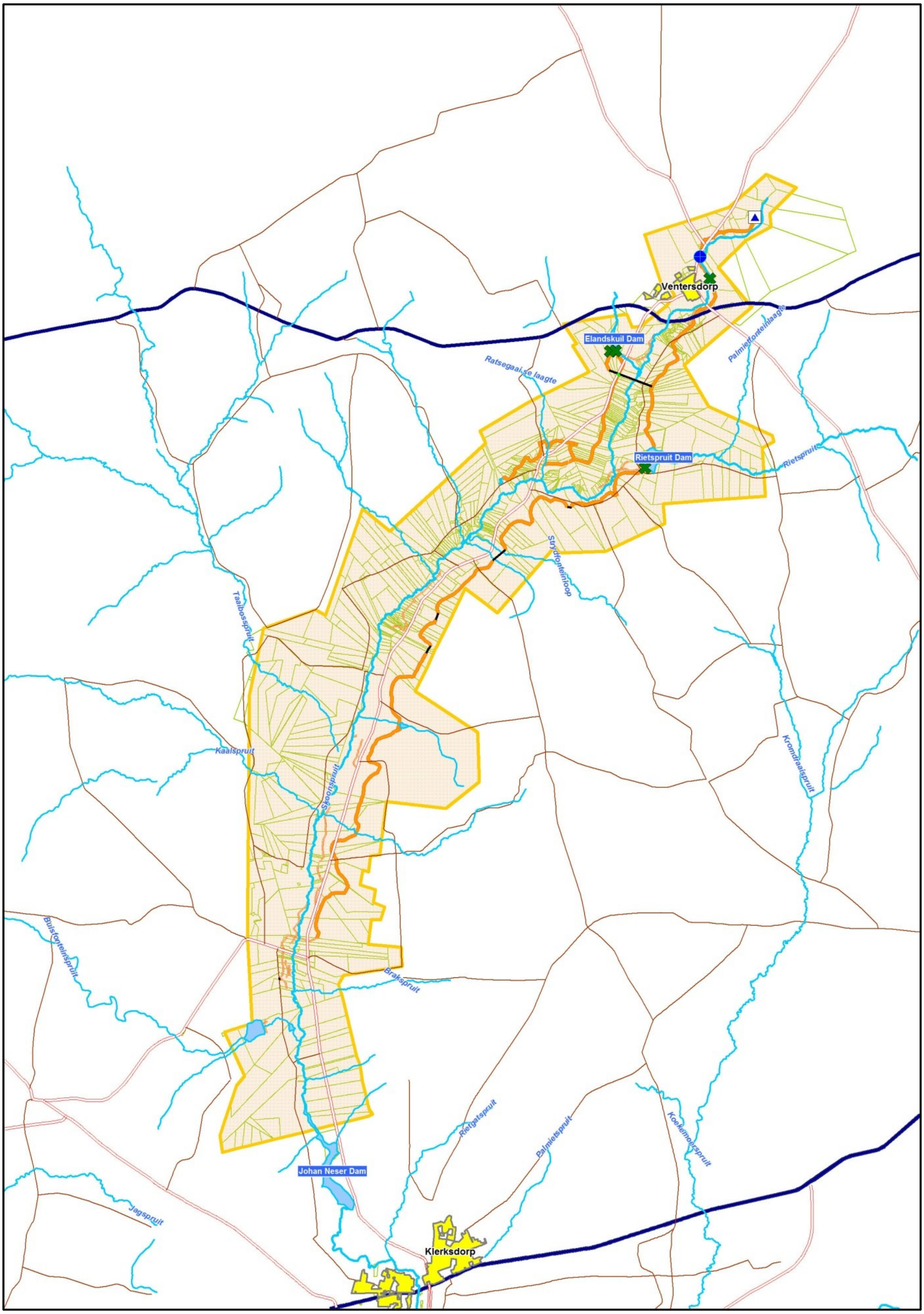

Figure 3.1: Schoonspruit Government Water Scheme

3.2.1 Water distribution Section

One of the key functions of the Schoonspruit River GWS is the distribution of the irrigation water as required and on time as well as civil and/or mechanical maintenance of the Irrigation Scheme (see **Figure 3.2** below).

As part of the water distribution and/or operation of the irrigation scheme, the Schoonspruit River GWS supplies not only the irrigators but also the water requirements of the domestic sector through the canal infrastructure.

There are two levels in the water distribution section which include the Water Control Officers as well as the Water Control Aid (previously known as the canal guards). The Control Water Control Officer and Chief Water Control Officer fall under the Proto CMA but perform the dual role of overseeing the smooth and efficient running of the Government Water Scheme. Their responsibilities are discussed in the following sections.

3.2.1.1 Chief Water Control Officer

The Schoonspruit River GWS does not have a Chief Water Control officer. There is a Chief Water Control for the Proto CMA who performs the dual role for the operation of the Government Water scheme. He fulfils the dual function of collecting the information provided by the Water Control Officers (WCOs), process it and issue the operational orders to be executed. These include the amount and timing of releases from the Elandskuil and Rietspruit Dams, the setting of the sluice gates and structures to deliver the amount and timing of irrigation water requested by the irrigator on a weekly basis.

The job description of the Chief WCO for the Government Water Scheme is to ideally carry out the following tasks:

(i) Control and approve the weekly water requests from the Water Control Officers (see their job description below);

(ii) Planning the operation of the scheme in order to match the supply as closely as possible with the irrigation water applications (i.e. demand);

(iii) Supervise that the orders provided to the WCOs are executed accurately;

(iv) Coordinate with the WCOs the operation of the main canal gates and the releases required, including the timing of the releases;

(v) Monitoring of the operation (i.e. collection of data related to water use and preparing accounting reports) and preparation of the annual irrigation plans and reports.

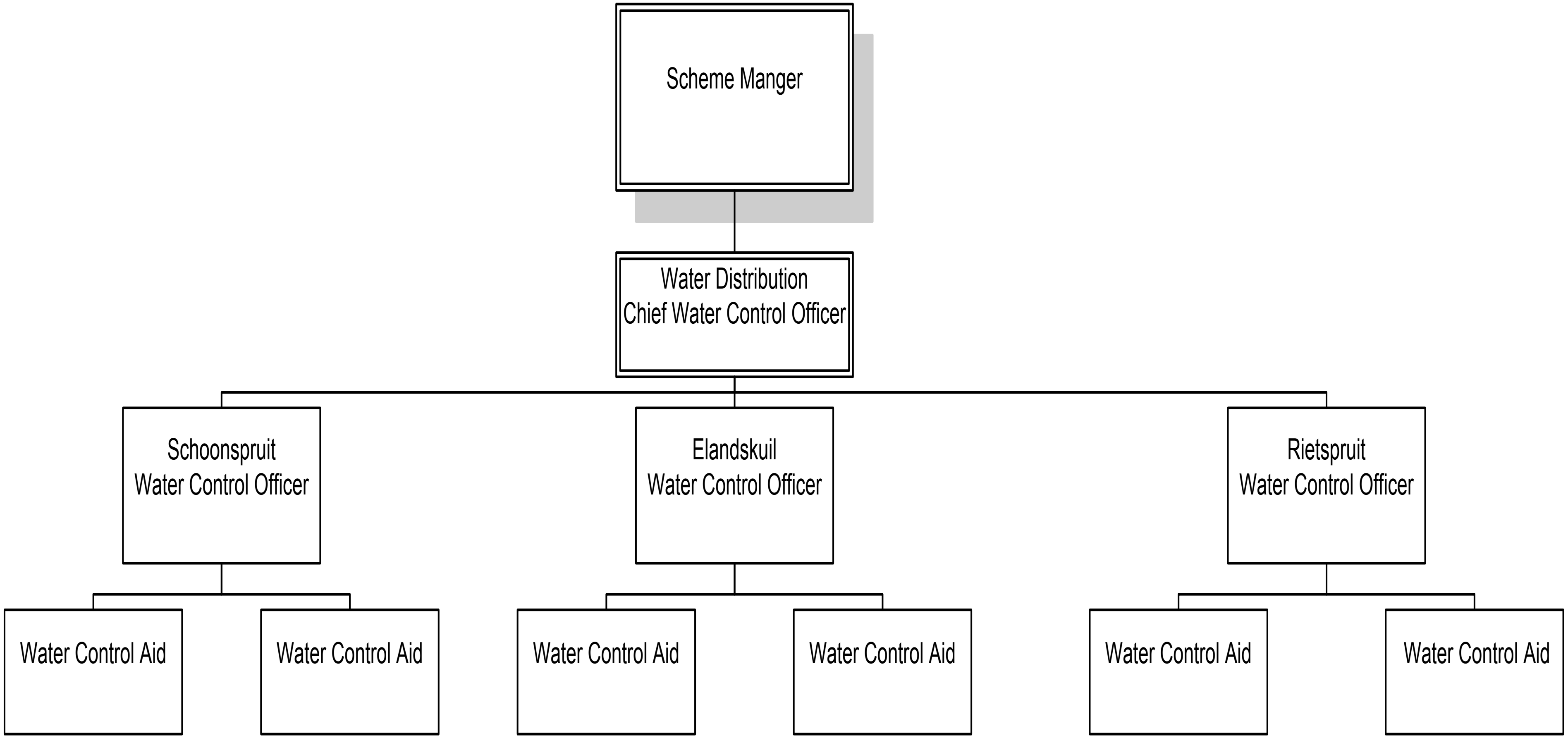

Figure 3.2: Organisational structure for water distribution in the Schoonspruit River Government

3.2.1.2 Water Control Officers

The Schoonspruit River Government Water Scheme is sub-divided into three (3) sections. Some of these sections are combined under one Water Control Officer (WCO). On the establishment provision is made for 1 Chief Water Control Officer and 2 Water Control Officers. The job description of the WCO is mainly to carry out the following tasks:

(i) Compile data such as Dam levels, Rainfall figures, Evaporation, releases out of Dams to the canals and rivers as well as tail end flows for compilation of weekly and monthly water disposal reports;
(ii) Capture all necessary data on the Water Administration System (WAS);
(iii) Transmit the water distribution orders to the Water Control Aids (WCAs) responsible for the different sections;
(iv) Control that the sluice gates are opened and closed as indicated by the Schoonspruit GWS scheme office;
(v) Receive data from the WCAs as to the required amount of water, and transfer the data to the main office;
(vi) Report to the Chief WCO any malfunctioning of sluice gates and structures and any water thefts;
(vii) Control and report on the state of maintenance of the stretch of canal for which they are responsible.

Manpower requirements

Data from several projects indicate that one WCO can cover 10 - 15km depending on the number of hydraulic structures in the canal. The main releases into the canal system, which are Elandskuil and Rietspruit Dams require one person per gate to operate.

3.2.1.3 Water Control Aids

The Water Control Aids (WCAs) are the main communication channel between the scheme management and the farmer. Therefore the success of a smooth relationship between the two parties depends on their capabilities and honesty.

Although the job descriptions of the WCAs may vary slightly, the following are considered to be the usual expected tasks to be carried out:

(i) Distribute and control the flows that each offtake must deliver;
(ii) Open and close offtake sluice gates and valves;

(iii) Collection of the water requests, if necessary;

(iv) Preparation of the daily forms for the water delivery;

(v) Communication to the WCOs of the request of water;

(vi) Control of the canals and watercourses to avoid unauthorised use of water;

(vii) Compilation of the agricultural and water data as needed;

In the Schoonspruit River Government Water scheme, the water control aids not only perform functions related to the operation of the system, but also conduct maintenance work during the off-season. The added duties during this period include the following:

- Cleaning of the irrigation canals;
- Small repairs in the small hydraulic works (intakes, siphons, joints, etc.);
- Supervision of repair works;
- Repairing and maintaining the sluice gates in their section.

Manpower requirements

The Schoonspruit River GWS has to distribute irrigation water to 2 432.6 ha with the six Water Control Aid posts.

As illustrated in the **Figure 3.1** above the Schoonspruit River GWS has sufficient posts on their structure to carry out the water distribution to its constituents, the irrigators in all the sections.

Because ownership of the irrigation infrastructure (i.e. irrigation canals, balancing dams and associated appurtenance works such as sluices and weirs to deliver the water to irrigators) is still with the DWA, any major refurbishment of the infrastructure is still undertaken by the Department of Water Affairs through the Infrastructure Branch who are also responsible for the operation and maintenance of the scheme.

3.3 Irrigation water use charge

3.3.1 Water User Charge

The irrigators in the Schoonspruit Government Water Scheme are charged a water use charge of R12.50 c/m^3, which is equivalent of R962.00 per ha/a. Compared to other irrigation schemes these costs can be considered to be reasonable to ensure irrigation agriculture is a viable undertaking. The WRI charge paid by the domestic and industries that are supplied from the Elandskuil and Rietspruit canals for 2010/11 financial year was 63.74 c per m^3 or if compared to agriculture, R4 907.98 per ha/a. This clearly indicates that the WRI charge for irrigation agriculture is currently heavily subsidised when compared to the water use charged for domestic and industries.

Each irrigator is responsible for the payment of the WRI charge to the Department of Water Affairs (DWA). The collection of the water use charge is also carried out by the DWA Head Office.

3.3.2 Water Resource Management Charge

Besides paying for the use of the water released from the Elandskuil Dam and Rietspruit Dam, the irrigators in the Schoonspruit Government Water Scheme also pay for the water resource management charge of the catchments. The current WRM charge for the Schoonspruit River catchment is 1.49 c/m^3 or R114.73 per ha/a.

The WRM charge is the same for all water users in the Middle Vaal Water Management Area (WMA) in which the Schoonspruit Government Water Scheme is situated. The purpose is to cover all management activities that are undertaken by a Catchment Management Agency (CMA) or a proto-CMA where one has not been established and to ensure the sustainable water resource management so that all users in the WMA have a fair and equitable share of the available water. The activities that are covered by the WRM include the following:

(i) water abstraction control to ensure that all get their fair share of water,
(ii) monitoring and pollution control to keep the rivers healthy,
(iii) planning for development of new schemes and to extend existing schemes,
(iv) clearing of invading alien plants which consume water that should be available for use.

For the irrigators in the Schoonspruit Government Water Scheme, the total cost of water including the management charge amounts to R1 077.23 per ha/a. This is comparable with a number of other irrigation schemes.

3.4 Water use permits / licenses and contracts

The authorisation for the water use, within the Schoonspruit Government Water Scheme (GWS) area of jurisdiction, lies in the Schedule, for 5 335 ha, drawn up in terms of section 88 of the 1956 Water Act, and approved by the Department in 1999. This scheduled use is deemed to be an Existing Lawful Water Use under section 32 of the National Water Act, 1998 and as such, does not require a Licence, but does need to be registered. The irrigators have permission to continue irrigating this scheduled area until licensing takes place, provided they pay all charges due to DWA.

The current irrigated area is 2 432.6 hectares, comprising 507 ha in the Schoonspruit canal system, 648 ha supplied from the Elandskuil Dam canal system and 1 277.9 ha supplied from the Rietspruit Dam canal system. Each of the irrigators in the Schoonspruit Government Water Scheme area is registered individually and the Registration certificates reflect the scheduled as well as the non-scheduled areas.

The water use authorisation for domestic water use in Schoonspruit and surrounding communities supplied by the scheme is held by the Water Services Authority (WSA) which is Ventersdorp Local Municipality who also hold the water use authorisation for the industrial water use. There is a service level agreement (SLA) between the domestic sector and the Schoonspruit GWS for the delivery of water for domestic purposes through the irrigation canal infrastructure.

The total allocations for the scheme is 18.7 million m^3/a, at 7 700 $m^3/ha/a$. A review of the Water Allocation Registration Management System (WARMS) database indicates that the total registered water use in the scheme area is 18.7 million m^3/a, which is supplied from the canal infrastructure.

It is important to note that over the period from 1999/2000 to 2005/06 water years, the annual inflow into the two schemes including the allowance for water losses have ranged between 37 million m^3/a and 71 million m^3/a (after patching for missing data) which is approximately 30%- 40% of the scheduled area according to the records of diversion into the main irrigation canal supplying the Schoonspruit Government Water Scheme.

3.5 Irrigated areas and types of crops

The Schoonspruit Irrigation GWS area comprises 5 335 hectares with the irrigation area estimated to be 46% of the scheme area at 2 432.6 hectares, at a scheduled quota of 7 700 $m^3/ha/a$.

There is a typical crop mix across the Schoonspruit Government Water Scheme. The irrigators in the scheme are growing diverse crops which include maize, wheat, sunflower, and vegetables. Under irrigation practices, farmers generally grow two harvests per year.

The main crop is maize which is an annual crop. The planting season for maize starts in September/October, with harvesting taking place in April. The average maize production is estimated to be 30 tonnes per ha.

3.6 Historic water use

In order to evaluate the water use of the Schoonspruit Government Water Scheme, the scheme was treated as having three sub-schemes namely the Schoonspruit, Elandskuil Dam and Rietspruit Dam scheme areas. The historic water use of each scheme is provided in the **Table 3.1** to **Table 3.3** below

3.6.1 Historic water use - Schoonspruit GWS

The historic water use for the scheme is based on two time lines because of gaps in information for the 2004/05 water year. This is provided in **Table 3.1 below**. The seven year data excluding 2004/05 up to 2008/09 demonstrate a range of water use in the Schoonspruit section of the irrigation scheme. Irrigation agriculture has ranged from 1.45 million m^3/a in 2001/02 up to 3.53 million m^3/a in 2008/09, with a seven-year average of 2.38 million m^3/a. This is approximately 61% of the water allocation from the Schoonspruit canal.

The other major water use is the municipal water use. There has been a steady increase in domestic consumption for the last three years of the assessment. Domestic water use has increased from 1.32 million m^3/a in 2001/02 to 2.13 million m^3/a in 2008/09 at a growth rate of approximately 4.2% per year.

Table 3:1: Historic water use levels (million m^3/a) for Schoonspruit GWS section

User	2001/02	2002/03	2003/04	2005/06	2006/07	2007/08	2008/09	7 year average
Irrigation	1.45	2.69	1.54	2.01	3.20	2.75	3.53	2.38
Household	0.03	0.03	0.03	0.30	0.03	0.03	0.03	0.06
Downstream Canals	15.27	14.99	15.98	22.78	19.10	17.61	19.17	17.54
Municipal use	1.32	1.57	1.37	1.65	1.75	1.86	2.13	1.63
Total Demand	18.07	19.27	18.91	26.73	24.08	22.25	24.86	21.62

Inflow into main canal	25.27	27.44	26.42	36.18	35.31	29.71	32.86	29.95
% losses	28%	30%	28%	26%	32%	25%	24%	28%

The scheme also provides household domestic consumption for the farming communities. The household consumption has been constant over the 6 year period.

The historical records indicate that an average of 17.54 million m^3/a, was supplied to the downstream irrigation canal supplying Elandskuil Dam and Rietspruit Dam. This has been considered a use because it is used to make up irrigation water requirements to the two scheme areas.

The average volume of water diverted into the Schoonspruit canal to match the irrigation demands as well as the water losses due to evaporation and seepage losses was 29.95 million m^3/a. When compared to the demands from the canal infrastructure the additional water to meet the water losses and operational spills is 28% of the total demand.

3.6.2 Historic water use - Elandskuil Dam Scheme area

Table 3.2 below provides the six year historic water use excluding 2004/05 up to 2007/08 for the Elandskuil Dam section of the irrigation scheme. Irrigation agriculture has ranged from 1.81 million m^3/a in 2001/02 up to 3.07 million m^3/a in 2006/07, with a six-year average of 2.25 million m^3/a. This is approximately 45% of the water allocation from the Elandskuil Dam irrigation canal.

There are no other major water users from this canal. The scheme however also provides household domestic consumption for the farming communities. The household consumption has been constant over the 6 year period.

Table 3:2: Historic water use levels (million m^3/a) for Elandskuil Scheme section

User	2001/02	2002/03	2003/04	2005/06	2006/07	2007/08	6 year average
Irrigation	1.81	2.45	1.76	2.09	3.07	2.35	2.25
Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Total demand	1.82	2.47	1.77	2.09	3.08	2.36	2.27
Inflow into canal	2.54	2.94	3.96	4.33	4.97	5.30	4.01
%water losses	28%	16%	55%	52%	38%	55%	41%

The average volume of water diverted into the Elandskuil irrigation canal to match the irrigation demands as well as the water losses due to evaporation and seepage losses was 4.01 million m^3/a. When compared to the demands from the canal infrastructure the additional water to meet the water losses and operational spills is 41% of the total demand.

3.6.3 Historic water use - Rietspruit Irrigation Scheme

The historic water use for Rietspruit irrigation scheme area is provided in **Table 3.3** below. There were no historical records available for 2004/05 as well as the last water years of 2008/09 to 2010/11. Therefore the assessment has been undertaken for the six years of available records since 2001/02. The average total water released into the Rietspruit Dam irrigation canal during this period, was 6.10 million m^3/a.

Irrigation water requirements from Rietspruit Dam has averaged of 4.53 million m^3/a, from 2001 to 2007 excluding the 2004/05 year. This is approximately 46% of the irrigation water allocation from the Rietspruit Dam.

There are no other major water users from this canal. The scheme however also provides household domestic consumption for the farming communities. The household consumption has been constant over the 6 year period.

No records are available from the canal tail ends to determine how much water returned to the river.

The average volume of water released into the Rietspruit irrigation canal to match the irrigation demands as well as the water losses due to evaporation and seepage losses was 6.10 million m^3/a. When compared to the demands from the canal infrastructure the additional water to meet the water losses and operational spills is 25% of the total demand.

Table 3:3: Historic water use levels (million m^3/a) for Rietspruit Irrigation Scheme area

User	2001/02	2002/03	2003/04	2005/06	2006/07	2007/08	6 year average
Irrigation	3.89	4.31	4.17	5.18	5.17	4.48	4.53
Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Downstream Canals	-	-	-	-	-	-	-
Municipal use	-	-	-	-	-	-	-
Total demands	3.90	4.32	4.18	5.19	5.19	4.49	4.55
Inflow into canal	5.08	5.70	5.74	6.92	6.79	6.34	6.10
% Water Losses	23%	24%	27%	25%	24%	29%	25%

4 INVENTORY OF THE EXISTING WATER INFRASTRUCTURE

4.1 Overview

The Schoonspruit Government Water Scheme comprises a weir at the dolomitic aquifers which diverts the water from the Ventersdorp Eye into the main irrigation canal; two storage dams, primary and secondary irrigation canal infrastructure, as well as the canal distribution system which delivers the water ordered to the irrigators at their farm turnouts through a number of sluice gates. Flow measurement at the farm turnouts is done using Rectangular weirs.

4.2 Water Supply Sources

4.2.1 Schoonspruit Weir

The main source of water supply for irrigation is from the dolomitic aquifers at the Ventersdorp Eye. A weir was constructed to divert the water from the dolomites into the Schoonspruit irrigation canal (see **Photo 4.1** below). The storage capacity of the weir is small as it is intended only to divert the amount required into the irrigation canal system.

Photo 4.1: Wall of the weir at the Ventersdorp Eye

The amount of water diverted into the canal cannot be regulated as it is dependent on the amount of water from the dolomitic aquifer and the capacity of the Schoonspruit irrigation canal. However the releases from the canal is dependent on the applications made by the irrigators, with any excess water going into the Rietspruit Dam to supplement the yield of the dam. Furthermore additional water is supplied to the Elandskuil Dam to supplement the dam through a pipeline from the Schoonspruit irrigation canal (see **Photo 4.2** below).

Photo 4.2: Schoonspruit canal to Elandskuil Dam siphon

4.2.2 Elandskuil Dam

The date of construction of the Elandskuil Dam is not known, however it was commissioned in 2000. Its purpose was to address the water shortages and restrictions that the farmers were experiencing on the right bank of the Schoonspruit River and supplied from the Swartleegte River.

The Elandskuil Dam has a capacity of 1.2 million m^3. Water is released to supply irrigators on the right bank of the Schoonspruit River. Because the capacity of the dam is very small, the irrigators are supplemented with irrigation water from the Schoonspruit canal through a major pipeline into the dam. This is mainly during the winter periods between July and September when the irrigation demand is high and the Elandskuil Dam alone cannot match the irrigation applications.

Besides releases for the Schoonspruit Government Water Scheme, the Elandskuil Dam also releases water to meet downstream environmental water requirements (EWR).

4.2.3 Rietspruit Dam

The Rietspruit Dam provides irrigation water to the irrigators downstream of the Dam. The dam is situated in the Rietspruit River system (see **Photo 4.3** below). The storage capacity of

Rietspruit Dam is 7.3 million m^3, with the yield of the dam supplemented by the surplus water from the Schoonspruit irrigation canal.

Water is released to supply irrigators downstream of the dam mainly on the left bank but also on the right bank. Water is released from the Rietspruit Dam based on the weekly demands of the irrigators. The volume of water released is measured downstream of the dam wall.

Photo 4.3: View of the Rietspruit Dam

4.3 Irrigation conveyance infrastructure

Figure 4.1 below, illustrates the conveyance and distribution infrastructure of the Schoonspruit Government Water Scheme. Water is released from the above two dams into the main canals, which then bifurcates into the secondary canals, supplying irrigators downstream of the dams. The canal infrastructure comprises primary and secondary canal systems, as well as siphons at river crossings. The total length of the canal systems amounts to approximately 95.4 km, most of which is concrete lined.

4.3.1 Schoonspruit primary Canal system

Table 4.1 below, lists the canal infrastructure from the Ventersdorp Eye to the Rietspruit Dam. There is one primary canal from the weir at Ventersdorp Eye and some branch canals in this irrigation sub-scheme area. The Schoonspruit primary canal comprises the following components:

Table 4:1: Canal Infrastructure on the Schoonspruit sub- scheme area

Item No	Canal Name	Type of canal	Total Length of canal (km)
1	Schoonspruit Main Canal	Primary canal, concrete lined	18.6
2	Pipeline	Primary canal, concrete lined	3.3
4	Branch canals	Distribution canal	5.5
Total length of canal system - Schoonspruit sub- scheme (km)			27.4

(i) *Schoonspruit main canal*: This is the main canal, which conveys the irrigation water from the weir at the Ventersdorp Eye before it discharges excess water into Rietspruit Dam. The canal supplies irrigators on the right bank for approximately 6 km before it crosses the Schoonspruit River to supply the irrigators on the left bank. It is estimated that there is 18.6 km of concrete lined canal infrastructure. The maximum hydraulic capacity of the canal is not known.

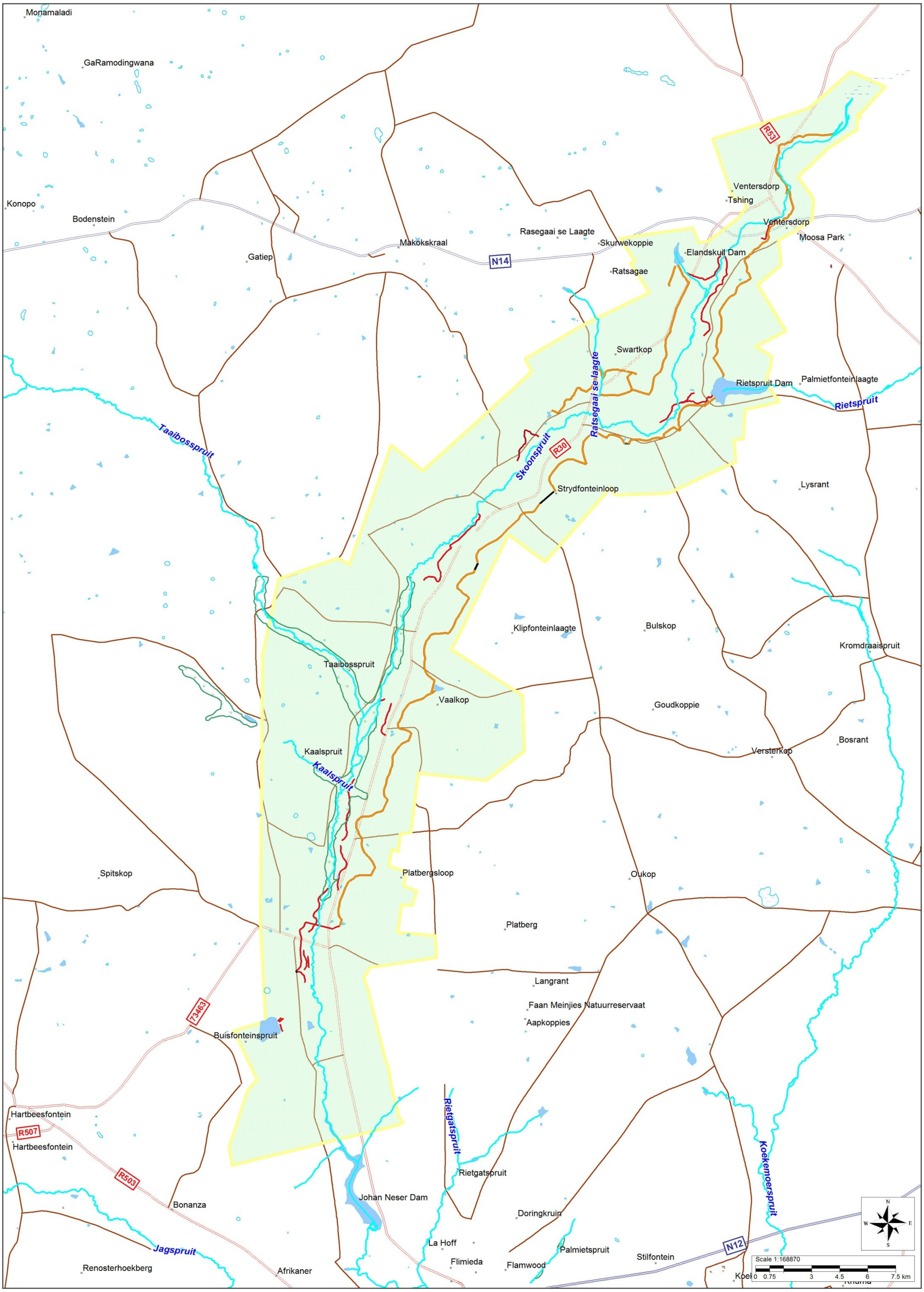

Figure 4.1: Schoonspruit Government Water Scheme Infrastructure

(ii) *Pipeline*: This is the pipeline which connects the Schoonspruit canal with the Elandskuil Dam on the right bank. The pipeline which is estimated to be 3.3 km supplements the irrigation water supplied from the dam.

(iii) *Branch canals:* There is approximately 5.5 km of branch canals supplying the irrigators in the upper section of the scheme.

4.3.2 Elandskuil Dam irrigation canal

The irrigation canals from the Elandskuil Dam are approximately 18.9 km of lined canal. It supplies the right bank irrigators up to the tail end where it discharges into a farmer's dam.

4.3.3 Rietspruit irrigation canal system

Table 4.2 below, lists the canal infrastructure downstream of Rietspruit Dam. This is where most of the irrigation scheme scheduled area is situated.

Table 4:2: Canal Infrastructure on the Rietspruit Irrigation Scheme

Item No	Canal Name	Type of canal	Total Length of canal (km)
1	Rietspruit Main Canal	Primary canal, concrete lined	44
2	Siphons		1.4
4	Branch canals	Distribution canal	22.6
Total length of canal system – Rietspruit sub-scheme (km)			68

On the left bank of the Schoonspruit River, there is one primary canal, and a series of branch canal systems with a total length of 68 km of canal infrastructure which includes the following:

(i) *Rietspruit main canal:* This main canal diverts irrigation water supplies from Rietspruit Dam on the left bank. It comprises approximately 44 km of concrete lined canal infrastructure. The main canal is the largest primary canal. However maximum design capacity of the canal is not known. The canal crosses the Schoonspruit River to supply irrigators on the right bank who cannot be supplied from the Elandskuil canal infrastructure.

(ii) *Right bank secondary canal*: This is the secondary canal which conveys the irrigation water for the farmers on the right bank not supplied by the Elandskuil canal system.

(iii) *Left bank secondary canal*: This is the secondary canal on the left bank, supplying the water users with their scheduled quota.

(iv) *Branch canals:* There are several branch canals supplying the water users with their allocations.

4.4 Irrigation storage and regulation system

4.4.1 General

The Elandskuil and Rietspruit Dams can be considered as balancing dams within the Schoonspruit GWS, as they are situated within the scheme area and are supplied by the main irrigation canal which is the Schoonspruit canal. Therefore their location provides for balancing storage for the downstream sections of the Schoonspruit Government Water Scheme, although they were not built to regulate downstream supplies per se.

4.5 Irrigation infrastructure distribution system

As illustrated in **Figure 4.1** and **Tables 4.1** and **4.2** above, there are approximately 28.1 km of branch canals in the Schoonspruit, Elandskuil and Rietspruit sections of the irrigation scheme which distribute the irrigation water to the water users through sluice gates which are measured using rectangular weirs.

The entire distribution canal infrastructure is concrete lined. No information with respect to the hydraulic capacity of the different distribution canal infrastructure was available; to compare with the maximum and average demands expected in the different irrigation sections.

4.6 Flow Measurement and telemetry system

4.6.1 Measurement of flow into the scheme area

Figure 4.2 below provides the existing location of the flow measurement system as well as the location of the additional flow measurements required to manage the irrigation water requirements in the Schoonspruit Government Water Scheme. As illustrated, the first measurement of the water diverted from the Ventersdorp Eye takes place at the weir built at the eye.

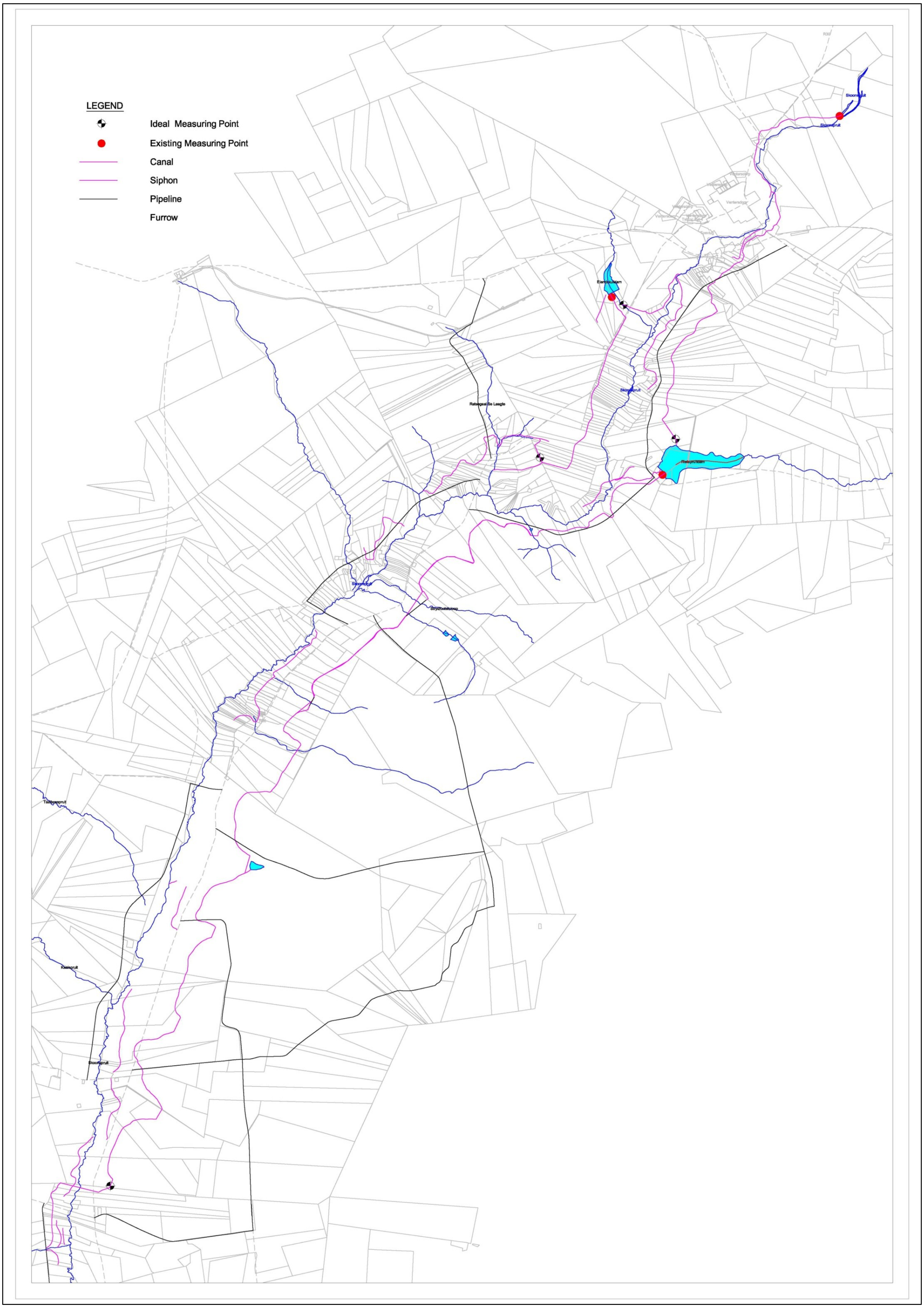

Figure 4.2: Schematic layout of the Schoonspruit Scheme with the existing water measurement system

There is a flow recorder which is used by the hydrological section of the Department of Water Affairs (DWA) to measure the total volume of water released into the Schoonspruit irrigation canal.

4.6.2 Measurement into the various canal systems

The Schoonspruit Government Water Scheme has three main irrigation canals, namely the Schoonspruit canal which supplies irrigators and domestic users upstream of Rietspruit Dam, the Elandskuil main canal supplying the water users on the right bank, and the Rietspruit primary canal supplying the water users on the left bank and the lower right bank of the Schoonspruit River. There are flow measuring structures at the outlet of Elandskuil Dam as well as at the outlet of the Rietspruit Dam.

There are however no flow measurements at the tail end of the Schoonspruit canal where it enters the Rietspruit Dam, as well as at the tail ends to measure the water returning to the river. No other direct measurements of water, including the branch canal end returns are currently performed in the system. Therefore the return flow is currently being estimated for the water balance assessment.

4.6.3 Measurement at user outlets

The Schoonspruit Government Water Scheme (GWS) measures the weekly volume of water delivered to the water users at the farm gate using rectangular weirs located downstream of the sluice gates. The sluice gates are adjusted depending on the water application by the irrigators. There are three streams which can be delivered to the irrigator by adjusting the sluices. These are 50 m^3/hr, 75 m^3/hr and 100 m^3/hr flow rates at the sluice gates.

4.6.4 Telemetry system

The Schoonspruit Government Water Scheme has no telemetry system nor automated measuring system and relies on manual flow measurements by water control officers to monitor the flow at various sites of the scheme.

5 INFRASTRUCTURE CONDITION ASSESSMENT

5.1 Overview

In order to determine the condition of the canal infrastructure, a methodology has been developed known as the Rapid Assessment Tool (RAT). This is a combination of methodologies designed to provide a quick and cost-effective analysis of condition within an irrigation scheme.

The main objective of undertaking the condition assessment is to define the extent and seriousness of problems contributing to poor conveyance efficiency.

RAT methodologies include surveys, rating of infrastructure, flow measurement, seepage loss tests, and GIS-based mapping and analysis, among other activities. These methodologies are still evolving. Two visual rating procedures have been developed:

- water supply conditions (“head conditions”);
- canal conditions.

The overall goal of this effort is to provide information which will allow decision makers involved in irrigation resource management to assess and compare the rehabilitation needs of irrigation networks.

5.2 Canal Condition Evaluation

It was not possible to undertake a condition assessment of the irrigation canals of the Schoonspruit Government Water Scheme, because at the time of developing the WMP, there were no dry periods to inspect the canals. However, a list of criteria for undertaking canal condition assessment was developed for use during the implementation phase. The Canal Condition Evaluation component of RAT includes visual rating methodologies on:

- the general condition of the canal;
- conditions which indicate seepage or structural problems.

There are service factors that are used in this procedure which may be grouped as follows:

- general condition of the canals;
- presence of cracks (hairline, pencil-size, and large);
- amount of patchwork;
- vegetation in canal and along embankment.

Tables 5.1 - 5.5 provide details on the rating factors and definition of numerical values that are recommended to be used during the dry periods.

Table 5:1: General Condition rating

Rating	Definition
1	Excellent – no visible cracks or vegetation
2	Good – having cracks greater than 3.0 m and some weeds
3	Fair – cracks 1.5-3.0 m apart, with moderate vegetation in canal and drainage ditch
4	Poor – cracks 1.0-1.5 m apart, with dense vegetation in canal and drainage ditch
5	Serious Problems – visible large cracks less than 1.0m apart with lush vegetation

Table 5:2: Criteria for hairline, pencil size and large cracks

Rating	Definition
1	None to Sparse
2	Greater than 3.0 m apart
3	1.5 – 3.0 m apart
4	1.0 – 1.5 apart
5	Less than 1.0 m apart

Table 5:3: Noticeable amounts of maintenance and repair (patchwork)

Rating	Definition
1	None to a few areas
2	A few areas
3	Sparse
4	Moderate
5	Severe

Table 5:4: Vegetation growing in canal lining

Rating	Definition
0	None
1	Sparse
2	Moderate
3	Dense

Table 5:5: Vegetation in drainage canals and along the outer embankment of the levee

Rating	Definition
1	Normal; rain-fed weeds only
2	Canal fed grass or small weeds only
3	Moderate; bushes & some small to no trees with no water near levee or drain
4	Dense; more bushes & larger trees, little or no standing water, little or no aquatic vegetation
5	Dense and lush; bushes, trees, lots of aquatic vegetation with standing water

5.3 Results and analysis of preliminary assessment

5.3.1 Condition evaluation of the canals

Although no detailed condition assessment could be undertaken on the Schoonspruit Government Water Scheme because the canals were operational, some information was gathered during the site visit that was conducted to familiarise with the irrigation scheme in May 2010. These are discussed below.

As illustrated in **Photo 5.1** below, the Schoonspruit canal which diverts the irrigation water requirements into the Schoonspruit Scheme, indicates significant algae build up from the land-use practices upstream. This has a significant impact on the hydraulic capacity of the canal. This means that there is a likelihood of overflow from the canal and increasing water losses from evaporation as well as leakage.

Photo 5.1: Photo of the Schoonspruit canal illustrating build-up of algae

The condition of the weir structure can however be considered to be in good condition. The general condition of the weir was given a rating of 3 because of the vegetation growth in the weir and the sediment build up.

Although the weir was overflowing, a preliminary visual inspection indicated that the weir did not exhibit any hairline, pencil size or large cracks. Therefore the condition rating on cracks was considered to be none to a few which is a rating of 1. However the vegetation and sediment build up as illustrated in the above photo was considered to be moderate to dense with a rating of 3.

5.3.2 Condition evaluation of the siphons

There is a significant length of siphon estimated to be nearly 3 km long and passes under the Schoonspruit River to the Rietspruit. There were no air valves that were identified. Indications were that the siphon was blocked possibly due to air entrapment, which may have caused siphon breakage.

6 SCHEME OPERATIONS AND OPERATING PROCEDURES

6.1 General scheme options

An Operation Service has as its chief objective the timely delivery of the irrigation water necessary to satisfy crop water requirements. The accomplishment of this objective implies the following main activities:

(i) Planning the Operation (preparation of the so-called Irrigation Plans);
(ii) Implementation of the Plan (actual water distribution);
(iii) Monitoring of the Operation (collection of data related to water use and preparation of the corresponding reports).

The Schoonspruit Government Water Scheme is dependent on the Ventersdorp Eye as its source of supply. As a spring the supply cannot be regulated. Water is diverted into the primary canal at the Ventersdorp Eye with water abstracted at the sluices by irrigators according to their water applications provided to the scheme operators. The scheme experienced irrigation water shortages on an annual basis, during the low flow periods. This was addressed with the construction of the irrigation canals, which provides the irrigators' scheduled quota throughout the year.

Since the scheme became operational, the irrigation scheme has experienced some water restrictions but not frequently, where the scheduled quotas have not been delivered to the farmers.

The Schoonspruit Government Water Scheme is owned and operated by the Department of Water Affairs (DWA). Water is only released from the Elandskuil and Rietspruit Dams for two reasons;

(i) to meet the environmental water requirements (EWR) of the Schoonspruit River; and
(ii) to meet the irrigation water requirements as well as domestic water use, based on the weekly requested demands from users in the scheme area.

6.2 Water ordering and delivery procedures

6.2.1 Overview

In order to ensure that the irrigators receive their scheduled quota as and when required, the Schoonspruit GWS operates the irrigation scheme based on "delivery on request" where each water user (irrigator) must submit a written request on a weekly basis and the water is delivered to the abstraction points along the canal systems.

6.2.2 Operation of matching irrigation supply and demand

The procedures followed by the irrigators in ordering their water requirements are as follows:

(1) Each irrigator determines how much water they require to order for the following week from the scheme, based on their irrigation scheduling as well as their scheduled quota.

(2) The irrigators submit their requests to the Schoonspruit GWS, by the close of business on Thursday, for their total water requirements, to be delivered the following week. Irrigators must specify their needs clearly on the request form and the GWS will endeavour to supply the water, as requested.

(3) The management at the Schoonspruit GWS then reconcile the total requested volume from the beginning of the water year with each irrigator's scheduled quota to ensure the irrigator does not use more water than the quota allocated to that property. The total volume of water required in each branch canal, is then calculated to determine how much water should be supplied in each of the different sections of canal systems based on the request. This is compared with the hydraulic capacity of the canal section to ensure that the volume of water ordered does not exceed the hydraulic capacity of the canal system including the expected canal losses.

(4) The above process is repeated from the branch canals up to the main canal to determine how much water needs to be released from the Elandskuil Dam and Rietspruit Dam. This includes the total compensation losses required to deliver the requested water.

(5) The requested water, including the compensation losses, are then reconciled with the available water in the balancing dams and the volume of water required to be released from the dams. Water is then requested from Elandskuil Dam and Rietspruit Dam in time to meet the requested water for the following week. Supplementary water is transferred from the Schoonspruit canal to Elandskuil Dam to meet any shortfalls from the applications.

(6) In the event that the requested volume exceeds the maximum hydraulic capacity of the canal systems, the requested volumes will be reduced proportionally to the determined hydraulic capacity of the canal infrastructure, taking into account the estimated water losses (Maximum Abstraction Right MAR).

(7) In order to reduce the water losses, the Schoonspruit GWS also determines the minimum volume of water that can be delivered in each canal system without

significant water losses. If the requests amount to less than the minimum threshold for release, then the irrigators in that particular section will not receive their requests.

(8) The Water Control Department (WCD) of Schoonspruit GWS sets up a flow chart of levels of the sluice gates and rectangular weirs based on the water requests of the week.

(9) Based on the availability and priorities, decisions are then made to release from Elandskuil Dam and Rietspruit Dam into the different canals based on the calculated volumes for the week to be delivered continuously during the week. The cycle commences on the Monday morning and ends on the Friday evenings, when the cycle is completed.

(10) The information regarding the volume of water allocated to each user is then communicated back by the WCOs to the consumers.

The above water ordering and delivery procedures have not been formally documented. It is important that the procedures are formally documented to enable all irrigators as well as the water control officers to be aware of the procedures. This will be useful particularly for new irrigators and WCOs to understand the process.

The water is supplied through sluice gates and Rectangular weirs to the irrigators, which are adjusted according to the water level (i.e. pressure) provided by the long weirs in the canal system. The individual off-takes are installed with sluice gates and Rectangular weirs, however because of submerged flow at some sluice gates it is not possible to measure the flows at all the sluices accurately.

The stop and start nature of the operation of the canals and laterals in the sections of the Elandskuil and Rietspruit scheme areas increases the extent of evaporation as well as leakage and seepage losses due to changes in the capillary forces and gravity as well as changes in the water table.

Due to the pressure variance in the canal system the pressure sluices have been calibrated to provide 10% more water than requested. Thus if there is any problem with the constant head being less than optimal the user will still receive water as requested.

6.3 Procedures during water supply shortages

Although there have not been frequent water shortages since the construction of the two dams, there are procedures that are followed to address any water supply shortages. These include the following:

(i) At the start of the water year, the available water from Elandskuil and Rietspruit Dams that can be supplied to irrigators is reconciled with the scheduled quota. Where it is envisaged that less water is available, the allocations to irrigators are curtailed equitably.

(ii) Priority is given to supply domestic water users in the event of water shortages. This is supplemented by transfers from the Vaal River System.

(iii) The available water allocation to each irrigator is then supplied based on the delivery on request basis.

(iv) The available water is reviewed during the course of the water year depending on rainfall and any changes are then made to the annual water allocation.

6.4 Water trading - Temporary water transfers

There may be periods when existing irrigators exhaust their scheduled quota before the end of the water year and may require additional irrigation water. The current practice is as follows:

(i) Irrigators cannot make a temporary transfer to lands that do not have any water rights. This is because the canals were designed to supply the existing water entitlements and are not likely to meet the additional demand.

(ii) Irrigators can however transfer water temporarily to another land which has a water use entitlement if there are shortages. However the transfer is subject to the canal having sufficient capacity for the additional stream. Furthermore the temporary transfer can only be supplied during those periods that the canal feeding existing irrigators is not being required by other irrigators. This should however be arranged with the WCO prior to delivery.

The irrigators then approach the Schoonspruit River GWS to facilitate the temporary transfer with the Department of Water Affairs (DWA) based on whether there is sufficient hydraulic capacity in the irrigation canal system for the transfer to be delivered to the temporary user.

6.5 Water pricing structure

6.5.1 Structure of irrigation

The water rate structure of the Schoonspruit River Government Water scheme is based on a single tariff structure. The structure is an area based fixed charge which has been structured that irrigators are charge a flat rate regardless of how much water they use during the year.

Therefore water users such as canal irrigators are required to pay 100% of their R962.50 per hectare per annum regardless of whether they use the water or not.

The current water pricing structure for the Schoonspruit River Irrigation Scheme does not provide any incentives for water users to improve their efficiency. The fact that the water rate for 100% of the scheduled quota is charged at the same water rate negates any incentives. Consideration should be given to an incremental water rate system.

6.5.2 Collection of the irrigation water use charges

The Schoonspruit River GWS managers, which is the DWA Infrastructure Branch is responsible for collection of the water use charges on behalf of the Department of Water Affairs (DWA) which includes the money which it uses to pay for the operation and maintenance of the irrigation scheme. Irrigators, domestic and industrial users are also billed directly by DWA for the WRM charges.

7 BEST MANAGEMENT PRACTICES FOR WATER MANAGEMENT IN SCHOONSPRUIT GOVERNMENT WATER SCHEME

7.1 OVERVIEW

Before determining the irrigation water use efficiency of the Schoonspruit Government Water Scheme, it was important to assess the expected seepage and evaporation losses based on the premise that the irrigation scheme infrastructure is being maintained as well as taking into account the useful life of the canal system infrastructure.

This is discussed in the following sections of this chapter.

7.2 Water losses Best Management Practice

According to Howell (2001), there are four basic losses that can result when water is diverted for irrigation, as follows:

1) Part of the water is consumed in evaporation (e.g. from channels) and transpiration (e.g. vegetation growing next to the channel).
2) Some water percolates to surface or subsurface areas (e.g. canal seepage or deep percolation) and cannot be recaptured (e.g. in the vadose zone, the ocean, or a salt sink) or can be recaptured (e.g. interceptor drains into a drainage canal or a drainage well) and used as an additional supply.
3) The drainage water becomes polluted with salts or chemicals (e.g. nutrients or pesticides) that are so concentrated that the water can no longer be used and must be discharged to a sink for disposal.
4) Untimely deliveries of water that cannot be used.(In the case of this section of the scheme, any excess water is delivered to downstream canals)

Quantifying these losses is the first step in determining the efficiencies of conveyance and distribution systems and to compare with the Best Management Practices (BMP) for each of water losses.

In order to establish the generally accepted practice that results in more efficient use, conservation or management of water, the estimate of the level of acceptable water losses due to seepage, evaporation and leakage was determined as part of setting the Best Management Practices (BMP) for acceptable water losses for the Schoonspruit Government Water Scheme.

7.2.1 Unavoidable water losses

There was no data to further disaggregate the water losses into evaporation, seepage, leakage and operational spills. No direct measurements of water to determine the losses due to evaporation and seepage of the concrete lined canals are currently performed in the irrigation scheme. Therefore an estimation method has been used to assess the extent of the avoidable and unavoidable water losses at a scheme level.

The main unavoidable losses occurring within the Schoonspruit Government Water Scheme served by the canal distribution networks include the following;

7.2.2 Best Management Practice for seepage losses:

Canals continue to be the major conveyance systems for delivering water for irrigation agriculture. The seepage losses from irrigation canals constitute a substantial percentage of usable irrigation water. Therefore computation of the canal seepage losses is an important aspect of determining the best management practices for sustainable irrigation water management practices for the scheme.

Canals are often lined to reduce the seepage losses as is the case in the Schoonspruit River Irrigation Scheme. A perfect canal lining which is well maintained reduces significantly the amount of seepage although the canal lining deteriorates with time and becomes ineffective in controlling the seepage.

Seepage losses from concrete lined, and unlined canals are normally expressed in l/s per 1 000 m^2 of wetted area and appear to fluctuate between approximately 0.35 l/s per 1 000 m^2 wetted area and 1.9 l/s per 1 000 m^2 (Reid, Davidson and Kotze (1986). For design purposes Butler (1980) suggested a value of 1.9 l/s per 1 000 m^2 wetted area. Therefore depending on the wetted area, this could result in an unavoidable loss rate of up to 15% of the inflow into an irrigation canal.

The seepage losses from concrete lined canal systems depend on a number of driving factors among which the following can be said to have a marked influence:

(i) The hydraulic conductivity of the canal lining which is the concrete;

(ii) Subsurface condition in so far as they affect drainage and the groundwater table;

(iii) The age of the canal and the amount and fineness of the material carried in suspension;

(iv) The flow of water in the canal and its depth and velocity;

(v) The relation between the wetted perimeter and other hydraulic elements of the canal, particularly the discharge;

(vi) The temperature of the water.

In order to determine the seepage losses of the Schoonspruit, Elandskuil and Rietspruit canals, the geometry of the canals were collected and used to determine the wetted perimeter and flow area of each segment of the canal. The formula used to calculate the seepage losses for curvilinear canal systems (i.e. parabolic canal geometry) is expressed as follows:

$$q_s = k*y*F \quad (1)$$

where q_s = seepage discharge per unit length of canal (m_2/s); k = hydraulic conductivity of the lining (m/s); y = depth of water in the canal (m); F = function of channel geometry (dimensionless); and yF = width of seepage flow at the infinity. The seepage function, F for parabolic canals was taken as

$$F = (T/y) + Pi^{\wedge 2}/4G \quad (2)$$

Where

T =top width of the channel at the water surface (m); y= flow depth of water (m); and G = 0.915965594, known as Catalan's Constant.

The seepage loss per unit length was then calculated using the hydraulic conductivity of the concrete lining; the canal geometry and the seepage rate based on the wetted perimeter.

It has been estimated that because nearly all the canal infrastructure in the Schoonspruit River Irrigation Scheme is lined, the average BMP unavoidable seepage losses was calculated to be 0.03 $m^3/m^2/d$ for the all Schoonspruit River canals assuming the canal infrastructure was in a very good condition. This is based on calculating the seepage losses based on the geometry of the canal infrastructure, the manning's n, the flowrate of each canal assumed to be flowing at maximum capacity and the calculated wetted area.

It has been estimated that the BMP unavoidable seepage losses for the Schoonspruit Government Water Scheme would be 9% of the net inflow. This has been used in the water balance to determine the expected seepage losses.

7.2.3 Best Management Practices for evaporation losses

The evaporation loss, expressed as a percentage of total inflow was determined based on the total surface area of the irrigation canals, the mean annual evaporation (MAE) based on the A-pan evaporation figure for the 1957 - 1979 hydrological record. The total annual evaporation from the irrigation canal surface area was determined to be 1.135 million m^3/a.

This was taken as the average over the six years records. Based on the calculated evaporation losses, the evaporation losses as a percentage of the total inflows was determined to be 3%. This is much higher than the estimated evaporation losses at approximately 0.3% of total inflow volume (Reid, Davidson and Kotze; 1986).

Therefore the BMP evaporation loss in the Schoonspruit Government Water Scheme area that was used was 3% of the total inflows which was taken as the unavoidable evaporation losses for the scheme area. This amount has been taken out of the gross water losses.

8 SCHOONSPRUIT GOVERNMENT WATER SCHEME WATER BALANCE ASSESSMENT

8.1 Overview

The key aspects in developing and implementing water management plans (WMP) in the agricultural sector, is to understand:

- how much water is diverted into the irrigation scheme area;
- how much water is delivered to the various sub-schemes or sections of the irrigation scheme;
- how much water is delivered to the irrigators in the various sub-schemes, and
- how much water is returned to the river/water resource.

This approach provides the irrigation water budget to account for any inefficiency in irrigation water management in the scheme. The Schoonspruit Government Water Scheme uses the Water Administration System (WAS) to account for the water used by the scheme and the water use efficiency accounting report (WUEAR) for reporting on matching irrigation supply and demand (MISD).

The purpose of calculating the water balance and water budget is to help Schoonspruit Government Water Scheme to answer three questions:

1) Is the water being distributed equitably among the irrigators and domestic and industrial consumers in the scheme?
2) How efficiently is water being used within the scheme area?
3) Is the scheme receiving its target allocation of water from the sources of supply?

The irrigation water budget for the Schoonspruit Government Water Scheme was undertaken at two levels. The first level was to determine the overall water budget, with a view to determining the extent of water losses at an irrigation scheme level. The second level, which is discussed in this chapter was to determine the water balance for the three sections of the Schoonspruit GWS, namely the Schoonspruit, Elandskuil and Rietspruit canal systems.

8.2 Quality and integrity of the available information

8.2.1 Sources of information

It is important to note the available records from the WUEAR that were used to conduct the water budget for the three sections in the Schoonspruit Government Water Scheme are for the period 2001/2004 and for the period 2005/09. No data was available for the 2004/05 water year. Another source of information for the volume of water diverted from the Ventersdorp Eye was from the DWA, hydrological branch. This was used to compare with the inflows into the Schoonspruit Government Water Scheme.

There is a need for the information from the recent water years to be made available in order to review whether there have been any significant changes in the irrigation scheme water use efficiency. This will be used to update the current data once the information is made available for analysis.

8.2.2 Integrity of the available data and information

The data and information used to date to carry out the water budgets for the Schoonspruit Government Water Scheme was from the available WUEARs prepared by the DWA Infrastructure Branch operating the scheme. The data used to prepare the WUEARs were based on measured data of the inflows into the irrigation canal; measured data on the outlet of Elandskuil and Rietspruit Dams at the beginning of the irrigation cycle; data from the water applications and supplied at the sluices of each irrigator. All other information was estimated in the WUEAR and therefore not necessarily used.

It would however appear that not all canal tail ends are measured. This needs to be investigated. However there are some of the canal tail ends which end at the irrigators' dams and any spills may have been accounted for in the amount of water delivered to the irrigator through the sluice.

The water budget has not included the precipitation during delivery of water to irrigators. The assumption made is that the amount of precipitation during delivery of irrigation water is negligible. This may not be the case during the rainy season and consideration of incorporating information regarding precipitation should be made in future irrigation water use accounting.

There were gaps in monthly records from the WUEARs in some of the years. In order to evaluate a full year a process of patching using average monthly records for the year was conducted. This has resulted in patching some of the records to determine the total annual inflow and outflow records in some of the years.

8.3 Evaluation of the operational losses

8.3.1 Overview

The determination of operational losses (and mechanisms to minimise it) is one of the most important tools for improving irrigation water use efficiency levels. Higher accuracy in determining these losses, can underpin the efforts to decrease losses over the extent of the whole canal distribution system. Decreasing “avoidable losses” from irrigation canals is often the only “relatively” inexpensive method available when contemplating water management measures.

Avoidable losses occur as a result of inefficient management in the operation of the canal system and can mainly be attributed to poor canal maintenance (leaks), incorrect pressures and inefficient runtime release determination, inaccurate water measuring structures and other restricting factors such as algae growth, etc.

Unavoidable losses from canal systems can be attributed to seepage and evaporation and is related to the surface area of water in the canal, wetted perimeter area of the canal and to the structural condition of the canal network.

8.3.2 Determination of the water losses

An irrigation water budget was developed for the Schoonspruit Government Water Scheme. The water budget was based on information from the WUEARs, where records of inflows and water applications were provided. The records of inflows which consist of all the sources of water supply to the Schoonspruit Government Water Scheme were provided on a weekly basis. These flows were converted to monthly records.

The water demand consists of all the water that is used on the scheme. This includes delivery to the irrigators and other users as well as deliveries to downstream canals. The rest of the water not accounted for such the canal seepage, operational spills, evaporation from the canals and percolation was taken as gross water losses of the scheme or section of the irrigation scheme.

The water budget is an important tool for analysing the water management issues, provided that adequate and reliable data was available. At a scheme level, there was sufficient data to determine a water budget, based on the WUEARs.

8.4 Water Balance Assessment - Schoonspruit GWS sub-section

8.4.1 Overview

The Schoonspruit Government Water Scheme was analysed on the basis that it comprises three irrigation sub-schemes namely the Schoonspruit sub- scheme (from eye to the Rietspruit Dam); the Elandskuil sub-scheme which is supplied from Elandskuil Dam up to including the irrigators downstream on the right bank of the Schoonspruit River; and the Rietspruit sub-scheme which supplies irrigators on the left bank and lower right bank of the Schoonspruit River from the Rietspruit Dam in the Rietspruit River catchment.

Three water balances have been prepared to assess the extent and magnitude of irrigation water use efficiency in each irrigation scheme section. This is discussed in the following sections.

8.4.2 Inflows into the Schoonspruit sub-scheme

The first measurement of water takes place at the Ventersdorp Eye, where water is diverted into the main irrigation canal on the right bank of the Schoonspruit River. Weekly records of the inflows into the main canal at the dam were evaluated. The records were aggregated into monthly records. Monthly records from 2001/04 water year to 2005/09 water year, were generated as illustrated in **Figure 8.1** below.

The total average diversion at Ventersdorp Eye for the period, was determined to be 29.95 million m^3/a. The maximum diversion took place in the 2005/06 water year when the total diversion for the year was approximately 36.2 million m^3/a. The water allocation for irrigation agriculture water use is 3.9 million m^3/a. The high diversion is based on the volume of water available from the eye and the excess water discharges into Rietspruit Dam. The average volume of water delivered to downstream canals which include into Rietspruit Dam is 17.5 million m^3/a.

The lowest volume of irrigation water diversion occurred in the 2001/02 water year when 25.27 million m^3/a, was diverted from the eye into the main irrigation canal. This may have been due to drought conditions in the Middle Vaal River catchment.

No data was available on the monthly rainfall in the Schoonspruit Government Water Scheme area for the same period. Therefore the precipitation was not included as an input into the water budget.

		INFLOWS					DEMANDS						GROSS WATER LOSSES			NON BENEFICIAL WATER LOSSES			BENEFICIAL WATER LOSSES			UTILISATION
WATER YEAR	MONTH	Schoonspruit Eye	Other Supplements	Balancing Dam	Precipitation	Total inflows	Irrigation water application	Households/Stock Consumption	Industrial	Municipality	Other Canals	Total Outflows	Total water losses	% of inflow	Water Use Index	Evaporation	Seepage	Unavoidable water losses	Canal End Point	Seepage & Leakage	% avoidable water losses	% of scheduled volume
																1.3%	10%					
2000/01																						
	June					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	July					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	August					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	September					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	October	2 552.80				2 552.80	325.70	2.80	-	120.70	1 376.10	1 825.30	727.50	28.5%	1.40	31.91	255.28	287.19	-	440.31	17.2%	
	November	1 566.40				1 566.40	83.60	2.20	-	91.70	2 036.80	2 214.30	-647.90	-41.4%	0.71	19.58	156.64	176.22	-	-824.12	-52.6%	
	December					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	January					-			-			-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	February	2 013.30				2 013.30	199.80	2.20	-	116.90	1 120.80	1 439.70	573.60	28.5%	1.40	25.17	201.33	226.50	-	347.10	17.2%	
	March	2 013.30				2 013.30	110.40	2.20	-	98.90	1 228.00	1 439.50	573.80	28.5%	1.40	25.17	201.33	226.50	-	347.30	17.3%	
	April	2 013.30				2 013.30	110.40	2.20	-	98.90	1 228.00	1 439.50	573.80	28.5%	1.40	25.17	201.33	226.50	-	347.30	17.3%	
	May	2 516.60				2 516.60	20.70	2.20	-	111.30	1 665.10	1 799.30	717.30	28.5%	1.40	31.46	251.66	283.12	-	434.18	17.3%	
	Subtotal	12 675.70				12 675.70	850.60	13.80	-	638.40	8 654.80	10 157.60	2 518.10	19.9%	1.25	158.45	1 267.57		-	1 092.08	8.6%	22%
2001/02																						
	June	2 013.30				2 013.30	43.90	2.20	-	87.40	1 306.90	1 440.40	572.90	28.5%	1.40	25.17	201.33	226.50	-	346.40	17.2%	
	July	2 516.60				2 516.60	80.50	2.80	-	110.30	1 605.80	1 799.40	717.20	28.5%	1.40	31.46	251.66	283.12	-	434.08	17.2%	
	August	2 013.30				2 013.30	133.90	2.20	-	111.70	1 191.70	1 439.50	573.80	28.5%	1.40	25.17	201.33	226.50	-	347.30	17.3%	
	September	2 042.20				2 042.20	122.80	2.20	-	104.30	1 230.90	1 460.20	582.00	28.5%	1.40	25.53	204.22	229.75	-	352.25	17.2%	
	October	1 905.00				1 905.00	106.30	2.80	-	126.80	1 126.20	1 362.10	542.90	28.5%	1.40	23.81	190.50	214.31	-	328.59	17.2%	
	November	1 566.40				1 566.40	83.60	2.20	-	91.70	942.40	1 119.90	446.50	28.5%	1.40	19.58	156.64	176.22	-	270.28	17.3%	
	December	1 566.40				1 566.40	72.10	2.20	-	117.70	928.00	1 120.00	446.40	28.5%	1.40	19.58	156.64	176.22	-	270.18	17.2%	
	January	2 612.20				2 612.20	355.00	2.80	-	131.60	1 378.40	1 867.80	744.40	28.5%	1.40	32.65	261.22	293.87	-	450.53	17.2%	
	February	2 013.30				2 013.30	199.80	2.20	-	116.90	1 120.80	1 439.70	573.60	28.5%	1.40	25.17	201.33	226.50	-	347.10	17.2%	
	March	2 161.20				2 161.20	41.80	2.20	-	84.60	1 416.60	1 545.20	616.00	28.5%	1.40	27.02	216.12	243.14	-	372.87	17.3%	
	April	2 161.10				2 161.10	126.60	2.20	-	112.20	1 304.10	1 545.10	616.00	28.5%	1.40	27.01	216.11	243.12	-	372.88	17.3%	
	May	2 701.10				2 701.10	88.60	2.80	-	122.10	1 717.90	1 931.40	769.70	28.5%	1.40	33.76	270.11	303.87	-	465.83	17.2%	
Sub-total		25 272.10	-	-	-	25 272.10	1 454.90	28.80	-	1 317.30	15 269.70	18 070.70	7 201.40	28.5%	1.40	315.90	2 527.21	2 843.11	-	4 358.29	17.2%	37%
2002/03	June	1 620.70				1 620.70	10.00	2.20		77.90	1 068.80	1 158.90	461.80	28.5%	1.40	20.26	162.07	182.33	-	279.47	17.2%	
	July	2 356.00				2 356.00	199.00	2.20	-	116.90	1 068.80	1 386.90	969.10	41.1%	1.70	29.45	235.60	265.05		704.05	29.9%	
	August	2 120.00				2 120.00	263.00	2.20		120.00	1 068.80	1 454.00	666.00	31.4%	1.46	26.50	212.00	238.50		427.50	20.2%	
	September	1 896.00				1 896.00	163.00	2.20		132.40	1 068.80	1 366.40	529.60	27.9%	1.39	23.70	189.60	213.30		316.30	16.7%	
	October	2 701.10				2 701.10	263.70	2.80	-	120.70	1 544.10	1 931.30	769.80	28.5%	1.40	33.76	270.11	303.87		465.93	17.2%	
	November	2 160.90				2 160.90	263.30	2.20	-	151.50	1 128.10	1 545.10	615.80	28.5%	1.40	27.01	216.09	243.10		372.70	17.2%	
	December	2 160.90				2 160.90	95.60	2.20	-	148.00	1 299.00	1 544.80	616.10	28.5%	1.40	27.01	216.09	243.10		373.00	17.3%	
	January	2 701.10				2 701.10	397.60	2.80	-	146.30	1 384.60	1 931.30	769.80	28.5%	1.40	33.76	270.11	303.87		465.93	17.2%	
	February	2 701.10				2 701.10	397.60	2.80	-	146.30	1 384.60	1 931.30	769.80	28.5%	1.40	33.76	270.11	303.87		465.93	17.2%	
	March	2 160.90				2 160.90	351.30	2.20	-	116.30	1 075.20	1 545.00	615.90	28.5%	1.40	27.01	216.09	243.10		372.80	17.3%	
	April	2 160.90				2 160.90	150.60	2.20	-	131.60	1 260.60	1 545.00	615.90	28.5%	1.40	27.01	216.09	243.10		372.80	17.3%	
	May	2 701.10				2 701.10	135.60	2.80	-	157.80	1 635.10	1 931.30	769.80	28.5%	1.40	33.76	270.11	303.87		465.93	17.2%	
Sub-total		27 440.70	-	-	-	27 440.70	2 690.30	28.80	-	1 565.70	14 986.50	19 271.30	8 169.40	29.8%	1.42	343.01	2 744.07	3 087.08	-	5 082.32	18.5%	69%
2003/04																						
	June	2 160.90				2 160.90	62.50	2.20	-	114.20	1 366.10	1 545.00	615.90	28.5%	1.40	27.01	216.09	243.10		372.80	17.3%	
	July	2 267.50				2 267.50	96.30	2.80	-	142.80	1 379.30	1 621.20	646.30	28.5%	1.40	28.34	226.75	255.09		391.21	17.3%	
	August	2 374.20				2 374.20	90.30	2.20	-	108.10	1 506.90	1 707.50	666.70	28.1%	1.39	29.68	237.42	267.10		399.60	16.8%	
	September	2 374.20				2 374.20	197.50	2.20	-	149.10	1 348.70	1 697.50	676.70	28.5%	1.40	29.68	237.42	267.10		409.60	17.3%	
	October	2 967.70				2 967.70	182.40	2.80	-	193.60	1 743.10	2 121.90	845.80	28.5%	1.40	37.10	296.77	333.87		511.93	17.3%	
	November	2 374.20				2 374.20	54.50	2.20	-	113.40	1 527.40	1 697.50	676.70	28.5%	1.40	29.68	237.42	267.10		409.60	17.3%	
	December	2 374.20				2 374.20	312.60	2.20	-	128.90	1 253.80	1 697.50	676.70	28.5%	1.40	29.68	237.42	267.10		409.60	17.3%	
	January	2 401.60				2 401.60	139.71	2.47		124.40	1 452.53	1 719.11	682.49	28.4%	1.40	30.02	240.16	270.18		412.31	17.2%	
	February	2 374.70				2 374.70	399.10	2.20	-	111.60	1 193.60	1 706.50	668.20	28.1%	1.39	29.68	237.47	267.15		401.05	16.9%	
	March	2 374.20				2 374.20	-	2.20	-	93.30	1 602.00	1 697.50	676.70	28.5%	1.40	29.68	237.42	267.10		409.60	17.3%	
	April	2 374.20				2 374.20	1.90	2.20	-	89.00	1 604.40	1 697.50	676.70	28.5%	1.40	29.68	237.42	267.10		409.60	17.3%	
	May					-						-	-	#DIV/0!	#DIV/0!			-			#DIV/0!	
Sub-total		26 417.60	-	-	-	26 417.60	1 536.81	25.67	-	1 368.40	15 977.83	18 908.71	7 508.89	28.4%	1.40	330.22	2 641.76	2 971.98	-	4 536.91	17.2%	39%
2004/05																						
	June					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	July					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	August					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	September					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	October					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	November					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	December					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	January					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	February					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	March					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	April	2 343.30				2 343.30	30.50	2.20		94.20	1 548.50	1 675.40	667.90	28.5%	1.40	29.29	234.33	263.62		404.28	17.3%	
	May	2 596.40				2 596.40	53.30	2.20		104.00	1 696.90	1 856.40	740.00	28.5%	1.40	32.46	259.64	292.10		447.91	17.3%	
Sub-total		4 939.70	-	-	-	4 939.70	83.80	4.40	-	198.20	3 245.40	3 531.80	1 407.90	28.5%	1.40	61.75	493.97	555.72	-	852.18	17.3%	2%
2005/06																						
	June	2 888.30				2 888.30	76.70	2.20	-	99.40	1 886.70	2 065.00	823.30	28.5%	1.40	36.10	288.83	324.93		498.37	17.3%	
	July	3 610.30				3 610.30	108.10	2.80	-	130.40	2 340.00	2 581.30	1 029.00	28.5%	1.40	45.13	361.03	406.16		622.84	17.3%	
	August	3 610.30				3 610.30	246.10	2.80	-	191.90	2 140.60	2 581.40	1 028.90	28.5%	1.40	45.13	361.03	406.16		622.74	17.2%	
	September	3 610.30				3 610.30	246.10	2.80	-	191.90	2 140.60	2 581.40	1 028.90	28.5%	1.40	45.13	361.03	406.16		622.74	17.2%	
	October	2 756.50				2 756.50	332.70	2.20	-	161.70	1 474.20	1 970.80	785.70	28.5%	1.40	34.46	275.65	310.11		475.59	17.3%	

Figure 8.1: Schoonspruit GWS - Water Balance

		INFLOWS					DEMANDS						GROSS WATER LOSSES			NON BENEFICIAL WATER LOSSES			BENEFICIAL WATER LOSSES			UTILISATION
WATER YEAR	MONTH	Schoonspruit Eye	Other Supplements	Balancing Dam	Precipitation	Total inflows	Irrigation water application	Households/Stock Consumption	Industrial	Municipality	Other Canals	Total Outflows	Total water losses	% of inflow	Water Use Index	Evaporation	Seepage	Unavoidable water losses	Canal End Point	Seepage & Leakage	% avoidable water losses	% of scheduled volume
	November	3 014.00				3 014.00	167.00	2.47		137.11	1 898.48	2 205.06	808.94	26.8%	1.37	37.68	301.40	339.08		469.87	15.6%	
	December	3 085.30				3 085.30	312.60	2.80	-	147.80	1 742.70	2 205.90	879.40	28.5%	1.40	38.57	308.53	347.10		532.30	17.3%	
	January	2 203.50				2 203.50	260.20	2.20	-	108.30	1 425.00	1 795.70	407.80	18.5%	1.23	27.54	220.35	247.89		159.91	7.3%	
	February	2 659.10				2 659.10	100.90	2.20	-	123.40	1 727.90	1 954.40	704.70	26.5%	1.36	33.24	265.91	299.15		405.55	15.3%	
	March	3 323.90				3 323.90	106.80	2.80	-	130.40	2 136.60	2 376.60	947.30	28.5%	1.40	41.55	332.39	373.94		573.36	17.2%	
	April	2 659.10				2 659.10	-	2.20	-	107.60	1 791.50	1 901.30	757.80	28.5%	1.40	33.24	265.91	299.15		458.65	17.2%	
	May	2 756.50				2 756.50	51.40	2.20	-	115.40	2 077.50	2 246.50	510.00	18.5%	1.23	34.46	275.65	310.11		199.89	7.3%	
Sub-total		36 177.10	-	-	-	36 177.10	2 008.60	29.67	-	1 645.31	22 781.78	26 465.36	9 711.74	26.8%	1.37	452.21	3 617.71	4 069.92	-	5 641.82	15.6%	51%
2006/07																						
	June	3 445.70				3 445.70	181.80	2.80	-	144.60	2 134.40	2 463.60	982.10	28.5%	1.40	43.07	344.57	387.64		594.46	17.3%	
	July	2 756.50				2 756.50	123.10	1.70	-	121.90	1 448.60	1 695.30	1 061.20	38.5%	1.63	34.46	275.65	310.11		751.09	27.2%	
	August	2 756.50				2 756.50	200.10	2.20	-	122.00	1 371.00	1 695.30	1 061.20	38.5%	1.63	34.46	275.65	310.11		751.09	27.2%	
	September	3 445.70				3 445.70	451.40	2.80	-	172.30	1 148.00	1 774.50	1 671.20	48.5%	1.94	43.07	344.57	387.64		1 283.56	37.3%	
	October	2 756.50				2 756.50	362.50	2.20	-	146.20	1 459.90	1 970.80	785.70	28.5%	1.40	34.46	275.65	310.11		475.59	17.3%	
	November	2 756.50				2 756.50	110.00	2.20	-	129.90	2 013.40	2 255.50	501.00	18.2%	1.22	34.46	275.65	310.11		190.89	6.9%	
	December	2 726.50				2 726.50	444.00	2.20	-	116.60	1 386.60	1 949.40	777.10	28.5%	1.40	34.08	272.65	306.73		470.37	17.3%	
	January	3 445.70				3 445.70	622.60	2.80	-	198.50	1 777.60	2 601.50	844.20	24.5%	1.32	43.07	344.57	387.64		456.56	13.3%	
	February	2 659.10				2 659.10	100.90	2.20	-	123.40	1 674.70	1 901.20	757.90	28.5%	1.40	33.24	265.91	299.15		458.75	17.3%	
	March	2 942.90				2 942.90	266.93	2.37		145.68	1 592.08	2 007.06	935.84	31.8%	1.47	36.79	294.29	331.08		604.76	20.5%	
	April	2 499.20				2 499.20	202.40	2.20	-	137.60	1 194.70	1 536.90	962.30	38.5%	1.63	31.24	249.92	281.16		681.14	27.3%	
	May	3 124.00				3 124.00	137.40	2.80	-	189.50	1 904.00	2 233.70	890.30	28.5%	1.40	39.05	312.40	351.45		538.85	17.2%	
Sub-total		35 314.80	-	-	-	35 314.80	3 203.13	28.47	-	1 748.18	19 104.98	24 084.76	11 230.04	31.8%	1.47	441.44	3 531.48	3 972.92	-	7 257.13	20.5%	82%
2007/08																						
	June					-						-	-	#DIV/0!	#DIV/0!			-			#DIV/0!	
	July	2 499.20				2 499.20	103.20	2.20	-	135.70	1 545.80	1 786.90	712.30	28.5%	1.40	31.24	249.92	281.16		431.14	17.3%	
	August	3 124.00				3 124.00	262.00	2.80	-	191.50	2 099.70	2 556.00	568.00	18.2%	1.22	39.05	312.40	351.45		216.55	6.9%	
	September	2 499.20				2 499.20	234.60	2.20	-	166.70	1 443.30	1 846.80	652.40	26.1%	1.35	31.24	249.92	281.16		371.24	14.9%	
	October	2 499.20				2 499.20	50.80	2.20	-	126.20	1 857.70	2 036.90	462.30	18.5%	1.23	31.24	249.92	281.16		181.14	7.2%	
	November	3 124.00				3 124.00	217.20	2.80	-	175.70	2 150.30	2 546.00	578.00	18.5%	1.23	39.05	312.40	351.45		226.55	7.3%	
	December	3 415.70				3 415.70	574.80	2.80	-	144.30	1 720.20	2 442.10	973.60	28.5%	1.40	42.70	341.57	384.27		589.33	17.3%	
	January	3 124.00				3 124.00	203.60	2.80	-	224.70	1 927.50	2 358.60	765.40	24.5%	1.32	39.05	312.40	351.45		413.95	13.3%	
	February	2 171.40				2 171.40	587.30	2.20	-	169.50	793.50	1 552.50	618.90	28.5%	1.40	27.14	217.14	244.28		374.62	17.3%	
	March	2 191.40				2 191.40	329.30	2.20	-	209.30	1 245.10	1 785.90	405.50	18.5%	1.23	27.39	219.14	246.53		158.97	7.3%	
	April	2 814.80				2 814.80	106.60	2.80	-	198.20	1 423.60	1 731.20	1 083.60	38.5%	1.63	35.19	281.48	316.67		766.94	27.2%	
	May	2 251.90				2 251.90	82.20	2.20		121.90	1 403.80	1 610.10	641.80	28.5%	1.40	28.15	225.19	253.34		388.46	17.3%	
Sub-total		29 714.80	-	-	-	29 714.80	2 751.60	27.20	-	1 863.70	17 610.50	22 253.00	7 461.80	25.1%	1.34	371.44	2 971.48	3 342.92	-	4 118.89	13.9%	70%
2008/09																						
	June	2 251.90				2 251.90	37.10	2.20	-	127.20	1 443.60	1 610.10	641.80	28.5%	1.40	28.15	225.19	253.34		388.46	17.3%	
	July	2 814.80				2 814.80	244.10	2.80	-	182.40	1 583.40	2 012.70	802.10	28.5%	1.40	35.19	281.48	316.67		485.44	17.2%	
	August	2 251.90				2 251.90	226.60	2.20	-	165.60	1 440.90	1 835.30	416.60	18.5%	1.23	28.15	225.19	253.34		163.26	7.2%	
	September	2 533.15				2 533.15	278.18	2.50		173.58	1 483.78	1 938.04	595.11	23.5%	1.31	31.66	253.32	284.98		310.13	12.2%	
	October	2 814.80				2 814.80	604.90	2.80	-	219.10	1 467.20	2 294.00	520.80	18.5%	1.23	35.19	281.48	316.67		204.14	7.3%	
	November	3 124.00				3 124.00	217.20	2.80		175.70	2 150.30	2 546.00	578.00	18.5%	1.23	39.05	312.40	351.45		226.55	7.3%	
	December	3 415.70				3 415.70	574.80	2.80		144.30	1 720.20	2 442.10	973.60	28.5%	1.40	42.70	341.57	384.27		589.33	17.3%	
	January	3 124.00				3 124.00	203.60	2.80		224.70	1 927.50	2 358.60	765.40	24.5%	1.32	39.05	312.40	351.45		413.95	13.3%	
	February	2 171.40				2 171.40	587.30	2.20		169.50	793.50	1 552.50	618.90	28.5%	1.40	27.14	217.14	244.28		374.62	17.3%	
	March	2 739.20				2 739.20	411.60	2.80	-	261.70	1 558.40	2 234.50	504.70	18.4%	1.23	34.24	273.92	308.16		196.54	7.2%	
	April	3 124.00				3 124.00	119.40	2.80	-	154.90	1 800.30	2 077.40	1 046.60	33.5%	1.50	39.05	312.40	351.45		695.15	22.3%	
	May	2 499.20				2 499.20	21.80	2.20	-	136.20	1 801.60	1 961.80	537.40	21.5%	1.27	31.24	249.92	281.16		256.24	10.3%	
Sub-total		32 864.05	-	-	-	32 864.05	3 526.58	30.90	-	2 134.88	19 170.68	24 863.04	8 001.01	24.3%	1.32	410.80	3 286.41	3 697.21	-	4 303.80	13.1%	90%
2009/10																						
	June	2 251.90				2 251.90	37.10	2.20	-	127.20	1 443.00	1 609.50	642.40	28.5%	1.40	28.15	225.19	253.34		389.06	17.3%	
	July	2 516.60				2 516.60	115.40	2.80	-	145.00	1 536.30	1 799.50	717.10	28.5%	1.40	31.46	251.66	283.12		433.98	17.2%	
	August	1 897.70				1 897.70	60.70	2.20	-	121.10	1 362.60	1 546.60	351.10	18.5%	1.23	23.72	189.77	213.49		137.61	7.3%	
	September					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	October	2 372.20				2 372.20	234.40	2.80	-	219.60	1 476.60	1 933.40	438.80	18.5%	1.23	29.65	237.22	266.87		171.93	7.2%	
	November					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	December					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	January					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	February					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	March					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	April					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
	May					-						-	-	#DIV/0!	#DIV/0!	-	-	-		-	#DIV/0!	
Sub-total		9 038.40	-	-	-	9 038.40	447.60	10.00	-	612.90	5 818.50	6 889.00	2 149.40	23.8%	1.31	112.98	903.84	1 016.82	-	1 132.58	12.5%	11%
		26 376.80	-	-	-	26 376.80	1 894.00	27.76	-	1 417.13	15 411.34	18 750.24	7 626.56	29%	1.41	329.71	2 637.68	2 967.39	-	4 659.17	18%	0.49
		33 517.69	-	-	-	33 517.69	2 872.48	29.06	-	1 848.02	19 666.99	24 416.54	9 101.15	27%	1.37	418.97	3 351.77	3 770.74	-	5 330.41	16%	0.74

Figure 8.2: Schoonspruit GWS - Water Balance

Because there are no balancing dams in the Schoonspruit sub- scheme, there are no net inflows or outflows to include from balancing dams.

8.4.3 Water Demands from Schoonspruit sub- scheme

Due to the water level and hence pressure variance in the canal system, there is a margin of error in the volume of water delivered to the water user and water users are requested to accept a margin of error of 10%. The monthly data on releases at the individual sluices and Rectangular weirs were aggregated in the WUEARs to provide monthly records of water requested and used by the irrigators.

This was taken as the crop evapo-transpiration (ET). Records of monthly deliveries to other water users, namely Ventersdorp Local Municipality for domestic supply was included in the water use.

8.4.3.1 Irrigation water demands

The volume of water applied for by the irrigators in the Schoonspruit Irrigation Sub-Scheme area varies from year to year, as does the cropping pattern for each year. For the past 6 water years the irrigation water application has ranged from 1.5 million m^3/a in 2000/01 year to 3.5 million m^3/a in 2008/09. Over the past six years, the average irrigation water demands was 2.4 million m^3/a. When compared with the scheduled quota for canal irrigators this represents on average approximately 61% of the scheduled irrigation quota.

8.4.3.2 Other demands

Besides irrigation water demands, the Schoonspruit Government Water Scheme also supplies domestic water supply to Ventersdorp Local Municipality for the town of Ventersdorp and the surrounding communities.

The domestic water demand from the irrigation canal infrastructure has been growing significantly over the six year period. The raw water abstraction from the canal system in 2001/02 was 1.45 million m^3/a, with an average growth rate of 4.2% per year from 2001/02 to 2008/09.

8.4.3.3 Delivery to downstream canals

The Ventersdorp Eye cannot be regulated and therefore the irrigation canal delivers more water than the demands in the sub-section supplied by the Schoonspruit canal. The excess water is delivered to downstream irrigation canals through two main storage dams, Rietspruit and Elandskuil Dams. The average water delivered to downstream canals over the six year period was 17.7 million m^3/a.

The total average water demand from the Schoonspruit Sub- Scheme, dependent on the canal infrastructure, delivered to the water users has been 4.08 million m^3/a over the last six years from 2001/02 to 2008/09 water year. This excludes the delivery to downstream canals for use by downstream irrigators.

8.4.4 Comparison of monthly diversions with monthly demands

There is a correlation between the monthly diversions at the Ventersdorp Eye irrigation primary canal with the monthly demands as illustrated in **Figure 8.3** below. The irrigation water supplied is more than the water requested by irrigators and other water users in the scheme including delivery to downstream canals as the scheme has tried to match the irrigation supplies with the irrigation demands. The difference in matching the supply to the demand is to take into account the losses needed to deliver the water required by the irrigators.

As illustrated in **Figure 8.3** below, there is a significant difference in trying to match the irrigation supply to the irrigation water demands, as significantly more water needs to be diverted to meet the irrigated water ordered.

The six year average percentage of water losses in order to meet the irrigation demands and downstream canals was determined to be 28% of the total water diverted into the sub-scheme. The additional water can be attributed to irrigation water losses owing to seepage, leakage losses in the irrigation canals, and evaporative losses from the open irrigation canal infrastructure and spills due to aquatic weeds. The above average percentage has been benchmarked against best management practice (BMP) in order to determine the extent required to meet the BMP for irrigation operation of the Schoonspruit sub- scheme.

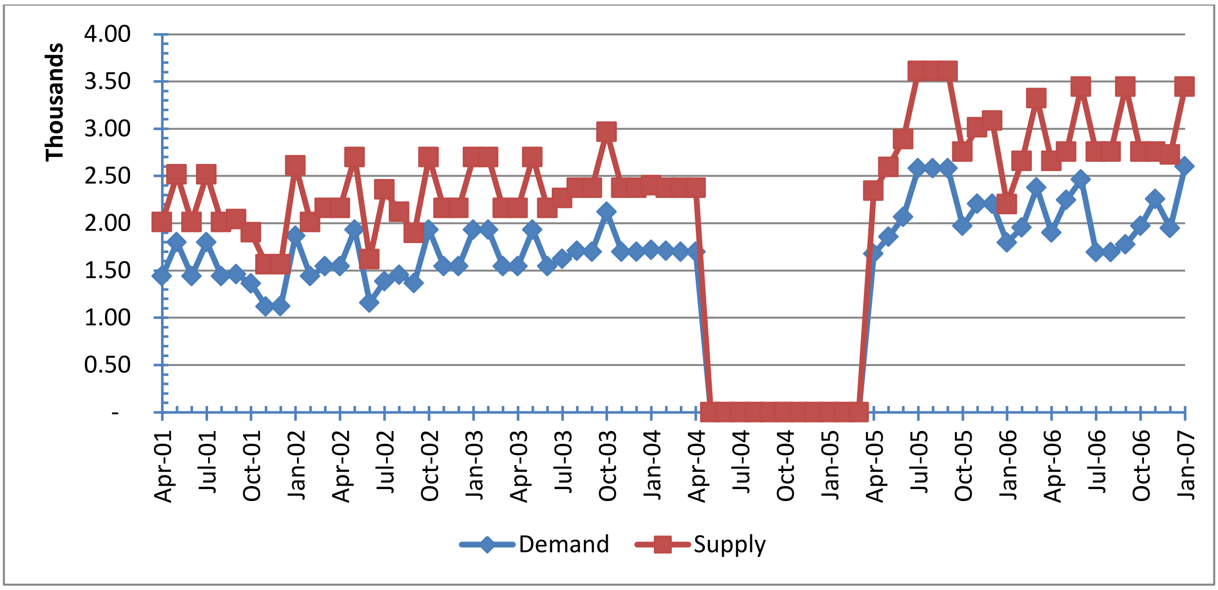

Figure 8.3: Comparison of deliveries and the demands

8.4.5 Gross Water losses - Schoonspruit Irrigation Sub-Scheme

8.4.5.1 Overview

An analysis of the percentage of inflow to the sub-scheme against water allocation indicates that since 2001/02 water year, the WCO released on average 28% more water at the Schhonspruit sub-scheme than the water applications by irrigators, downstream canal deliveries and domestic water users.

Figure 8.1 indicates that the average gross water losses including the return flow, was 28% of the total diverted flow over the period. This translates to approximately 8.4 million m^3/a of water losses in the Schoonspruit Irrigation Sub-Scheme. This amount includes both avoidable water losses and unavoidable water losses.

Figure 8.4 below provides a trend analysis of the total water losses and the estimated gross water losses. It is important to note that during the period between September/October to January/February the amount of water losses as a percentage of diverted volume is consistently higher than normal. This may be attributed to the fact that the water losses are high due to leaks as the demand for water is high during this period.

The water depth in the canal infrastructure is high and there is potential for overflows because of the aquatic weeds found in the canals. The top section of irrigation canals are more exposed to the elements and general wear and tear (small breakages, chips, etc.) than the lower section resulting in higher leakages when the canal is running close to or at full capacity.

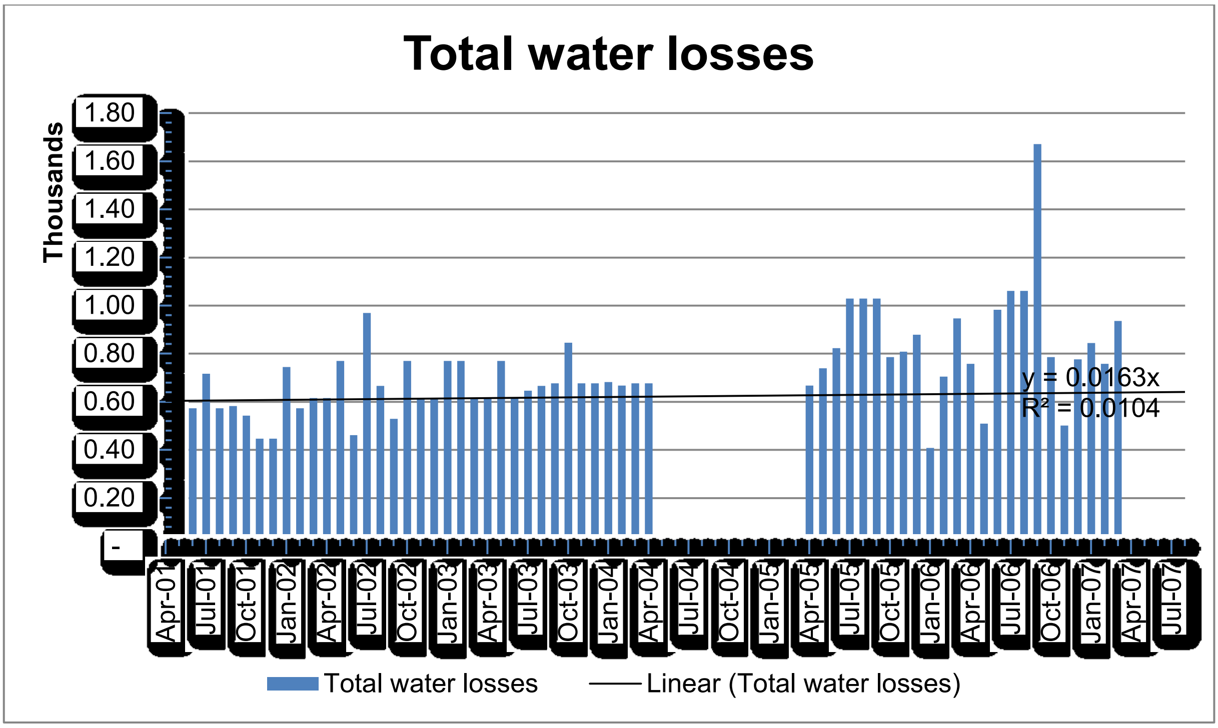

Figure 8.4: Water losses in Schoonspruit Government Water Scheme area

8.4.5.2 Analysis of water losses

Table 8.1 below provides a breakdown of the water losses for the Schoonspruit sub-scheme. As illustrated in the table, the unavoidable water losses are the expected losses based on BMP as calculated and determined in the previous chapter on the seepage and evaporation losses. These are based on the canal infrastructure; which is concrete lined and the wetted area. The wetted area has been based on the assumption that the canal is generally operated at its normal operating depth for 5 days of the week.

8.4.6 Unavoidable water losses

8.4.6.1 Seepage losses

The seepage loss from canals is governed by hydraulic conductivity of the subsoils, canal geometry, hydraulic gradient between the canal and the aquifer underneath, and initial and boundary conditions. Although a portion of the seepage losses is unavoidable due to the type of conveyance infrastructure, there is a portion of the seepage which can be avoided through the maintenance of the conveyance infrastructure.

Seepage losses which cannot be avoided are losses from small cracks due to constant movement of water through the bottom and sides of the canal system whereas leakage is due to abnormally large cracks in the canal infrastructure which can be reduced through maintenance.

Table 8:1: Summary of the water losses for Schoonspruit sub- scheme (million m^3/a)

Description	Unavoidable losses	Avoidable losses	Total losses	% of total losses
Seepages	2.115			25%
Evaporation	0.417			5%
Filling losses		5.951		70%
Leakages				
Spills				
Operational Losses				
Over delivery to users				
Canal end returns (supply Elandskuil & Rietspruit canal)				0%
Other				0%
Total	2.532	5.951	8.483	
% of total losses	30%	70%	100%	
% of total volume released into system	8%	20%	28%	

Based on the BMP for lined canal infrastructure, the seepage losses which cannot be avoided was calculated using the seepage rate of 0.6 l/s per 1000 m^2 of wetted perimeter. This provides expected seepage losses of 8% of the net inflow. This translates into 2.1 million m^3/a of the 6 year period of available records.

8.4.6.2 Evaporation losses in canals

The evaporation losses were calculated based on the pan evaporation and the surface area of the canals. This was determined to be approximately 1.3% of the system input volume. The total estimated evaporation losses for the Schoonspruit section of the scheme is 0.42 million m^3/a. This amount is considered as unavoidable water losses due to evaporation from the canal surfaces.

8.4.7 Avoidable water losses

8.4.7.1 Leaks and spills:

The determination of the volume of water that is wasted as a result of leakages is very difficult to calculate and can only really be determined through accurate measuring or undertaking tests such as ponding tests on the irrigation canals. Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal infrastructure network due to its age.

An important factor that has a marked effect on leakages is the water depth in a canal system. The top section of irrigation canals are more exposed to the elements and general wear and tear (small breakages, chips, joints between concrete panels, etc.) than the lower section resulting in higher leakages when the canal is running close to or at full capacity.

Given the high amount of algae and water grass in the canal, there are likely to be operational spills as the algae reduces the hydraulic capacity of the canal leading to potential overflows in some sections of the canal network.

In the case of the Schoonspruit Government Water Scheme, the leaks and spills have been taken as the difference between the unavoidable losses (i.e. evaporation losses and seepages), and the gross water losses.

As expected because of the age of the canal infrastructure and the condition of some sections of the canals, the leaks and spills are high at the average of approximately 5.95 million m^3/a, or 18% of the system input. Because the leakages, spills and operational losses cannot be disaggregated, the extent of leakages and therefore the extent of maintenance cannot be established.

8.4.7.2 Aquatic weeds and algae

Aquatic weed and algae growth in irrigation canal systems is fast becoming one of the major operational problems in scheme management, especially on those schemes where water is becoming progressively eutrophic. Du Plessis and Davidson (1996) list the following impacts of excessive aquatic weed growth on irrigation canal systems:

(i) A negative influence on hydraulic capacity and flow speeds in the canals. This decrease in canal capacity occurs particularly when the water demand is at its highest.
(ii) Overestimation of the amount of water supplied, because of the artificially increased water levels that are measured at calibrated weirs.
(iii) Water loss because of the flooding of canals.
(iv) Impediment of floodgate and sluices at dividing structures.
(v) Water logging of long-weirs.
(vi) Structure (slab) failure of concrete-lined irrigation canals due to flooding.
(vii) Aquatic weed fragments block irrigation systems and filters at water purification plants.
(viii) The mechanical removal of the biomass is extremely labour intensive, expensive and mostly ineffective.

It is likely that the high water losses can be attributed to algae growth in the irrigation canals which is reducing the hydraulic capacity of the canal system and therefore more water is required to meet the applications.

8.4.7.3 Operational losses and canal end returns:

Apart from the two losses described above, there are also other losses on the canal system which can be classified as operational losses due to the way the scheme is operated. Such losses include start-up and shut-down losses, operational wastage due to the lack of quick response to changes in demand, water not used (outflows) due to unexpected drops in demand and losses due to incorrect metering. These losses are estimated to fluctuate between 9% and 17% of the irrigation water losses (Reid, Davidson and Kotze, 1986).

For the Schoonspruit sub- scheme, the canal tail ends deliver water to either Elandskuil or Rietspruit Dams. This is considered a demand as water is used by downstream irrigators in the Schoonspruit GWS. However, there are no flow measurements available at the deliveries to the two dams. The figures are estimates which have been included in the water balance assessment as demands.

8.4.7.4 Total avoidable water losses - Schoonspruit sub- scheme

The estimated avoidable water losses for the six year period from 2001/02 to 2008/09 water years have averaged approximately 5.95 million m^3/a (see **Table 8.1** above). The high avoidable water losses can be attributed to the following management issues:

(i) The excessive growth of nuisance aquatic vegetation (algae and aquatic macrophytes) causes extensive operational problems in irrigation canals, and plays a significant role in increased water loss and wastage.

(ii) The condition of the canal infrastructure and lack of sufficient dry periods to carry out the required maintenance of the irrigation canals.

(iii) The lack of sufficient flow measurement to determine the deliveries to other canal systems which is resulting in estimating the deliveries to downstream canal systems which may affect the calculation of the avoidable water losses.

8.5 Water balance assessment - Rietspruit sub-scheme

8.5.1 Inflows into Rietspruit Irrigation Scheme

The first measurement of water takes place at the Rietspruit Dam, where water is released from the dam into the main irrigation canal on the left bank of the Rietspruit River. Monthly records of the inflows into the main canal at the dam were evaluated. The records were aggregated into monthly records. Monthly records from 2001/02 water year to 2008/09 water year were generated as summarised in **Table 8.2** below.

The total average flow released from the Rietspruit Dam for the period was determined to be 6.13 million m^3/a.

8.5.2 Precipitation

No data was available on the monthly rainfall in the Rietspruit Irrigation Sub-Scheme area for the same period. Therefore the precipitation was not included as an input into the water budget.

8.5.3 Demands

The supply to individual water users is measured through rectangular weirs.

8.5.3.1 Irrigation water demands

The volume of water that is requested by the irrigators in the Rietspruit Irrigation Scheme area varies from year to year, as does the cropping pattern for each year. For the past 6 water years excluding 2004/05, the irrigation water application has ranged from

3.6 million m^3/a in 2001/02 year to 5.4 million m^3/a in 2005/06. The average irrigation water demands was 4.58 million m^3/a. When compared with the scheduled quota for canal irrigators this represents on average approximately 47% of the scheduled area. It would appear irrigation agriculture downstream of Rietspruit Dam has been very low compared to the scheduled area.

8.5.3.2 Other demands

There are no other demands supplied from the Rietspruit Irrigation canal system.

Table 8:2: Water Balance assessment summary - Rietspruit Irrigation Sub-Scheme

User	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	6 year (2001-2004 & 2005-2008) average
Irrigation	3.57	4.09	5.04	Nd	5.37	4.46	4.93	4.58
Household	0.01	0.01	0.01	Nd	0.01	0.01	0.01	0.01
Downstream Canals	-	-	-	Nd	-	-	-	-
Municipal use	-	-	-	Nd	-	-	-	-
Total demands	3.58	4.10	5.05	Nd	5.38	4.48	4.94	4.59
Inflow into Rietspruit canal	4.71	5.41	6.79	Nd	7.15	5.93	6.82	6.13
Water Losses	1.13	1.31	1.74	-	1.77	1.45	1.88	1.55
Water losses as % inflow	24%	24%	26%	-	25%	24%	28%	25%

8.5.4 Comparison of monthly diversions with monthly demands

There is a correlation between the monthly diversions at the Rietspruit Dam into the Rietspruit irrigation primary canal with the monthly demands as illustrated in **Figure 8.5** below. The irrigation water supplied is more than the water used by irrigators and other water users in the scheme as the scheme has tried to match the irrigation supplies with the irrigation demands. The difference in matching was to take into account the losses needed to deliver the water required by the irrigators. It is also interesting to note that as the demand increases the amount of water to be diverted is much more. This may be due to algae growth and spills as a consequence.

As illustrated in **Figure 8.6** below, there is a difference in trying to match the irrigation supply to the irrigation water demands, as significantly more water needs to be diverted to meet the irrigated water ordered.

The six year average percentage of additional water required to meet the irrigation demands was determined to be 27% of the total water diverted.

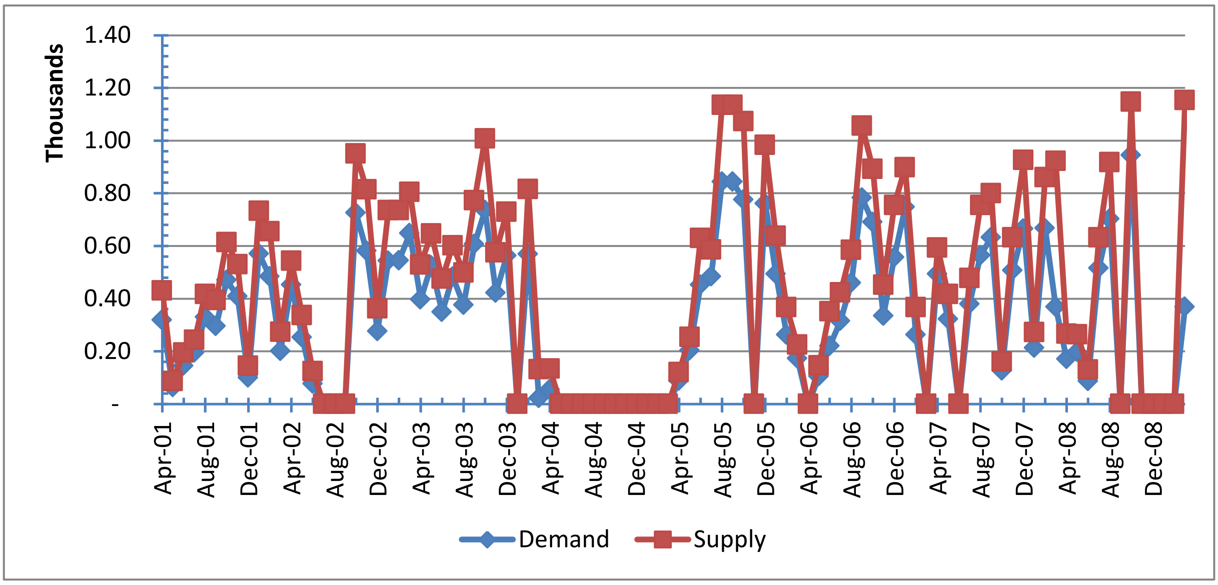

Figure 8.5: Comparison of deliveries and the demands - Rietspruit canal system

8.5.5 Gross Water losses

An analysis of the percentage of inflow indicates that since 2001/02, the WCOs release on average 25% more water than the demands from the Rietspruit Dam which amounts to 1.55 million m^3/a additional water to account for evaporation, seepage, leakage and operational losses.

Figure 8.6 below provides a trend analysis of the total water losses and the estimated gross water losses. It is important to note that during the September/December period the amount of water losses as a percentage of diverted volume is consistently higher than normal. This may be attributed to the fact that there are leaks due to the water depth in the canal infrastructure as more water is used in the scheme.

The high water depth due to the high demand during this period results in higher leakages when the canal is running close to or at full capacity. This is because the top section of the irrigation canals is more exposed to the elements and general wear and tear (small breakages, chips, etc.) than the lower section.

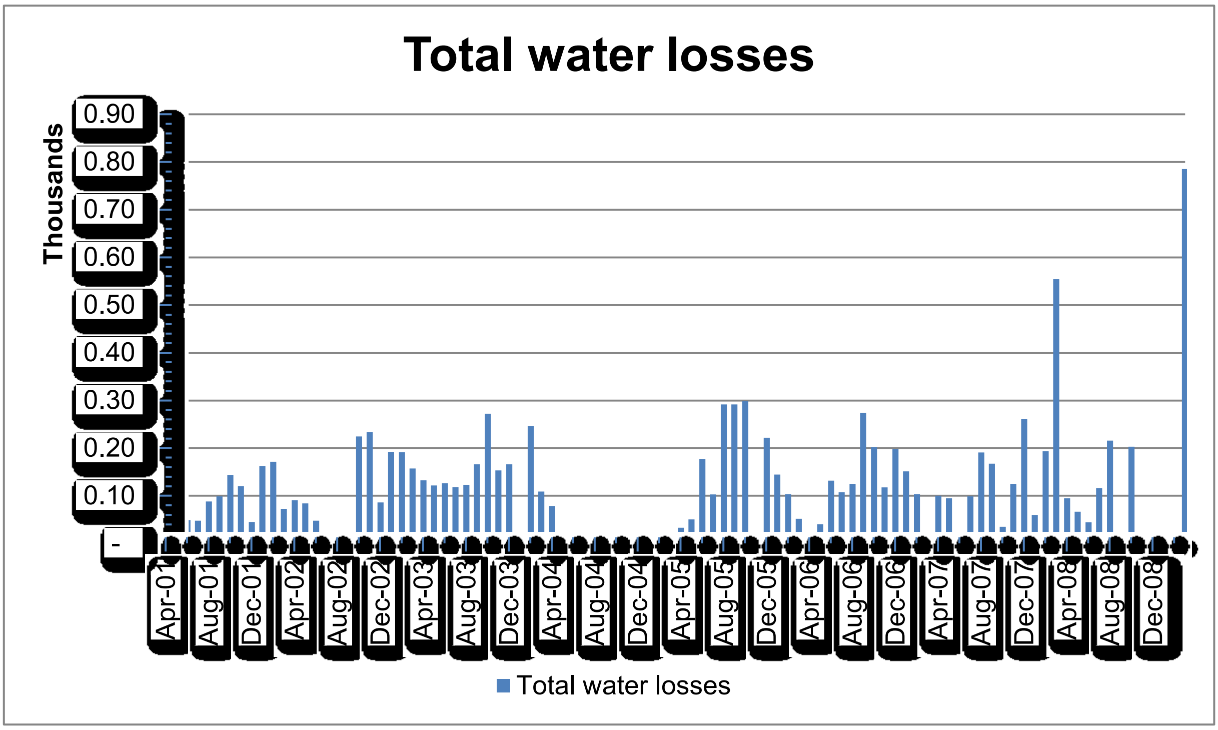

Figure 8.6: Water losses in Rietspruit Irrigation Scheme

8.5.6 Unavoidable water losses

No direct measurements of water, to determine the losses due to evaporation and seepage of the concrete lined canals are currently performed in the system. These are derived information, as discussed below. Measurement of operational spills at the canal end returns is also not being performed in the system because of lack of flow measurements. Therefore an estimation method has been used to assess the extent of the avoidable and unavoidable water losses at a scheme level.

The main unavoidable losses occurring within the Rietspruit Irrigation Sub-Scheme served by the canal distribution networks include the following:

8.5.6.1 Best Management Practice for seepage losses:

The expected seepage losses based on best management practices (BMP) was determined based on *inter alia*, soil characteristics, water depth in the canal, concrete lining, flow speed, soil capillary tension, amount of sediment, etc.

It has been estimated that because nearly all the canal infrastructure in the Rietspruit Irrigation Sub-Scheme is lined, the BMP unavoidable seepage losses would be 4% of the net inflow. This equates to approximately 0.25 million m^3/a.

8.5.6.2 Best Management Practices for evaporation losses

The evaporation loss, expressed as a percentage of total inflow was determined based on the total surface area of the irrigation canals, the mean annual evaporation (MAE) based on the A-pan evaporation figure for the 1957 - 1979 hydrological record. The total annual evaporation from the irrigation canal surface area was determined to be 0.04 million m^3/a. This was taken as the average over the six years records. Based on the calculated evaporation losses, the evaporation losses as a percentage of the total inflows was determined to be 0.6%. This is much less with the estimated evaporation losses at approximately 3% of total inflow volume (Reid, Davidson and Kotze; 1986).

Therefore the BMP evaporation loss in the Rietspruit Irrigation Sub-Scheme area that was used was 0.6% of the total inflows which was taken as the unavoidable evaporation losses for the scheme area. This amount has been taken out of the gross water losses.

8.5.6.3 Total Unavoidable water losses

Based on the above Best Management Practice (BMP) for evaporation losses, and expected seepage losses from lined canal infrastructure, the estimated seepage losses for the Rietspruit irrigation scheme is 5% of the net inflow while the total unavoidable water losses for the Rietspruit Sub-Scheme were determined to be 0.3 million m^3/a as illustrated in **Table 8.3** below.

8.5.6.4 Conveyance efficiency at BMP

The calculated unavoidable water losses of 0.3 million m^3/a or 5% of the net inflow into the scheme is considered as the expected conveyance efficiency level if the canal infrastructure is well maintained and there are no operational spills. This also takes into account that the canal tail end water back to the Schoonspruit River is considered a loss.

This should be considered the expected water losses for the Rietspruit irrigation sub-scheme when the BMP are taken into account and should be the additional water required to match water supplies for the scheme with the irrigation water demands.

Table 8:3: Summary of the water losses for Rietspruit Irrigation Sub-Scheme

Description	**Unavoidable losses**	**Avoidable losses**	**Total losses**	**% of total losses**
	(m^3*10^6)	**(m^3*10^6)**	**(m^3*10^6)**	
Seepages	0.245	-		3%
Evaporation	0.037			0%
Filling losses				0%
Leakages		0.344		4%
Spills				0%
Operational Losses				0%
Over delivery to users				0%
Canal end returns		0.92		11%
Other				0%
Total	**0.282**	**1.264**	**1.546**	
% of total losses	**18%**	**82%**	**100%**	
% of total volume released into system	**5%**	**21%**	**25%**	

8.5.7 Avoidable water losses

8.5.7.1 Leaks and Spills

As expected because of the age of the canal infrastructure and the condition of some sections of the canals, the leaks and spills are high at the average of approximately 0.34 million m^3/a.

8.5.7.2 Operational losses and canal end returns:

Apart from the two losses described above, there are also other losses on the canal system which can be classified as operational losses due to the way the scheme is operated. Such losses include start-up and shut-down losses, operational wastage due to the lack of quick response to changes in demand, water not used (outflows) due to unexpected drops in demand and losses due to incorrect metering.

At present there are no measurements being taken from the canal tail ends. These are based on inaccurate measurements and estimates. The average spills at canal end points was estimated at approximately 0.9 million m^3/a. It represents that more water is being released into the canal system than is required which could have been left in the Rietspruit Dam. This would have improved the yield of the system to help meet demands during low flow periods. On the Rietspruit Scheme where the scheme is manually operated these losses are likely to be high as the time to react to any changes in demands are likely to take longer.

8.5.7.3 Total avoidable water losses - Rietspruit irrigation scheme

The estimated avoidable water losses from 2001/02 to 2008/09 water years have averaged approximately 1.26 million m^3/a (see **Table 8.3** above). The largest component of the avoidable water losses in the Rietspruit Irrigation is due to the operational losses at the canal tail ends. These can be reduced by changing the current operational policy which allows for flows at canal tail end estimated at an average of 0.9 million m^3/a. This is 15% of the total system inflow.

8.6 Water balance assessment - Elandskuil irrigation sub-scheme

8.6.1 Inflows into Elandskuil Irrigation Sub-Scheme

The first measurement of water takes place at the Elandskuil Dam, where water is released from the dam into the main irrigation canal on the left bank of the Elandskuil River. Monthly records of the inflows into the main canal at the dam were evaluated. The records were aggregated into monthly records. Monthly records from 2001/02 water year to 2008/09 water year were generated as summarised in **Table 8.4** below.

The total average water released from the Elandskuil Dam for the period, was determined to be 4.04 million m^3/a.

8.6.2 Precipitation

No data was available on the monthly rainfall in the Elandskuil Irrigation Sub-Scheme area for the same period. Therefore the precipitation was not included as an input into the water budget.

8.6.3 Demands

The supply to individual water users is measured through rectangular weirs.

8.6.3.1 Irrigation water demands

The volume of water that is requested by the irrigators in the Elandskuil Irrigation Scheme area varies from year to year, as does the cropping pattern for each year. For the past 6 water years excluding 2004/05, the irrigation water application has ranged from 1.79 million m^3/a in 2001/02 year to 2.84 million m^3/a in 2006/07. The average irrigation water demands was 2.27 million m^3/a. When compared with the scheduled quota for canal irrigators this represents on average approximately 45% of the scheduled area. It would appear irrigation agriculture downstream of Elandskuil Dam has been very low compared to the scheduled area.

8.6.3.2 Other demands

There are no other demands supplied from the Elandskuil Irrigation canal system, except for minimum supply for household use.

Table 8:4: Water Balance assessment summary - Elandskuil Irrigation Sub-Scheme

User	2001/02	2002/03	2003/04	2005/06	2006/07	2007/08	6 year average
Irrigation	1.79	2.47	1.92	2.14	2.84	2.45	2.27
Household	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Johann Nasser Dam	-	-	-	0.09	-	-	0.01
Municipal use	-	-	-	-	-	-	-
Total Demands	1.80	2.48	1.93	2.24	2.85	2.47	2.30
Total released into sub-scheme	2.33	2.97	4.14	4.67	4.68	5.43	4.04
Water Losses	0.53	0.49	2.20	2.44	1.83	2.97	1.74
Loss as a % of inflow into Sub-Scheme	23%	16%	53%	52%	39%	55%	40%

8.6.4 Comparison of monthly releases with monthly demands

There is a correlation between the monthly releases from the Elandskuil Dam into the Elandskuil irrigation primary canal with the monthly demands as illustrated in **Figure 8.7** below. The irrigation water supplied is more than the water used by irrigators and other water users in the scheme as the scheme has tried to match the irrigation supplies with the irrigation demands. The difference in matching was to take into account the losses needed to deliver the water required by the irrigators. It is also interesting to note that as the demand increases the amount of water to be diverted is much more as a result of the algae growth with spills as a consequence.

The six year average percentage of additional water required to meet the irrigation demands was determined to be 40% of the total inflow into the sub-scheme.

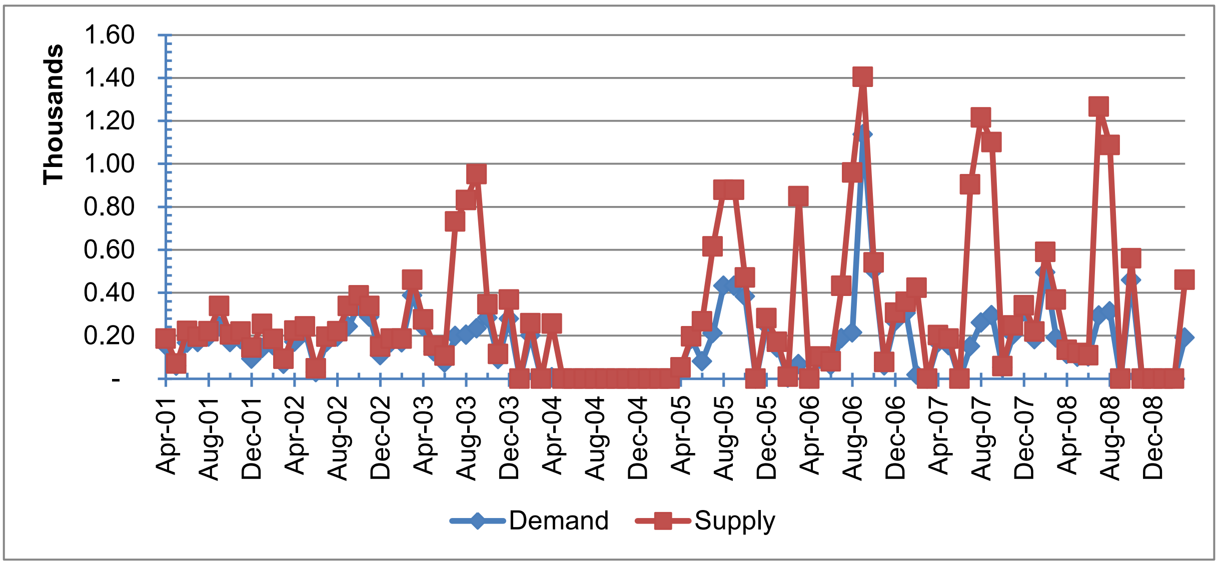

Figure 8.7: Comparison of deliveries and the demands - Elandskuil canal system

8.6.5 Gross Water losses

An analysis of the percentage of inflow indicates that since 2001/02, the WCOs released on average 40% more water than the demands from the Elandskuil Dam which amounts to 1.74 million m^3/a additional water to account for evaporation, seepage, leakage and operational losses.

Figure 8.8 below provides a trend analysis of the total water losses and the estimated gross water losses. It is important to note that the water supplies of Elandskuil Dam are supplemented from the Ventersdorp Eye through a pipeline connecting the Schoonspruit canal to the dam. The additional water is provided mainly between July and October each year. The spills at the canal tail ends during this period are very high indicating that more water is diverted than is demanded by irrigators.

Because of the high water depth due to the high demand during this period, there are higher leakages experienced.

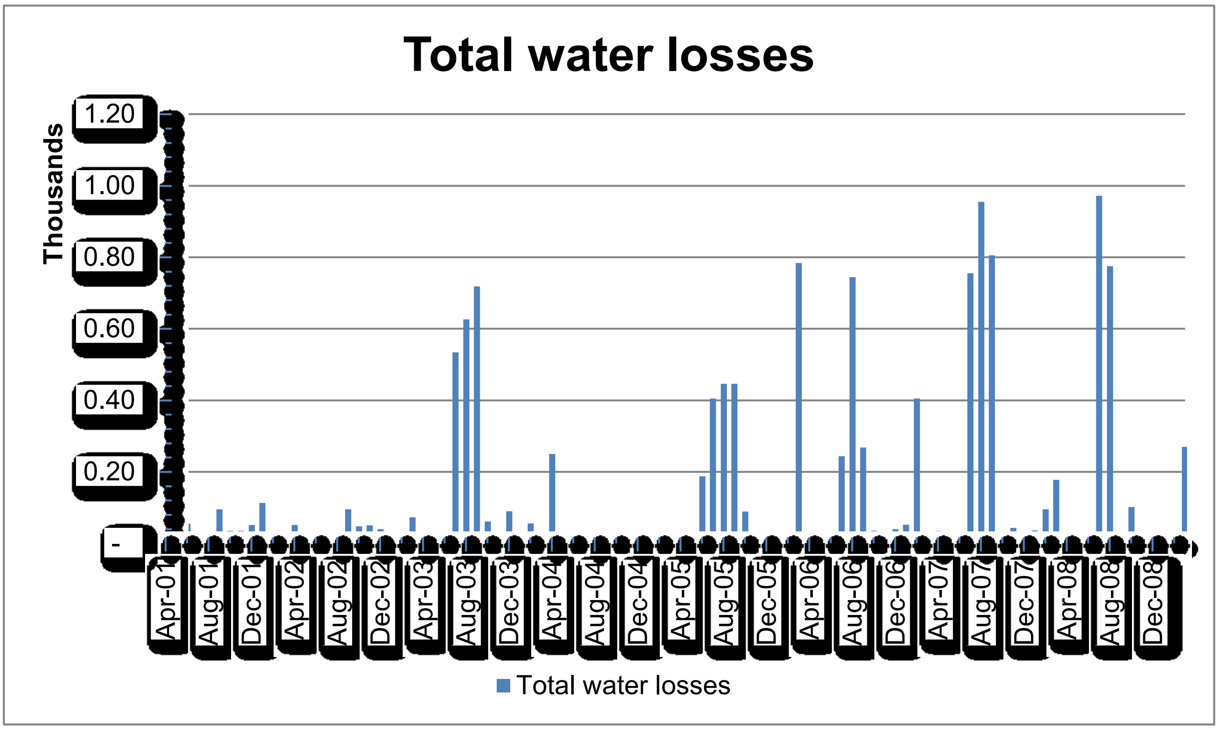

Figure 8.8: Water losses in Elandskuil Irrigation Sub-Scheme

8.6.6 Unavoidable water losses

No direct measurements of water, to determine the losses due to evaporation and seepage of the concrete lined canals are currently performed in the system. These are derived information, as discussed below. Measurement of operational spills at the canal end returns is also not being performed in the system because of lack of flow measurements. Therefore an estimation method has been used to assess the extent of the avoidable and unavoidable water losses at a scheme level.

The main operational losses occurring within Elandskuil Irrigation Sub-Scheme served by canal distribution networks include the following;

8.6.6.1 Best Management Practice for seepage losses:

The expected seepage losses based on best management practices (BMP) was determined based on *inter alia*, soil characteristics, water depth in the canal, concrete lining, flow speed, soil capillary tension, amount of sediment, etc

It has been estimated that because nearly all the canal infrastructure in the Schoonspruit Irrigation Sub-Scheme is lined, the BMP unavoidable seepage losses would be 4% of the net inflow. This equates to approximately 0.20 million m^3/a.

8.6.6.2 Best Management Practices for evaporation losses

The evaporation loss, expressed as a percentage of total inflow was determined based on the total surface area of the irrigation canals, the mean annual evaporation (MAE) based on the A-pan evaporation figure for the 1957 - 1979 hydrological record. The total annual evaporation from the irrigation canal surface area was determined to be 0.01 million m^3/a. This was taken as the average over the six years records. Based on the calculated evaporation losses, the evaporation losses as a percentage of the total inflows was determined to be 0.2%. This is much less that the estimated evaporation losses at approximately 0.3% of total inflow volume (Reid, Davidson and Kotze; 1986).

Therefore the BMP evaporation loss in the Elandskuil Irrigation Sub-Scheme area that was used was 0.2% of the total inflows which was taken as the unavoidable evaporation losses for the scheme area. This amount has been taken out of the gross water losses.

8.6.6.3 Total Unavoidable water losses

Based on the above Best Management Practice (BMP) for evaporation losses, and expected seepage losses from lined canal infrastructure, the estimated seepage losses for the Elandskuil irrigation scheme is 5% of the net inflow while the total unavoidable water losses for this part of the Schoonspruit Government Water Scheme were determined to be 0.21 million m^3/a as illustrated in **Table 8.5** below.

Table 8:5: Summary of the water losses for Elandskuil Irrigation Sub-Scheme

Description	Unavoidable losses (m^3*10^6)	Avoidable losses (m^3*10^6)	Total losses (m^3*10^6)	% of total losses
Seepages	0.200			12%
Evaporation	0.01			1%
Filling losses		0.216		13%
Leakages				
Spills				
Operational Losses				
Over delivery to users				
Canal end returns		1.276		75%
Other				0%
Total	**0.210**	**1.492**	**1.701**	
% of total losses	**12%**	**88%**	**100%**	
% of total volume released into system	**5%**	**37%**	**42%**	

8.6.6.4 Conveyance efficiency at BMP

The calculated unavoidable water losses of 0.21 million m^3/a or 5% of the net inflow into the scheme is considered as the expected conveyance efficiency level if the canal infrastructure is well maintained and there are no operational spills. This also takes into account that the canal tail end water back to the Schoonspruit River is considered a loss.

The above expected water losses should be considered the BMP water use efficiency for the Elandskuil irrigation sub-scheme. This should therefore be the additional water required to match water supplies for the scheme with the irrigation water demands.

8.6.7 Avoidable water losses

8.6.7.1 Leaks and Spills

As expected because of the age of the canal infrastructure and the condition of some sections of the canals, the leaks and spills are high at the average of approximately 0.22 million m^3/a.

8.6.7.2 Operational losses and canal end returns:

Apart from the two losses described above, there are also other losses on the canal system which can be classified as operational losses due to the way the scheme is operated. Such losses include start-up and shut-down losses, operational wastage due to the lack of quick response to changes in demand, water not used (outflows) due to unexpected drops in demand and losses due to incorrect metering.

At present there are no measurements being taken from the canal tail ends. These are based on estimates. The average spills at canal end points was estimated at approximately 1.3 million m^3/a. It represents that more water is being diverted into the canal system than is required which could have been left in the Elandskuil Dam. This would have improved the yield of the system to help meet demands during low flow periods. On the Elandskuil Scheme where the scheme is manually operated these losses are likely to be high as the time to react to any changes in demands are likely to take longer.

8.6.7.3 Total avoidable water losses - Elandskuil irrigation scheme

The estimated avoidable water losses from 2001/02 to 2008/09 water years have averaged approximately 1.5 million m^3/a (see **Table 8.5** above). The largest component of the avoidable water losses in the Elandskuil Irrigation is due to the operational losses at the canal tail ends. These can be reduced by changing the current operational policy which allows for flows at canal tail end estimated at an average of 1.3 million m^3/a. This is 33% of the total system inflow.

8.7 Schoonspruit Government Water Scheme - water losses

Table 8.6 below provides the total water losses of the whole Schoonspruit Government Water Scheme. As illustrated in the table the total average water losses for the six year period of records (excluding 2004/05 water year) were 11.8 million m^3/a out of a total inflow into the irrigation canals of 40.4 million m^3/a. This indicates the percentage water losses of 29% of the system input volumes. However this figure is based on a number of inaccurate measurements and estimation of flows at the canal tail ends. The confidence limit put on this figures is 60% CI.

Table 8:6: Scheme wide water losses for Schoonspruit Government Water Scheme

Description	Unavoidable losses	BMP for operation & distribution	Avoidable losses	Total losses	% of total losses
Seepages	2.56			2.56	22%
Evaporation	0.46			0.46	4%
Filling losses		4.06	4.69	8.75	74%
Leakages					
Spills					
Operational Losses					
Over delivery to users					
Canal end returns					
Other					
Total	3.03	4.06	4.69	11.78	
% of total losses	26%	34%	40%	100%	
% of total volume released into system	7%	10%	12%	29%	

Based on the above table the BMP expected water losses should be 7% of the volume of water diverted into the canal systems. This component is considered as unavoidable water losses as very little can be done (at a very high cost) to reduce the evaporation losses as well as seepage losses of the canal systems.

The largest component of the water losses is the avoidable water loss which is due to the operational losses including leakages and spills. These can be managed by improved maintenance of the canal system and removal of aquatic weeds which affects the hydraulic capacity of the canal system. The other component of the avoidable water loss component is return flows at canal tail ends which can be minimised by responding quickly to changes in demands and proper estimation of the unavoidable water losses.

9 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

9.1 Overview

Chapter 8 indicated that the water losses in the Schoonspruit Government Water Scheme for the three sub-schemes are all generally higher than the expected BMP water losses due to seepage and evaporation. This illustrates that there is a need to implement water management measures to improve the water use efficiency of the scheme. However there are existing water management measures and programmes in place which the scheme operators are conducting as part of efficient and effective irrigation water management of the Schoonspruit Government Water Scheme.

The Schoonspruit Irrigation GWS has been implementing measures to improve the management of delivery to the irrigators. These have included the following:

(i) Water order and request measures which ensures that only the water applied for is supplied;

(ii) Flow measurement and preparation of WUEARs which provides an indication of the extent of water losses and scheme irrigation water use efficiency levels;

(iii) Carrying out maintenance of the canal system during dry periods to reduce avoidable canal losses.

These existing water management measures are discussed in more detail below.

9.2 Existing Water Management Measures

9.2.1 Flow measurements

The Schoonspruit GWS has installed flow measurements at all the farm turnouts in order to measure the water delivered to each irrigator in the scheme. The availability of sluices at each farm turnout ensures that each irrigator can only get the scheduled allocation they are entitled to.

There are also flow measurement, namely Rectangular weirs at some of the critical diversion points to measure how much water is diverted at different points of the irrigation scheme. There are flow measurements at the Ventersdorp Eye which provides the flow rate and volume of water released into the Schoonspruit canal and flow measurements at the canals at Elandskuil and Rietspruit Dams which provides information on the volume of water released into these canals.

The existing flow measurement can provide the overall gross water losses of the three sub-schemes of the Schoonspruit Government Water Scheme. However this cannot provide the operational losses at canal tail ends as there are no flow measurements. If there are, then the flow measurements are not being read and included in the WUEARs.

9.2.2 Water ordering policy

The Schoonspruit Government Water Scheme has a water ordering policy which enables only the amount of water applied for plus the estimated water losses to be diverted into the main irrigation canals. The irrigators and other users apply for their water needs for the following week to allow the scheme operators to plan how much water must be released to meet these demands.

9.2.3 Water Shortage Contingency Plan

The Schoonspruit Government Water Scheme has a water contingency plan. The basic objectives of the plan:

(i) Hydrologic forecasting to predict water supply;
(ii) Definition of water allocation procedures to be used during drought periods;
(iii) Identification of alternative or supplemental water supplies.

At the beginning of each water year, information on hydrologic forecasting to predict water availability is provided to water users that will help them decide which crops to irrigate and how many hectares to farm. For example, given a forecast, farmers can choose to irrigate less land or grow crops that require less water.

Defining the water allocation and curtailments to farmers before the drought conditions begin provides irrigators with fairly certain information as to what they can expect in terms of water deliveries and will allow them to plan accordingly.

9.2.4 Flexibility in the Balancing Dam

One of the ways the Schoonspruit Government Water Scheme uses to manage and match the supply to the delivery is the use of the Rietspruit and Elandskuil Dams as "balancing dams", although they are not strictly balancing dams per se.

Rietspruit and Elandskuil Dams play an important role in helping the WCO match water deliveries to irrigation water requirements by reducing the time of delivery to downstream irrigators. Together with the farm dams that are in the scheme the reservoirs allow farmers to use their allocations at their convenience, both in terms of time of irrigation and the amount of water used. In addition to increasing water delivery flexibility, the storage reservoirs are used to:

(i) Reduce overall system spills as well as capture spills from upstream users as well as the Ventersdorp Eye which is difficult to regulate, for the benefit of the irrigation scheme;
(ii) Capture storm water runoff from the tributaries where these dams are located which provides an additional source of supply.

Although the Schoonspruit Government Water Scheme also has the ability to check or shut down canals and branch canals to avoid spills, this can only be done after 12 hours because the system is not automated, unless cancellation of water orders are conducted timeously. The loss is taken to the account of the farmer who requested the water, although it will be a loss to the scheme.

9.2.5 Operation and maintenance of the canal infrastructure

9.2.5.1 Maintenance of the canal system

The ownership of the canal infrastructure at the Schoonspruit Government Water Scheme is with the DWA Infrastructure Branch which is also responsible for the operation and maintenance of the canal infrastructure.

During dry periods, significant maintenance is carried out on the primary canal and secondary canals. The availability of Elandskuil and Rietspruit dams provides the flexibility during the dry period to provide some of the irrigators from the dams. It also reduces the amount of water required for filling.

9.2.5.2 Penalties for not taking up the requested water

According to the scheme operating rules, when an irrigator orders a certain volume of water and he/she does not take up their full water application, the scheme operators impose a penalty by deducting the volume of water applied for from the scheduled quota of the irrigator. The irrigators must provide changes to their irrigation water application by a certain timeframe to enable the scheme operators to adjust the supplies to the scheme.

This procedure provides incentives for irrigators to schedule their irrigation water requirements and minimise the scheme water losses.

9.3 Impact existing water management measures

The existing water management measures described have helped reduce water losses in the Schoonspruit Government Water Scheme. However, the findings of the water balance assessment indicate that the water losses in the GWS are still very high. There is still significant potential to improve irrigation water use efficiency in the Schoonspruit Government Water Scheme if specific water loss control and operational measures are put in place.

The water management issues contributing to the high water losses and the management to address these issues with a view to improving irrigation water management in the Schoonspruit Government Water Scheme are discussed in detailed in the following chapter.

10 WATER MANAGEMENT ISSUES AND GOALS

10.1 Overview the management issues

The water budget analysis discussed in the previous chapter together with discussions held with Schoonspruit GWS, has helped to identify several key water management issues. First there are substantial losses taking place in the Schoonspruit Government Water Scheme, as illustrated by the water budget. There is insufficient data to clearly determine where and how losses are occurring. Currently there are no records as to how much water spills due to operational issues at the tail water discharges or due to over-irrigation.

The water budget analysis did reveal, however, that on an annual basis, there is sufficient water to meet the Schoonspruit Government Water Scheme's irrigation demands. It also highlighted that irrigators are currently not utilising their full water allocation.

In addition to the water budget analysis, some limited discussions were held with the management and other people who are knowledgeable about the Schoonspruit Government Water Scheme. This was done to determine the key issues the scheme is facing. **Table 10.1** below provides the key issues identified and these are discussed in more detail in the following sections of this chapter.

10.2 Water Measurement and Accounting Systems

10.2.1 Lack of sufficient water measurement

Effective water measurement and accounting is necessary for developing sound water management programmes. There is a lack of sufficient flow measurement in the Schoonspruit Government Water Scheme. The ideal water measurement system for Schoonspruit GWS would have flow measurements at all points in the diversion, conveyance and delivery system where flow diversion takes place (i.e. to branch canals), including farm turnouts and tail ends, drainage and system spill (at the Schoonspruit primary canal) locations (see **Figure 10.1** below).

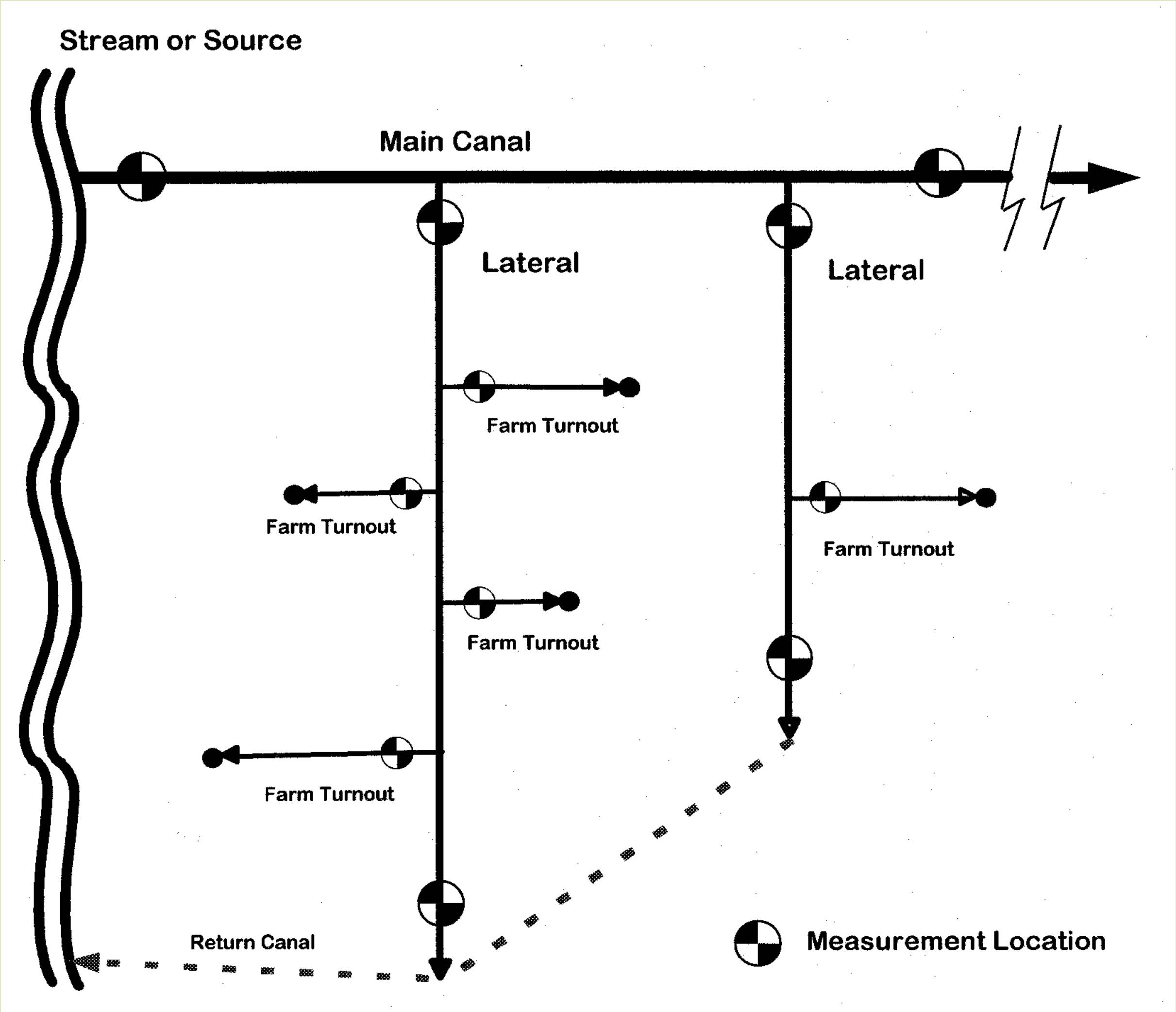

Figure 10.1: Irrigation Scheme with ideal water measurement system

Source: Bureau of Reclamation

Although there are some flow measurements, there are no flow measurements at some of the critical points or no measurements are being taken:

(i) There is no flow measurement on the Schoonspruit primary canal where excess water is rejected or spills back to the river.

(ii) There is no accurate measurement of the deliveries to other canals from the Schoonspruit canal. This includes the delivery into Rietspruit Dam which makes it difficult to calculate how much water is actually lost in the upper canal system.

(iii) There are no flow measurements at the three canal tail ends, namely Elandskuil canal tail end, Branch canal 16 spillway to the river as well as the Rietspruit canal tail ends. There may be no need to measure the spills at the Elandskuil canal tail end as it is measured as supply to the irrigator's farm dam.

From the WCO's perspective, adequate water measurement will help with:

- Assembling information needed for a detailed water balance to be done which provides the basis to implement measures to reduce water losses;
- Identifying areas where additional efficiency measures can be achieved;
- Implementing a cost recovery system based on deliveries (this is available as each irrigator is measured through the sluices).

10.2.2 Lack of real time monitoring

The Schoonspruit Government Water Scheme is a manually operated system with no electronic measurements or telemetry infrastructure linked to any of the existing flow measurements within the scheme area to carry out real time or near real time flow monitoring and control of deliveries.

The ideal system for improving irrigation water use efficiency would be to provide data on a real-time basis through the use of automatic and data transmission devices such as the Android Telemetry system used by some irrigation schemes in the country.

The lack of real time reduces the scheme operators' capacity to respond to changes in demand by water users thereby improving the efficiency of irrigation water management.

10.2.3 Management Goal 1

The objective to address the above irrigation water management issue is to ensure that the following is achieved by the Schoonspruit GWS:

(i) Continuation of regular measurement of flows into all primary and branch canals, as well as measurement at the tail end of the canal system;

(ii) Inclusion in the measurement should be the operational spills at the reject points, in order to enable operational spills to be measured;

(iii) Ensuring that all measuring devices in the scheme are in good operating condition and regularly calibrated;

(iv) Implementation of telemetry infrastructure, so that the flow measurement data is sent via the telemetry to the Schoonspruit GWS office for direct input into the WAS programme. This should be with a view to track water usage, identify where losses are occurring and allow the Schoonspruit GWS to operate the scheme more efficiently.

10.2.4 Weak Water Accounting System

One of the critical aspects of irrigation water management is the use of water accounting system which may vary depending on the complexity of the scheme conveyance system. The Schoonspruit Government Water Scheme does have a simple water accounting system which allows for tracking of water deliveries to individual users. However the current water accounting system does not have the capabilities to monitor and control the operation of the scheme to reduce water losses. This can be done by installing the Water Administration System (WAS).

The WAS is a water accounting system that was developed as a tool to be used by Irrigation Boards/Schemes to optimise their irrigation water management and minimise management-related distribution losses in irrigation canal systems. The WAS consists of seven modules, integrated into a single programme and these modules can be implemented partially or as a whole.

However, at present the WAS is not being fully utilised at scheme level. There will be substantial benefit in utilising the WAS system to undertake Water Use Accounting Reporting (WUEAR), at sub-scheme level or at irrigation wards with a view to determining which of the irrigation wards are experiencing significant water losses. This can provide priority areas, where issues need to be addressed in irrigation water management in the Schoonspruit Government Water Scheme.

It has been estimated that field measurements indicated water savings of between 10% and 20% on fully implementing the water release module of the WAS program alone. In the case of Schoonspruit Government Water Scheme, the WAS programme has been installed for about 10 years but the records indicate that these savings have not been achieved because the WAS programme has not been fully utilised.

10.2.5 Management Goal 2

The management objective to address the above issue, is to ensure that all the modules of the WAS programme, particularly the water order and water release modules, are implemented fully and that weekly and monthly WUEAR are generated.

Furthermore, the measured data module should be linked to a telemetry system, to enable direct reading of the measured data in the WAS programme. This can be used to undertake automatic reporting on water losses, not only at scheme level, but also at sub-scheme levels.

10.2.6 Irrigation water balance is not conducted in detail

10.2.6.1 Overview

Although there is data available from the different flow measurements in the Schoonspruit Government Water Scheme, there are some components that are not being measured, or being estimated or not included in the water balance assessment. These include the following:

(i) Measurement of operational spills at the rejects, as well as at the canal tail ends;

(ii) Measurement of evaporation using pan evaporation, to determine local evaporation losses, is currently not being conducted. Therefore the losses calculated at present from the water budget are unreliable or inaccurate;

(iii) Measurement of precipitation records is currently not being included in the water budget, which may indirectly result in higher operational spills if irrigators do not take up their full water demands.

10.2.6.2 Irrigation outfalls and operation spills are not included in the irrigation water budget

The irrigation water budget at scheme level for the Schoonspruit Government Water Scheme, indicated that the scheme "water losses", comprising seepage losses, evaporative losses, operational spills, over irrigation, as well as the canal tail ends and return flows, was averaging approximately 11.8 million m^3/a (see **Table 8.6** in previous chapter). It is currently difficult to disaggregate the losses. This is due to a lack of sufficient flow measurement in the irrigation scheme particularly at critical points.

10.2.7 Management Goal 3

The goal to address the above issue is to ensure that all the flow measurements in the Schoonspruit Government Water Scheme are included in determining water budgets and calculating water losses at scheme as well as sub-scheme level. This will enable the GWS to undertake comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified.

10.3 Operational water management issues

10.3.1 Canal and branch canal operating procedures

A review of the operation of the canals appears to suggest that the WCOs at times run canals full in order to serve certain branch canals and/or farm turnouts. This may be the reason for the high water flows at canal tail ends. Therefore during periods of reduced demand, this practice may result in significant spills at the ends of the canals.

This issue is particularly significant for Rietspruit and Elandskuil canal systems where it would appear that the canals are run full resulting in significant spills at canal tail ends as illustrated in the water balance assessment. To avoid these spills at canal tail ends, the scheme operators may have to institute a policy whereby canal levels are more actively managed than is currently the case and would fluctuate weekly. This will require adjustment of deliveries based on changes in demand.

10.3.2 Management Goal 4

The management goal is therefore to reduce the operational spills and wastage by building flexibility in the scheme operation with a view to installing a telemetry infrastructure. This will require timely information gathering, processing and dissemination to water control aids which is essential for efficient system control and to minimizing system waste through spills as is currently the case.

The other goal is to encourage irrigators to construct bigger storage to enable them to have sufficient water stored during dry periods.

10.3.3 The additional water to meet the water losses of the scheme is not limited to a percentage or volume of water

The scheduled quota for the Schoonspruit Government Water Scheme (GWS) is 18.731 million m^3/a. It is understood that this is the allocation to be supplied at the farm turnouts in the irrigation scheme and does not include the water losses required to ensure the scheduled quota is delivered. The additional water due to conveyance and distribution water losses is borne by the Department of Water Affairs and is considered additional to the scheduled quota.

There is very little incentive for the scheme to save the additional water required to deliver their scheduled quota because there is no limit set of how much additional water the scheme should be allowed in order to deliver its entitlement. This is an aspect that needs to be address in order to improve the scheme irrigation water use efficiency.

10.3.4 Management Goal 5

The objective of addressing the above water management issue is to determine the unavoidable water losses due to seepage losses and evaporation and establish over a period the percentage of the unavoidable water losses to the volume of water diverted into the irrigation canal system. This can be used to set the limit of additional water required to deliver the scheduled allocation of the Schoonspruit Government Water Scheme.

10.4 Infrastructure related management issues

10.4.1 General

In order to properly develop the Schoonspruit Government Water Scheme water management plan, it was essential that an assessment of the overall condition of the conveyance, distribution and control infrastructure to identify potential issues was carried out. As indicated in Chapter 4, a high level condition assessment together with discussions with the Schoonspruit GWS was undertaken. The included the operation and maintenance system, the conveyance and distribution system. No assessment of the on-farm delivery systems was conducted. The main issues that were identified are discussed in the following sections.

10.4.2 Hydraulic capacity of the canals is affected by aquatic weeds and algae growth

One of the major issues that was identified in the Schoonspruit Government Water Scheme is the growth of aquatic weeds and algae in the canals. This has had a serious impact on the condition of the canals and the hydraulic capacity of the canal systems. The algae proliferation during the summer in particular is as a result of several factors including high levels of nitrogen (N) and phosphorous (P) from untreated domestic wastewater and agricultural runoff, long daylight duration, high temperature, low flow velocity, and long watercourse retention time.

The current canal slope is fixed and cannot be changed. Current operation of the canal is demand-based, meaning that the flow in the canal is directly related to the water delivery requirements downstream. Water is only delivered based upon demand, and the rate of delivery is based on the rate of downstream water use. Hence, canal flow must be matched to water use and canal flow cannot be increased without an increase in downstream use. Based on the irrigation demands for the 6 years of records, the demand is not anticipated to increase significantly in the near future; therefore canal flow will not be able to be increased.

Therefore the algae growth and aquatic weeds in the canal systems is likely to exacerbate. This will affect the water use efficiency of the scheme unless the aquatic weeds and algae is completely removed. Currently the algae are removed using hand rakes and this is not addressing the problem.

Therefore, effective management of aquatic weeds in the canal will result in the ability of the canal to convey water at design flows. Further, improvements in water quality (i.e., less algae present to clog farmer’s drip emitters and filters) are anticipated to increase the demand for water delivery. An increase in demand will require an increase in flow. An increase in flow may result in less algae establishment and proliferation.

10.4.3 Condition of canal infrastructure

Although there are no measurements to determine the actual leakage in the Schoonspruit canal systems, the assessment carried out in the previous chapter have highlighted that there are likely to be high water losses due to leakage in canals, particularly on joints.

It is therefore important to undertake a detailed condition assessment of the canal conveyance infrastructure during the dry periods to determine the sections that require refurbishment.

10.4.4 Management Goal 6

The management objective to address the above issues is to develop and implement an effective management of the aquatic weeds and algae proliferation as well as refurbishment programme to reduce irrigation canal losses within 5 years.

10.5 Institutional Water Management Issues

10.5.1 Lack of incentive in current irrigation water pricing structure

One of the ways to encourage efficient water use is to base the scheme's pricing and billing procedures at least in part, on the quantity of water delivered. This is not the case in the agricultural sector where the water pricing for the sector is based on the area irrigated or fixed charge per area of irrigated land regardless of the quantity of water used which is a major disincentive to efficient water use.

Because irrigators are charged for their scheduled quota regardless of the volume of water they use, this can lead to excessive water use as irrigators are likely to order up to their allocation even if they do not necessarily require the water.

The Schoonspruit GWS could benefit from implementing an incentive based water pricing structure to encourage efficient water use by increasing the unit price of water as deliveries increase. With incentive based pricing, a base price per unit of water is charged for all water deliveries up to a certain amount to cover the operating costs. Water use in excess of the amount is then charged at a higher unit price.

10.5.2 Management Goal 7

The objective to address the issue of a lack of incentive based water pricing structure is to review the current pricing structure of the Schoonspruit Government Water Scheme and take into account the scheme operating costs in developing an incentive based pricing structure for the scheme.

10.6 Summary of the water management issues

Table 10.1 below presents a summary of the water management issues as discussed above. In order to improve water use efficiency in the Schoonspruit GWS these management issues need to be addressed as discussed in the following chapter.

Table 10:1: Schoonspruit Government Water Scheme: Identified water management issues

Item No.	Water Management Issue	Issue description	Comments
1	Water measurement & Accounting system	***1. Water measurement*** - There are insufficient flow measurement at critical control points of the irrigation scheme. This includes deliveries to Rietspruit and Elandskuil Dams and canal tail ends. This creates problems when determining water balances for the scheme and identifying potential areas to improve water use efficiency.	Install flow measurement for monitoring flows and control of deliveries.
		2. Real time monitoring: There is no real time monitoring in place to provide the flexibility of adjusting water deliveries in time as water demands change	Review and determine the business case for automation and telemetry system
		3. Water Accounting System - The current water accounting system does not provide sufficient information for monitoring and control of water deliveries. The WAS – release module is currently not being used which would improve the management of the irrigation water and improve irrigation water use efficiency.	Implement the WAS – release module once the flow measurements are installed
2	Operational water management	***4. Conveyance and distribution operating procedures*** - The canals are generally run full. This has the effect that when the demands changes there is	Run the canals based on demands

Item No.	Water Management Issue	Issue description	Comments
	issues	potential for operational spills contributing to the high water losses.	plus the water losses
		5. Additional water to meet losses not fixed- The cost of the additional water is borne by the DWA. Therefore the irrigation scheme does not have the incentive to ensure the water losses are minimised.	
3	Infrastructure related water management issues	***6. Aquatic weeds and algae growth in canal systems*** - The scheme has a serious problem of aquatic weeds and algae growth in the canals. This is reducing the hydraulic capacity of the canals meaning more water than is necessary is being diverted. This is contributing to the high water losses of the scheme.	Develop and implement a programme to eradicate aquatic weeds and algae.
		7. Condition of the canal infrastructure - The condition of the canal infrastructure particularly at the joints of the concrete panels appears to indicate cracks as grass is growing in these joints. The leakage losses indicate that more maintenance of the infrastructure is required.	Implement a refurbishment programme of sections of the canals which are not in good condition.
4	Institutional Water Management	***8. Lack of incentive based pricing structure -*** Irrigators are paying for water based fixed costs per irrigated area regardless of the amount of water (i) Current pricing is area based (per ha)	Financial incentives are necessary to encourage efficient water use

Item No.	Water Management Issue	Issue description	Comments
	Issues	(ii) Irrigators are losing on the benefits of their full water use entitlements. (iii) Area based assessment encourage water waste and produce inequitable water costs between efficient and inefficient users.	

11 SCHOONSPRUIT GWS WATER MANAGEMENT PLAN

11.1 Identification and evaluation of water management measures

There are numerous water management measures that can be implemented to address the water management issues and achieve a wide range of the goals identified in the previous section. However, only a few of the measures have the capacity to accomplish the goals to improve irrigation water use efficiency in the Schoonspruit Government Water Scheme.

The priority water management measures to improve irrigation water use efficiency on the Schoonspruit Government Water Scheme include the following:

(1) Installation of water measurements at all the critical points to enable recording of flow rates and volume of water diverted and/or spills, etc.

(2) Implementation of the WAS – release module to reduce operational losses such as canal tail ends spills to be carried out as well as undertaken water balance assessment at scheme as well as sub-scheme level.

(3) Removal of aquatic weeds and algae growth from the irrigation canals to reduce water losses.

(4) Implement an incentive based water pricing structure to improve irrigation water use efficiency and reduce significant fluctuations in demand.

(5) Repairing of the existing delivery canals, which will reduce leakage losses, improve flow rates and increase head at diversion points.

11.2 Best Management Practices for irrigation water management in Schoonspruit Government Water Scheme

11.2.1 Overview

In order to evaluate the candidate water management measures it was important to first of all determine the water loss target by incorporating not only the unavoidable water losses but also determining the attainable level of water losses based on the Best Management Practices (BMP) that can be achieved in the Schoonspruit Irrigation that takes account of the technical and managerial capacity of the Government Water Scheme. This is discussed in the following sections.

11.2.2 Gross water losses

The water losses in the Schoonspruit Government Water Scheme are considered to be very high at 29% of the total system input volume of water released from the Ventersdorp Eye, Elandskuil Dam and Rietspruit Dam. The total water losses were determined to be 11.77 million m^3/a based on the seven years of available records. It has been estimated that the unavoidable water losses due to evaporation losses and seepage is 3.03 million m^3/a, which translates into 7% of the total volume of water diverted into the Schoonspruit canal system.

In order to determine the potential water that can be saved from the two sub-schemes, the unavoidable water losses as well as the BMP for operational and distribution efficiency were determined

11.2.3 Unavoidable water losses

Based on the evaluation of the unavoidable water losses for the Schoonspruit Government Water Scheme, the water delivery Best Management Practice (BMP) should be based on the allowable water losses of approximately 7% of the total inflow into the irrigation canal.

There should be a policy established by the Schoonspruit GWS to use this as a basis for improving irrigation water management and to use this as the water saving target in the long term.

11.2.4 Best Management Practice for operational and distribution efficiency

Besides the seepage and evaporation losses which are unavoidable because of the type of conveyance infrastructure which are open channels and are liable to leak because of the hydraulic conductivity of the concrete lining, there are operational losses which are unlikely to be recovered at a scheme level due to a number of factors. These factors include the following:

(i) Canal filling – The Schoonspruit GWS allows for a minimum of 2 weeks scheduled dry period to allow for the maintenance of the canal infrastructure and repairs necessary at measuring structuring, etc. During this period the canal is emptied to allow for the maintenance to be carried out. A significant volume of water is then required to fill the canals before they can deliver the irrigation applications to the users in the scheme. Canal filling also takes place after weekends. This canal filling is included as part of the operational losses which cannot be recovered through any major intervention measures.

(ii) Operational performance losses – The existing sluices and Rectangular weirs have in inherent error that needs to be included in the operational performance of the scheme even after improving the calibration of the flow measurements. These metering errors have to be taken into account when determining the Best Management Practice (BMP) for in the Schoonspruit Government Water Scheme distribution efficiency

(iii) Untimely deliveries of water that cannot be used as a result of cancellations which will take a minimum of 12 hours to make adjustments to the releases. These losses can result in either operational spills at the canal tail ends representing a loss to the scheme or excess water which is delivered to downstream storages or canals within the scheme.

A Water Research Commission (WRC, TT466/10) which was conducted in 2010, has provided guidelines of the desired range of operational losses due to metering errors, canal filling losses after each dry period that have to be included in order to determine the BMP for operational and distribution efficiency (WRC 2010). This is additional to the unavoidable losses determined in the previous sections. This desired range is expressed as a percentage of inflow into the irrigation scheme. The desired range for operational losses (i.e. metering errors, canal fillings, etc.) is 10% of the inflow into the irrigation scheme.

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the Schoonspruit irrigation canal systems. This has been used in setting the water savings and the target water losses of each of the two canal systems.

11.2.5 Target water losses in the Schoonspruit Government Water Scheme

The unavoidable water losses in the Schoonspruit Government Water Scheme were determined to range between 5% for the Elandskuil canal and 8% for the Schoonspruit canal with the average unavoidable losses for the Schoonspruit scheme being 7% of the total releases into the irrigation canals. This water is additional to the irrigation water use required at the farm edge.

Furthermore there are operational performance inefficiencies in operating the Schoonspruit scheme including trying to match the delivery to the irrigation applications as mentioned in the previous section. Based on the WRC study the attainable range of operational losses which are not likely to the recovered through water management intervention measures is 10% of the total releases into the Schoonspruit canal systems. **Table 11.1** below provides the water loss target for the Schoonspruit canal system.

As illustrated in **Table 11.1** below, the expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses will be 17% of the total releases into the Schoonspruit canal system.

Therefore based on the 6 year average and taking into account the unavoidable water losses and expected operational inefficiencies, the expected water losses were determined 7.08 million m^3/a. When compared with the total losses of 11.77 million m^3/a for the same period, there is still potential to implement water saving measures to reduce the current water losses from 29% to the target water losses of 17% of the total releases into the Schoonspruit canal system.

Table 11:1: Acceptable water losses in the Schoonspruit canal system

Description	Unavoidable losses	BMP Distribution Efficiency	Acceptable water losses	Target water savings	Total losses
Seepages	2.56		2.56		2.56
Evaporation	0.46		0.46		0.46
Filling losses		4.06	4.06	4.69	8.75
Over delivery to users					
Leakages					
Spills					
Operational Losses					
Canal end returns					
Total	3.03	4.06	7.08	4.69	11.77
% of total volume released into system	7%	10%	17%	12%	29%
% of total losses	26%	34%	60%	40%	100%
Total releases					40.57

11.3 Water Measurement and Water Accounting Systems

11.3.1 Water measurement

11.3.1.1 Install water measurement devices at critical points of the canal system

A scheme's measurement should be capable of recording the volume of water released into the irrigation canal, lost due to operational spills, water delivered to individual water users including other canals and the amount of water lost from the scheme due to spills at canal tail ends. In order to achieve this, the Schoonspruit Government Water Scheme requires additional water measurements. This includes the installation of flow measurement devices at 5 critical points with the irrigation scheme as follows:

(i) Installation of a flow measurement device on the Schoonspruit main canal where excess water spills back to the river;

(ii) Installation of flow measurement device on the irrigation canals delivering excess water into the Rietspruit Dam;

(iii) Installation of flow measurement device on the canal tail ends of the following canals

a. Rietspruit canal tail end;
b. Branch 16 - spillway to the river;
c. Elandskuil canal tail end.

These devices will be permanently installed to monitor deliveries and operational spills into particular canal systems.

Given the size of the irrigation scheme it is not envisaged in the short term to install a remote control system to send the information from the flow measurements to scheme headquarters. For the short term it is recommended that the flow measurements are taken on a daily/weekly basis by the water control aids who can send the information by cellular phone to the Water Control Officer for use in the accounting system. This information will allow the GWS to track water usage, identify where changes in deliveries are needed within a 24 hour period, and identify where losses are occurring and allow the scheme to manage irrigation water use efficiently.

11.3.1.2 Initial Capital Costs and O&M Costs

Table 11.1 below indicates that initial capital costs and related operation and maintenance costs. The estimated initial capital investment is the cost of the installation of water measurement devices. This has been estimated to be R250 000-00. The O&M costs to maintain the water measurements in good working condition by conduction calibration of the devices is estimated at R50 000 per year.

As indicated further in **Table 11.1** below, the expected water savings due to the installation of water measurement devices in order for the scheme operators to the operate the system more efficiently. This has been estimated to be 1.41 million m^3/a allowing for a 80% success rate.

Some of the water saved will be available in the Elandskuil Dam as well as Rietspruit Dam for use during dry periods for the downstream canal irrigators. Furthermore some of the water saved will benefit the downstream users as the savings will end up in the downstream dams such as Johann Nasser Dam which will benefit the domestic and industrial users in Klerksdorp.

The rand value water savings from installation of water measurement devices is expected to be R0.1 million per year based on the water use charge of R0.12 per m^3 for canal irrigators.

The water saved can either be sold to the domestic water users such as the Ventersdorp Municipality. The demands for water in the town of Ventersdorp and the surrounding communities have increased significantly. Therefore any water savings that the Schoonspruit Government Water Scheme makes can be sold to the domestic consumers at a much higher unit cost than for irrigators. This amount can be used to offset the capital investment required to install the water measurement devices.

Table 11:2: Summary of the costs and potential savings - Installation of flow measurement devices

Item	Description	Water Savings Million m3/a	Cost Savings R per year	Sub-Total	Total
Installation of flow measurements	Install flow measurements at critical points				
Installation period					Six months
Productive period					20 years
Initial Capital Investment Costs	Water measurement devices (Rectangular weirs; Long crested weir, etc.)			250 000.00	
Annual O&M Expenses	Calibration of devices, taking of readings			50 000.00	
Water Savings					
Reduction in water losses due to installation of measurement devices	Water Savings	1.41	61 703.76		
Average Incremental Cost (AIC)					0.06

11.3.2 Task 2: Implementation of WAS Release Module

The importance of relevant and opportune information in decision making cannot be overemphasized. Managing irrigation systems is no exception to the rule. On the contrary, information is vital since daily decisions with regard to water deliveries and other aspects may affect the well-being of many farmers. Traditionally, managers of irrigation systems have tried to cope with this problem through the compilation of field information that was manually processed.

Unfortunately, the number of users in the Schoonspruit irrigation system runs in the order of hundreds and manual processing of information becomes a lengthy and costly exercise. As a consequence, relevant information is often not available on time or is incomplete and many *ad hoc* decisions have to be made.

11.3.2.1 Review the current use of WAS

As mentioned earlier, the Schoonspruit Scheme does not have a comprehensive water accounting system to track water deliveries and also determine the areas of improving irrigation water management. The scheme has not implemented all the modules of the WAS programme to manage and reduce water losses.

The system includes the following seven modules:

Administration module

This module provides the details of all water users on an irrigation scheme. Information managed by this module includes addresses, notes, cut-off list, list of rateable areas, scheduled areas, household and livestock pipes installed on canals, industrial water quotas, crops and areas planted and crop yields.

Water order module

This module captures all the weekly and monthly water requested by each farmer in the scheme. It also includes any additional water requests or any cancellations of water orders.

This module is very useful to determine the extent of additional requests, as well as the cancellations, as this will provide a clear indication of the extent of operational spills on rejects and tail ends in the case of cancellations. It will also highlight the flexibility that the Schoonspruit Government Water Scheme has in responding to cancellations.

Water release module

This module takes information from the water order module and calculates the volume of water to be diverted from the water supply sources into the main canal and all its branches allowing for lag times and any water losses and accruals to supply the requests for the week.

A schematic layout of the total canal network or river system, is captured with detail such as the cross sectional properties, positioning of sluices or pumps, canal or river slope, structures and canal or river capacities. Discharges are converted to the corresponding measuring plate readings where needed, so that the sluice gates can be set to deliver the volume of water requested.

The Schoonspruit GWS is currently not utilising the water release module.

Measured data module

This module provides the field data that is measured from the rates and volume of water delivered to each user and the rate and volume of water diverted into the scheme, as well as the rate and flow at different points in the canal system. This data is very useful in conducting water balance assessments not only at scheme level but also at sub-scheme level.

Other modules

The above three modules are the key modules in accounting for water use in an irrigation scheme. However there are other modules which include the following:

(i) *Water accounts module*- this module administers all water accounts for an irrigation scheme or water management office. The water accounts module is a full debit system, from which monthly reports can be printed, including invoices on pre-printed stationery, reconciliation reports, age analysis and audit trail reports.

(ii) *Crop water use module* is used to calculate the water usage per crop between two specified dates for all the planted crops on a scheme, based on the plant date, the area planted and the crop water use curve.

(iii) Reporting Module – includes an extensive range of water and financial reports. Water balance sheets, distributions sheets, WUEAR and various other operator defined reports can be generated. This module is currently in use at a scheme level.

Therefore, the Schoonspruit Government Water Scheme (GWS) needs to review their water accounting system and incorporate all applicable modules of the WAS programme in undertaking its water accounting.

11.3.3 Initial Capital Expenditure and O&M Costs

The Schoonspruit GWS requires the WAS programme installed at their offices. However, in order to ensure that all WAS modules are operational, will require the training of the water control personnel. The programme should also be set up to enable that water budgets at sub-scheme levels (i.e. for each of the two bigger canals, Rietspruit and Elandskuil) can be carried out.

The estimated operation and maintenance costs for operating the WAS programme includes an annual fee of R24 000 to obtain the latest updates of the programme and maintenance of the programme.

The estimated water savings has been included together with the installation of water measurements discussed in section 10.2 above. As mentioned above, it is estimated that 1.41 million m^3/a, could be saved, by undertaking the installation of water measurement devices and implementation of a water accounting system such as the WAS programme.

The capital investment required to carry out these two tasks is minimal, compared to the significant benefit in reducing water losses in the Schoonspruit Government Water Scheme. This should be considered priority by the GWS.

11.4 Conveyance infrastructure water management measures

11.4.1 General

The conveyance infrastructure rehabilitation programme is to carry out the refurbishment of the infrastructure in the conveyance system that was found to be causing significant leaks and seepage. This is discussed in the following section.

11.4.2 Task 3: Management of aquatic weeds and algae

11.4.2.1 Chemical aquatic weed management

Considering the losses caused by aquatic weeds, their management is of utmost importance to improve the availability of water from the source to its end users. This does not only improve availability but also the conveyance efficiency. Irrigation and drainage systems provide favourable conditions for the growth of aquatic weeds which interfere with the delivery systems of irrigation water, maintenance of canals, drains, etc. These systems often get choked with the weeds and cause environmental pollution. This is the case in the Schoonspruit Government Water Scheme.

Mechanical removal has been used in the Schoonspruit Government Water Scheme with very little effect. It has also been found that in peak summer months the biomass cannot be removed efficiently.

Therefore the recently recommended chemical process of removing aquatic weeds is proposed based on the successful pilot projects conducted at Hartbeespoort and Roodeplaat canals. This water-soluble aldehyde, which comes in liquid form and has Acrolein as its active ingredient, can be used in operational systems without interrupting irrigation water deliveries, and is characterised by superior effectiveness and quick dissipation without any residue.

Acrolein has been found effective in controlling submerged aquatic weeds and algae. It is used on a large scale in many countries in flowing canals and drainage ditches for quick control of aquatic vegetation. Being volatile, it evaporates from treated water within a short time of its application. It is effective at concentrations varying from 4 -15 ppmv. Acrolein has pungent and foul smell. It is a non-selective, contact herbicide for control of submerged weeds. Canals require regular treatment as the Acrolein is not translocated to the root systems of the plants but merely chemically mows the plants off at bed level. It also kills snails and mosquitoes.

The herbicides may be introduced over a time period of 30 min to 4 hrs in 3 m^3/s. Dosages are to be adjusted with water temperature, weed intensity and speed of water flow in system.

Acrolein is injected in water directly from the cylinder through an injecting system. It is toxic to fish. It is irritating to eyes and generally toxic to humans but can be applied without any problem when proper application equipment is used.

Research and extensive field use during a period of 10 years with Acrolein showed that this chemical is not toxic to irrigated crops at concentrations required to control submerged aquatic weeds (Timmons et.al., 1969, USDA 1963).

11.4.2.2 Initial Capital Costs and O&M Costs

The initial capital expenditure for the treating the aquatic weeds and algae with Acrolein is estimated to be R750 000. This is illustrated in **Table 11.2** below. The operation and maintenance costs for the siphon which includes flushing of the siphon and repair of air valves was estimated at R0.150 million per year.

Table 11:3: Summary of the costs and potential savings - Chemical management of aquatic weeds and algae

Item	Description	Water Savings Million m3/a	Cost Savings R per year	Sub-Total	Total
Chemical treatment of aquatic weeds	Inject acrolein to manage aquatic weeds and algae				
Installation period					Annually
Productive period					20 years
Initial Capital Investment Costs	Procurement of contractors			750 000.00	
	Chemical injection of acrolein				
				-	750 000.00
Annual O&M Expenses	Maintenance of aquatic weeds			150 000.00	
Water Losses					
Estimated reduction in water losses due to removal of aquatic weeds	Water loss reduction	1.50	180 321.49		
Average Incremental Cost (AIC)					0.14

The removal or management of the aquatic weeds and algae growth in the irrigation canals has the potential to save approximately 1.5 million m^3/a, while the average incremental cost of implementing the measure is only R0.14 per m^3 or R 1109 per ha per annum. This would be very prohibitive if the cost is to be borne by the irrigators. Hence the need for the DWA to cover the initial costs of the managing the aquatic weeds as this problem is external to the irrigation water management of Schoonspruit.

Based on the above capital cost estimates and the estimated water savings, this measure is considered to be justifiable for implementation by the DWA as well as the Schoonspruit GWS. The capital investment required to carry out this, is minimal compared to the significant benefit in reducing water losses in the Schoonspruit Government Water Scheme. This should be considered a priority by the irrigation scheme.

11.4.3 Conveyance infrastructure refurbishment and canal relining

It is likely that there are sections of the conveyance infrastructure of the Schoonspruit canal system which may require relining as well as replacement of the concrete panels. A condition assessment of the canal system should be conducted and the results of the assessment used to develop a canal refurbishment and renewal programme for the Schoonspruit Government Water Scheme. It is understood that canal condition assessment was conducted. However the findings of the assessment are not known.

Given the high water losses as a result structural failure of concrete lined irrigation canals due to flooding because of the aquatic weeds and algal growth, there is significant scope for refurbishment of the existing canal infrastructure, in order to reduce the current water losses. This will provide the GWS with the baseline to ensure efficient utilisation of the assets.

The capital cost requirements to enable the GWS to carry out the refurbishment of the infrastructure is beyond the normal maintenance costs of the Scheme. The lining and relining of canals requires significant capital investment which the DWA will need to provide, since they own the assets.

The refurbishment of the canal infrastructure is likely to save approximately 1.78 million m^3/a (see **Table 11.4** below). However this will come at a significant cost. The total cost estimate for relining of the canal sections with concrete and sealing of the wetted perimeter was determined to be R9 million while the operation and maintenance costs to maintain the infrastructure in good condition from thereon was calculated as R0.75 million per year.

Table 11:4: Summary of capital investment requirement & benefits - Rehabilitation of the canal infrastructure

Item	Description	Water Savings Million m^3/a	Cost Savings R per year	Sub-Total	Total
Replacement of canal sections and relining	Refurbishment of infrastructure				
Installation period					One year
Productive period					20 years
Initial Capital Investment Costs	Refurbishment of infrastructure			9 000 000.00	
	Procurement of contractors				
	Maintenance of infrastructure			750 000.00	9 750 000.00
Annual O&M Expenses	Flashing, repair of air valves, etc			150 000.00	
Water Losses					
Reduction in water losses due to leaking siphon	Leakage reduction	1.78	180 321.49		
Average Incremental Cost (AIC)					0.27

A condition assessment of the canal system will need to be conducted and the results of the assessment should be used to develop a canal refurbishment and renewal programme for the Schoonspruit Government Water Scheme

Therefore the DWA should carry out the rehabilitation of the deteriorating conveyance infrastructure. The conditions of the transfer of the refurbishment when the GWS is transferred to a WUA should be carefully monitored to ensure that rehabilitation of the infrastructure is undertaken.

11.5 Task 4: Incentive based water pricing

11.5.1 General

To achieve an incentive for efficient water use, the price of irrigation water must be directly related to the volume delivered unlike the current situation where it is based on the scheduled quota.

In order to encourage irrigators to use water efficiently, it is recommended that an incentive based water pricing structure for Schoonspruit Government Water Scheme is considered, based on the optimal crop water requirements of the main crop, which is maize. The implementation of incentive water pricing in irrigation agriculture, requires that comprehensive regulatory and operational criteria to be met before considering the economic criteria for incentive based pricing of irrigation water.

11.5.2 Regulatory aspects for incentive pricing

An orderly system of distributing water is already in place in the Schoonspruit Government Water Scheme, based on the regulatory framework for distributing water among the farmers. The rules and procedures defining the water ordering and water releases are in place. These include responsibilities of the GWS and those of the irrigators, priorities in case of shortage or excess supplies; penalties for breach of rules, and so on. Based on this, there is immediate scope for improving water distribution through pricing. Furthermore, there are already flow measurement devices (i.e. sluice gates and Rectangular weirs), for measurement of the quantity delivered.

From a regulatory perspective, the water pricing strategy can be used to in determining incentive pricing structure with two or three levels of pricing, to encourage efficient use of irrigation.

11.5.3 Operational aspects for incentive pricing

Measurement and charging at the farm level will require substantial investment in equipment, and an associated administrative bureaucracy, to collect and collate data on farm-level deliveries, and undertake the billing process.

The Schoonspruit Government Water Scheme already has the operational systems in place such as weekly ordering, as well as the sluice gates (however not very accurate) to measure each irrigator's use. Furthermore, the scheme has the administrative system to carry out billing based on actual use, rather than on a scheduled basis.

With the above operational aspects in place, the direct link between service and payment are achieved, and the efficiency incentive that pricing is designed to produce, can be met.

11.5.4 Economic aspects for incentive pricing

The current pricing, based on the scheduled quota does not provide the economic incentives for improving water use efficiency at farm level, as irrigators feel that they are entitled to the full use of their scheduled quota, even when they can achieve higher levels of production with less water.

If the charging system is to have an impact on consumption, then the system of payment must be such as to induce the desired economic response. In the case of Schoonspruit, the benefit of incentive pricing means irrigators can expect to pay less for their irrigation compared to the current scheduled quota which provides an economic incentive to the irrigators.

Because the Schoonspruit GWS needs to undertake fixed operation and maintenance activities, the incentive based pricing should consider the potential effects on revenue generated through water sales. However any savings made from reduction in water use at field edge, can be sold to other users such as the domestic sector whose demand is growing. This will provide supplemental revenue that could be used to develop more improvements to the scheme.

The potential savings are on the on-farm water use efficiency. The estimate is that there is likely to be savings of between 15% - 20% of the historic water use of 9.12 million m^3/a (i.e. 0.8 million m^3/a).

12 IDENTIFICATION AND ASSESSMENT OF WATER MANAGEMENT MEASURES

12.1 General

12.1.1 Legal provision for developing and implementing a WMP

The development and implementation of a Business Plan is a legal requirement to be undertaken by a GWS in terms of section 21 of Schedule 4 of the National Water Act (Act 36 of 1998). The constitution of a GWS - referred to schedule 5 for model constitution - outlines the principle functions to be performed by the GWS and will include the following:

(i) Prevent water from any water resource being wasted;
(ii) Exercise general supervision over water resources;
(iii) Regulate the flow of watercourse;
(iv) Investigate and record quantities of water;
(v) Supervise and regulate the distribution and use of water from a water resource.

The Business Plan for a GWS will thus incorporate a Management Plan setting out standards and Best Management Practices. Another key clause in the National Water Act is Section 29(1), which reads as follows:

"*A responsible authority may attach conditions to every general authorisation or licence -*

b) relating to water management by:

(i) specifying management practices and general requirements for any water use, including water conservation measures;

(ii) requiring the monitoring and analysis of and reporting on every water use and imposing a duty to measure and record aspect of water use, specifying measuring and recording devices to be used;

(iii) requiring the preparation and approval of and adherence to, a water management plan."

In light of the above legal requirements, the Schoonspruit GWS has developed a WMP in terms of the provisions of the act to enable it to manage the irrigation water in the scheme effectively and efficiently.

12.2 Establishment of water saving targets for Schoonspruit River Irrigation Scheme

12.2.1 Introduction

The implementation of a Water Management Plan for the Schoonspruit River Irrigation Scheme to reduce water losses will imply reducing the water diverted per unit of the land area irrigated in the scheme. As is expected this will not affect the yields of the wheat, maize and potatoes that are being irrigated in the scheme area.

Therefore reducing the water diverted per unit of land area would mean an increase in productivity per unit of water which would be a clear indication of progress towards greater efficiency for the Schoonspruit River Irrigation Scheme assuming the scheduled quota of 7 700 m^3/ha/a remains constant.

In the Schoonspruit River Irrigation Scheme, the trend line indicates that there has been no improvement in the diversion per unit of irrigated areas from 2000 to 2008 water years for the Schoonspruit River Scheme (see **Figure 12.1** below). If at all the scheme appears to experience more water losses as indicated by the equivalent depth per unit of area irrigated in 2008.

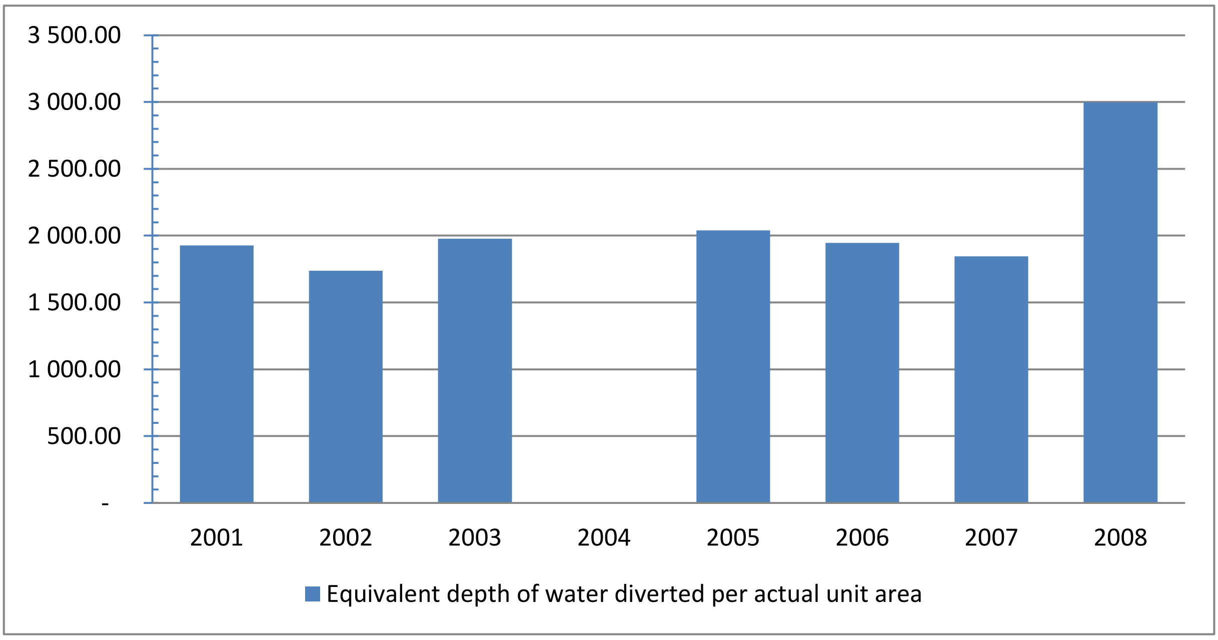

Figure 12.1: Trend line of increasing irrigation water releases expressed as an equivalent depth of water released per actual unit area irrigated (Schoonspruit Government Water Scheme)

However, in the case of the Elandskuil canal system the trend line indicates a slight increase in the release per unit of irrigated areas from 2000 to 2008 water years (see **Figure 12.2** below). Hardly much has changed in irrigation water use efficiency over the last 2 years of records.

Any improvements for example in on-farm water use efficiency maybe likely to be offset with the increase in water losses. This conclusion has however only been reached with very limited data as no other historical data was available and will need to be verified in time.

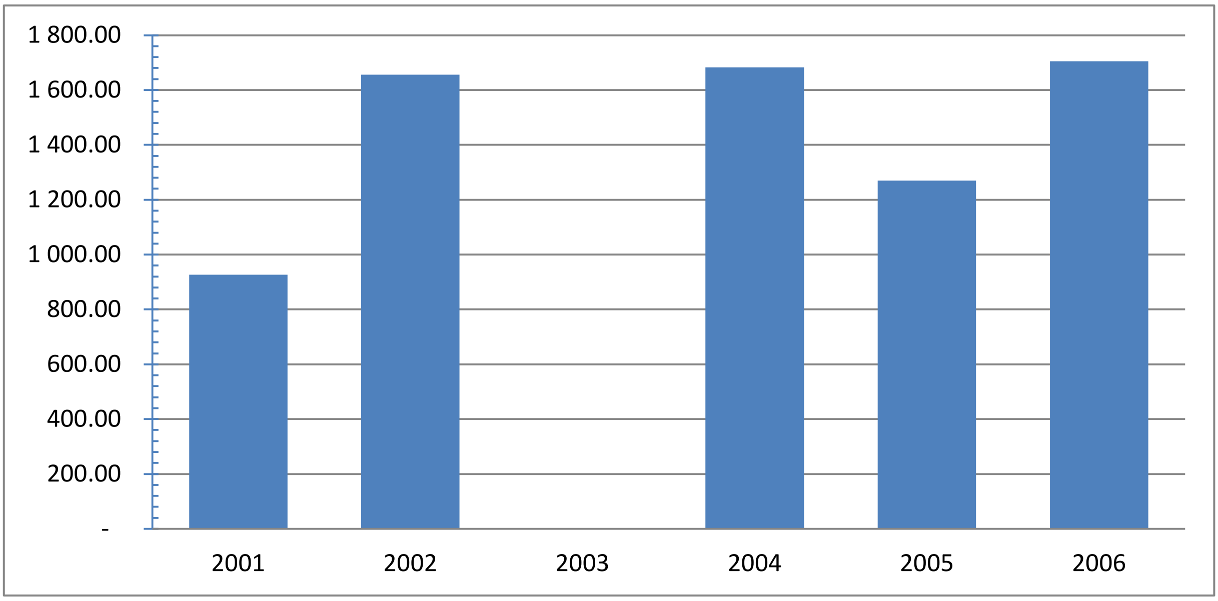

Figure 12.2: Trend line of the equivalent depth of water released per actual unit area irrigated for the Elandskuil

In the case of the Rietspruit canal system the trend line indicates an increase in the diversion per unit of irrigated areas from 2000 to 2008 water years (see **Figure 12.3** below). The increase may be due to the deteriorating condition of the canal infrastructure and/or the increase in the algae growth in the canal which affects the hydraulic capacity of the canals. The other issue could be increase in the operational spills at the canal tail ends. This can be addressed by continuous monitoring to reduce the operational spills.

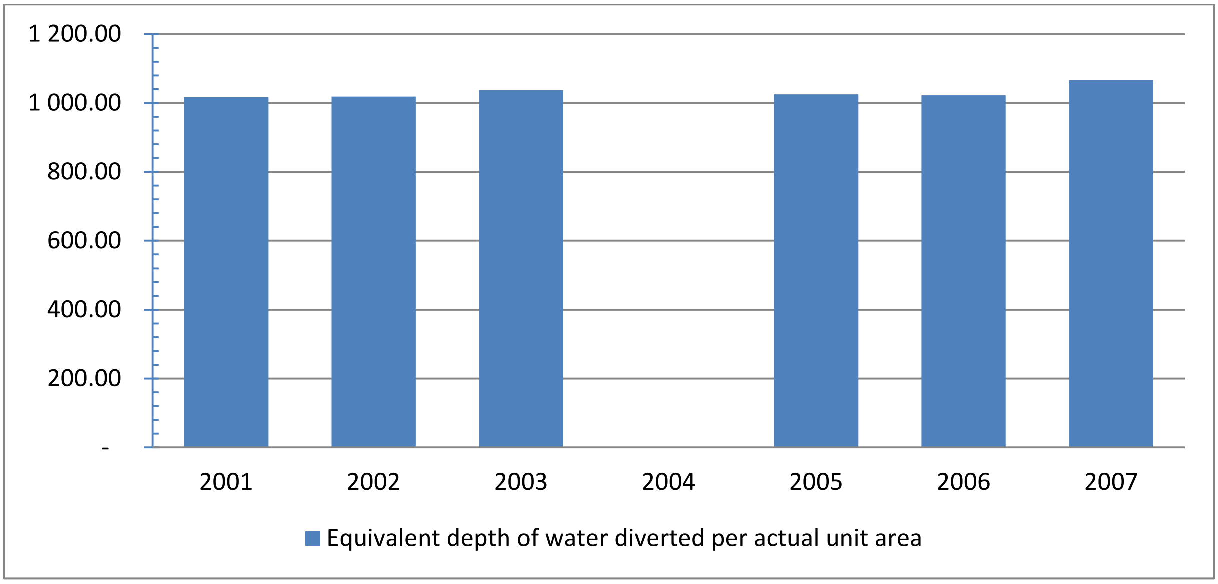

Figure 12.3: Trend line of the equivalent depth of water released per actual unit area irrigated for the Rietspruit canals

Therefore in setting water saving targets for the Schoonspruit River Irrigation Scheme, the use of the equivalent depth per unit area irrigated as a performance indicator is proposed. Any decrease per unit of actual irrigated area will indicate progress being made by the scheme towards greater irrigation water use efficiency. This performance indicator can be used at scheme as well as at sub-scheme level in the Schoonspruit River Irrigation Scheme. Currently this measure is not being used when the irrigation schemes submit their WUEARs.

12.2.2 Recommended water saving targets

Because there has not been a decline in the trend line of the releases per unit area irrigated over the observed period, it would appear there is significant scope in implementing the irrigation management intervention measures discussed in the previous chapter. The water saving targets recommended for the Schoonspruit River Irrigation Scheme is provided in **Table 12.1** below. Based on the projected water saving targets, the Schoonspruit River Irrigation Scheme can achieve a 12% reduction in irrigation water losses relative to 2012 levels, by the end 2022 based on the components provided in **Table 12.1** below.

Table 12:1: Projected water saving targets for the Schoonspruit River Irrigation Scheme

Irrigation Component	Intervention	Estimated water savings	Percentage of irrigation diversion	Time frame for implementation
Conveyance Infrastructure	Refurbishment & resealing	1.78	4%	5 to 8 years
Distribution infrastructure	Flow measurement & monitoring	1.41	4%	2 years
	Recalibration of Rectangular weirs			
Operational	Canal tail ends /	1.50	4%	2 years
	Control of algae			
Sub-Total Scheme target		4.69	12%	3 to 5 years
On Farm irrigation	Incentive pricing	0.82	1%	
	Irrigation systems		0%	

12.2.2.1 Short term water saving targets

For the short term which has been taken as 3 years, the total water savings from implementing the flow measurements; recalibration of Rectangular weirs and operational spills due to algae and water grass of 1.41 million m^3/a, and 1.5 million m^3/a respectively can be achieved. This is the water savings that have been targeted to be saved over a period of 3 years for the Schoonspruit River Irrigation scheme until 2015.

12.2.2.2 Long term water saving targets

For the long term a further 1.78 million m^3/a, is envisaged to be saved by refurbishment of the canal infrastructure while another 0.82 million m^3/a could potentially be saved through implementing incentive based pricing. This will require amendments to the current water pricing strategy which is currently being reviewed. It is unlikely that these water savings can be realised in the next three years. They are considered for the medium to long term in this water management plan. Therefore because of the complexities in implementing incentive based pricing and the timeline, it is recommended that this measure be implemented last.

The long term target is however to reduce the water losses to approximately 17% of the total inflow into the system. The annual water savings targets are discussed together with the action plans for implementation of the identified measures.

12.2.3 Water saving targets

The total water savings from implementing the above measures excluding incentive based water pricing structure is 4.69 million m^3/a. This is the water savings that have been targeted to be saved over a period of 3 years for the Schoonspruit Government Water Scheme.

12.3 Priority list of potential measures for implementation

12.3.1 General

The evaluation of the potential measures for implementation in the Schoonspruit Government Water Scheme area, to improve water use efficiency and reduce water losses, indicates that all measures are economically justified for implementation based on the unit cost of water saved.

The priority for implementation based on the amount of water savings and the average incremental cost of water saved is as follows:

(i) *Installation of water measurement and flow monitoring* - This measure has the third most benefit with estimated water savings of 1.41 million m^3/a, at an average incremental cost of R0.06 per m3. It is however easier to implement and should be considered a priority as all other measures are dependent on availability of sufficient water measurements in the Schoonspruit Government Water Scheme.

(ii) *Control of canal tail end spills and Chemical management of aquatic weeds and algae growth in canals* - This measure has the second most benefit with estimated water savings of 1.5 million m^3/a, at an average incremental cost of R0.14 per m^3. It should be carried out at the same time as the first intervention measure.

(iii) *Water Accounting System* - This measure is aligned to the installation of water measurement and will provide the system necessary to identify areas where irrigation water management can be improved. The changes in operation of the canals and canal tail ends can result in water savings of approximately 1.41 million m^3/a as indicated in water measurement if no water is allowed at the canal tail ends.

(iv) *Incentive based water pricing structure*- This measure has the lowest benefit with estimated water savings of 0.82 million m^3/a. The average incremental cost to implement this water management measure is likely to be very low as this will be done at national level.

(v) *Refurbishment & resealing* – this intervention measure has a high benefit with an estimated savings of 1.78 million m^3/a. The average incremental cost to implement this measure is likely to be very high.

Table 12.2 below provides the plan of activities required in order to ensure all management measures are undertaken by the Schoonspruit River GWS according to a planned timeframe, detailed water balance assessments are conducted on a quarterly basis and a management report presented to DWA on the status of water losses, water saving targets as well as the actions taken to reduce water losses..

Table 12:2: Schoonspruit River Irrigation Scheme: Water Management Measures and action plan

Priority	Goal	Action Plan	Timeline (Start)	Responsible Authority
1	To measure all critical points in the Schoonspruit River irrigation scheme	(i) Measure the 3 main canal tail ends on a continuous basis	June 2013	Schoonspruit GWS
		(ii) Measure the inflow from canal into the Elandskuil and Rietspruit dams	June 2013	
		(iii) Calibrate the measurement structures as required	June 2013	
2	Undertake detailed water balance assessments of the scheme	(i) Split the Schoonspruit River scheme into the sub-schemes and prepare water balance assessments and WUEAR to DWA on a sub-scheme basis	June 2013	Schoonspruit GWS
		(ii) Prepare detailed water balance assessment for the sub-schemes and split the losses to reflect operational losses from canal tail ends	June 2013	
		(iii) Set water saving targets to reduce operational losses at canal tail ends	June 2013	
3	To enable real or near real time flow	(i) Detailed design of the flow measurement and automatic recording or remote telemetry units (RTU) required for flow measurement	Oct. 2013	Schoonspruit GWS
		(ii) Install new automated monitoring or telemetry system infrastructure including software	Feb. 2014	

Priority	Goal	Action Plan	Timeline (Start)	Responsible Authority
	monitoring	to ensure compatibility with WAS (iii) Calibrate the flow measurements such as flumes and sluices to improve the accuracy in flow measurement (iv) Prioritise areas of significant water losses	 May 2014 June 2014	
4	To fully implement the WAS programme	(i) Review current use of WAS programme modules (ii) Implement WAS release module (iii) Set up WAS programme to carry out water balances at scheme and sub-scheme level	March. 2013 June. 2013 June. 2013	Schoonspruit GWS
5	Reduce algae growth in canals	(i) Identify the types and species composition of aquatic weeds and algae (ii) Prepare a tender for supply of Acreolin or similar approved (iii) Inject Acrolein to manage aquatic weeds and algae (iv) Assessment of the effect of chemical removal of algae	April 2013 June 2013 Oct 2013 June 2014	Schoonspruit GWS

Priority	Goal	Action Plan	Timeline (Start)	Responsible Authority
6	To conduct the refurbishment of the canals	(i) Classify the condition of all canal segments based on the condition of the canals. In cooperation with scheme personnel, conduct field reconnaissance to obtain attribute data and rate the condition of segments.	Aug 2013	Schoonspruit GWS
		(ii) Prepare a motivation to DWA for refurbishment of the poor sections of the canals requiring total reconstruction as well as relining.	Oct 2013	
		(iii) Engage with the DWA Infrastructure branch to motivate for refurbishment of the identified canal sections.	Nov 2013	DWA / Schoonspruit GWS
		(iv) Prepare tender documents & specifications; Procure SP & undertake total construction of canal sections and relining of the canals with bitumen emulsion.	March. 2014	DWA
		(v) Assess water savings made from total construction of sections of the Schoonspruit River canal and relining of canal sections.	May 2015	DWA
7	To implement incentive pricing	(i) Review current irrigation water pricing strategy and update administration systems	June 2013	DWA / Schoonspruit
		(ii) Provide inputs in updating the DWA water pricing strategy	July 2013	

Priority	Goal	Action Plan	Timeline (Start)	Responsible Authority
	structure for the WMA in 3 years	(iii) Engage with irrigators on incentive pricing structure (iv) Install accurate flow measurement & implement water billing based on incentive pricing rate (v) Update the operating rules of Elandskuil and Rietspruit Dams to supply irrigators based on incentive pricing rate	August 2013 March 2014 June 2014	GWS
8	To enable the Schoonspruit GWS to take ownership and implementation of the WMP	(i) Review the existing organogram with respect to the responsibilities and job descriptions for liaison of the CWCO with the WCC (ii) Update the Regional office organogram to include a WCC.	Oct 2012	Schoonspruit GWS DWA

12.4 Action Plan for implementation

12.4.1 Priority 1: Install additional flow measurement

A number of activities and tasks for implementation of installation of additional flow measurements as identified in **Figure 12.1** below. The first priority action plans focus on establishing the location of the additional water measurement devices and designing the additional flow measurements. This will assist the Schoonspruit GWS to conduct the flow measurements at all critical points of the Schoonspruit Government Water Scheme, including the tail end spills and also at rejects.

Besides the monitoring of flows, the Schoonspruit GWS will now be in a position to conduct detailed irrigation water budgets for the scheme as well as at sub-scheme level such as a water budget for the Rietspruit canal and Elandskuil canal system on its own. This will enable the WCOs to confirm whether the Elandskuil canal system has the highest water losses and what could be the reasons for the water losses. Furthermore, the WCOs will be able to determine the different types of water losses.

The updating and calibration of the existing Rectangular weirs should also be conducted to enable accurate flow measurements to be taken.

12.4.2 Priority 2: Management of aquatic weeds and algae

One of the most critical water management measures that need to be implemented is the removal and control of the aquatic weeds and algae growth in the Schoonspruit irrigation canals. The following actions are needed to implement a programme to control aquatic weeds and algae growth in the canals:

(i) Identify the types and species composition of aquatic weeds and algae growing in the canals as well as the source of the problem. This should include determining the physical and chemical characteristics of water and sediment in the canal system.

(ii) Conduct a critical evaluation of the benefits and problems encountered with ongoing management activities to provide a useful baseline for development of a management plan that enhances cost effectiveness and efficacy of aquatic vegetation management in canals.

(iii) Prepare a management plan to implement aquatic weed and algae removal and control based on chemical process using herbicides such as Acrolein. Prepare a tender document for acquiring and implementing the chemical eradication of the aquatic weeds.

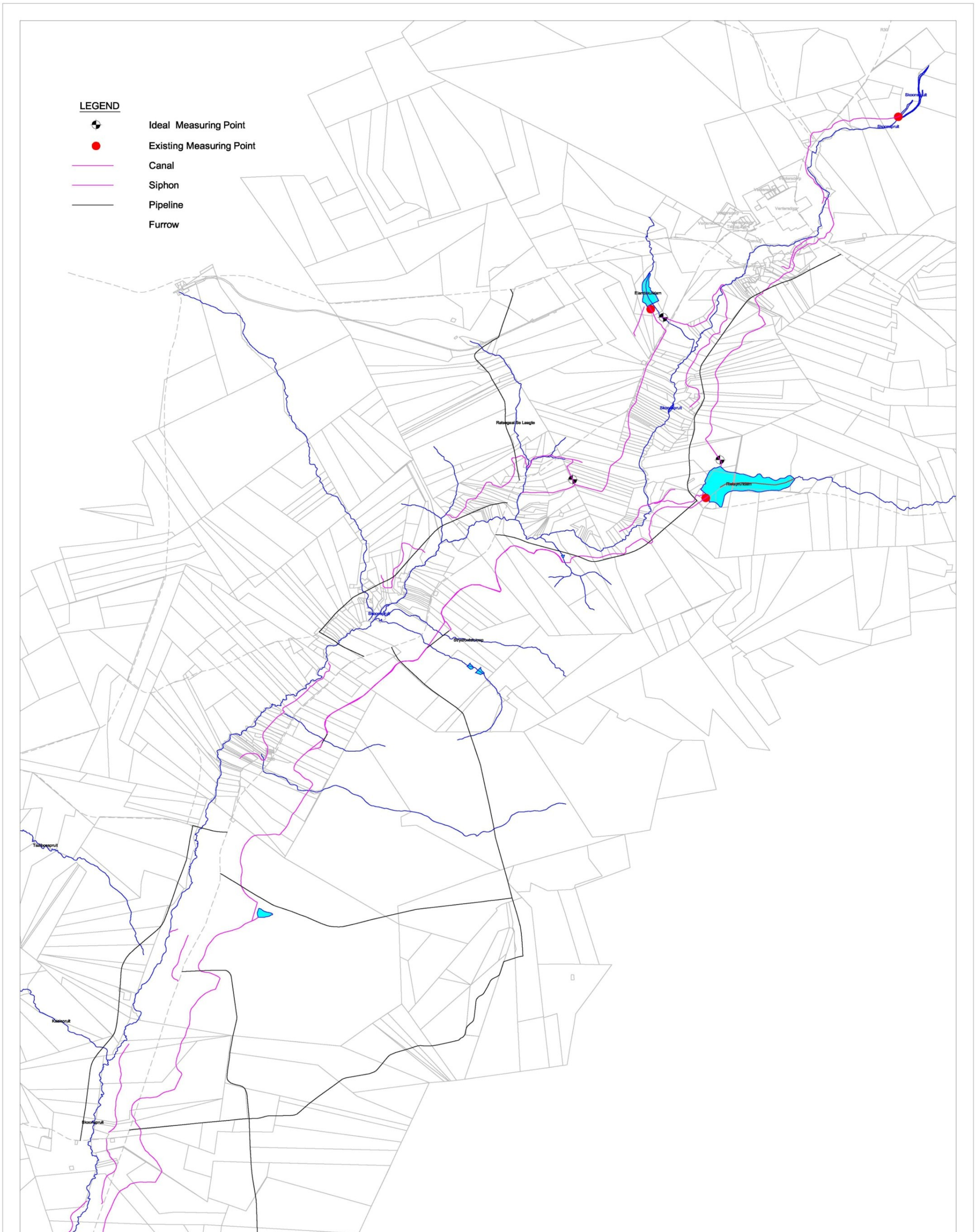

Figure 12.4: Proposed additional flow measurement and refurbishment of the existing telemetry system infrastructure

(iv) Invite tenders and implement an aquatic weed and algae removal and control programme for Schoonspruit Government Water Scheme.

(v) Conduct a post project evaluation of the impact of the programme on reducing water losses and improving irrigation water management.

12.4.3 Priority 3: Implementation of WAS programme

The benefits of installing sufficient water measurements cannot be fully realised without the implementation of the WAS programme, which needs to be linked with the data and records from the flow measurement system. The following actions are required to implement a water accounting system for the Schoonspruit Government Water Scheme:

(i) Review and evaluate the existing water accounting system being used by the scheme operators and identify where the gaps are.

(ii) Determine how the water order and release modules should be linked to the flow measurement system.

(iii) Implement all relevant modules of the WAS programme.

The WAS programme can then use the information and flow records to match the water ordered and the water released, to minimise operational spills, as well as to reduce any current flows at the tail ends. The flow at the tail ends is considered as a loss, although it may have a beneficial use downstream. The downstream demands can however be supplied by direct flows in the Schoonspruit River and/or releases from Elandskuil Dam and Rietspruit Dam.

12.4.4 Priority 4: Updating and implementation of the Water Management Plan

The Scheme Manager will be responsible for amongst others the implementation and updating of the Water Management Plan (WMP) for the scheme.

The roles and responsibilities of the applicable Scheme Manager for the updating and implementation of the WMP will be the following:

(i) Take flow measurements and conduct a detailed water balance assessment on a monthly basis at scheme and sub-scheme level

(ii) Compile Water Use Efficiency Accounting Reports and submit it on a monthly basis to the DWA Regional Office

(iii) Do recommendations on observations regarding water conservation issues and report to the Chief Executive: SAAFWUA and DWA on ways to address the identified issues

(iv) Develop activities that build on and complement other WC/WDM initiatives taking place at other water schemes

(v) Present water conservation information and training to irrigators and inform other scheme managers about success stories undertaken by the scheme

(vi) Maintenance and modernisation of the irrigation infrastructure

(vii) Liaise with DWA and other scheme managers to ensure consistent, efficient and effective deployment of water conservation messages, resources and services throughout the scheme

(viii) Monitor the plan and schedule for implementing water conservation program components

(ix) Report quarterly to DWA on the implementation status of the WMP, i.e. actions taken to reduce water losses and achievements towards achieving water saving targets, goals and objectives

(x) Annually review and update the WMP with a water conservation program for the scheme with goals, objectives, improved water saving targets, action steps, measures, and timelines taking into consideration the latest measured data and the measures that have already been implemented.

12.4.5 Priority 5: Implement incentive pricing

This requires a review and updating of any regulatory and operational criteria required to enable the Schoonspruit GWS to implement incentive based pricing. The action plans and time frame including the following:

(i) Review and update the regulatory aspects of incentive based water pricing structure by proving inputs into the updating of the water pricing strategy;

(ii) Evaluate the average actual water use by irrigators as a percentage of their scheduled allocation. This can be done through a questionnaire and reviewing the historical records of irrigation demands;

(iii) Determine the fixed operation and maintenance costs of the Schoonspruit Government Water Scheme and assess the revenue requirements for sustainable operation of the scheme;

(iv) Establish the base price of irrigation water per unit of water based on the revenue requirements of the scheme to meet the O&M costs;

(v) Determine the marginal costs per unit of water in excess of the base price and design one or more pricing levels above the base price;

(vi) Establish that the operational and accounting aspects of water pricing are in place;

(vii) Implement the incentive based water pricing structure for Schoonspruit Government Water Scheme.

Besides the reduction in water use and potential additional revenue that Schoonspruit Government Water Scheme may benefit from implementing incentive based pricing, the reduction in on-farm irrigation will help the scheme to:

(i) Reduce erosion;
(ii) Improve the crop yield and quality;
(iii) Reduce fertiliser leaching; and
(iv) Reduce drainage problems and downstream water quality problems.

As the DWA's water pricing strategy is currently under review and update, where amendments may be required to encourage incentive based pricing in the strategy, this should be considered.

12.5 Funding of the Schoonspruit Government Water Scheme WMP

12.5.1 General

All of the Water Conservation and Demand Management measures involve an initial capital investment requirement including the replacement costs over the useful life of the infrastructure. This is followed by on-going operations and maintenance which is required to ensure the installed infrastructure assets can provide the required performance for its intended use.

It has been proven in the analysis of the identified water use efficiency measures that implementation of these measures provides the most viable option at present to improving irrigation water use efficiency and reduce water losses in the Schoonspruit Government Water Scheme. However this will come at a cost to the water users. The additional cost for implementing these measures was done using the least cost planning approach where the average incremental costs (AIC) of each intervention measure were determined.

However the financing of the candidate measures should take into account the beneficiaries from water savings made during the implementation of the above identified measures. This is discussed in the following section.

12.5.2 Financing by water users of the Schoonspruit GWS

The benefits in implementing monitoring of the flows to irrigators will directly benefit the Schoonspruit irrigators and ensure that irrigation water is managed effectively to enable the scheme operators to provide the water to irrigators when required and on time. Therefore based on the fact that the beneficiaries are the irrigators in the Schoonspruit Government Water Scheme, the financing of the following aspects should be borne by Schoonspruit;

(i) Providing additional flow measurement and monitoring system;

(ii) Implementation of the full module of the WAS programme to enable water accounting to be conducted as well as to fulfil the legal requirements in terms of the Act to provide annual reporting to the DWA on the irrigation water management for the scheme.

12.5.3 Financing by the DWA

The canal infrastructure in the Schoonspruit Government Water Scheme is owned by the Department of Water Affairs (DWA) as the Schoonspruit is a GWS. Therefore the operation and annual maintenance of the infrastructure carried out by the DWA.

The impact of the aquatic weeds and algae on the condition of some of the infrastructure may have deteriorated to the extent that it requires refurbishment, the cost of which is prohibitive to be carried out by the irrigators through increase in water tariffs. Furthermore this problem is external to the operation of the scheme as the reasons for aquatic weeds may be due to upstream management. This problem is considered a water management area problem and requires the DWA to provide the financing necessary to reduce the water losses due to the aquatic weeds and algae growth in the canals and for refurbishment of the canals.

It is therefore recommended that the DWA provide the funding necessary to reduce water losses as follows:

(i) Implementation of a programme to remove and control the aquatic weeds and algae growth in canal systems.

(ii) Refurbishment of the sections of irrigation canals which are in a bad condition which are identified through a ponding test.

(iii) Implementation of the incentive based pricing by Schoonspruit GWS

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

The following can be concluded from the assessment of the water supply/requirements conducted for the Schoonspruit Government Water Scheme area and can be summarised as follows:

- The Schoonspruit Government Water Scheme is situated in the Middle Vaal Water Management Area. The scheme has an enlisted area of 2 432.6 ha at an allocation of 7 700 ha/a, which includes canal as well as river irrigators. The total water allocation for Schoonspruit is 18.73 million m^3/a.
- The main crops that are under irrigation include maize which is the main crop, vegetables (approximately 730 ha.), as well as irrigation of pasture.
- The Schoonspruit Government Water Scheme receives its raw water supplies from the dolomitic aquifers of the Ventersdorp Eye. It is supplemented by the Elandskuil Dam and Rietspruit Dam which was to address the water supply shortages and reliability of supply problems that the scheme was experiencing. Water is released to supply Schoonspruit Government Water Scheme, from the three sources namely the Ventersdorp Eye and the Elandskuil and Rietspruit Dams to meet the demands of the irrigators based on the weekly orders.
- The irrigation water is diverted into the main canal which is from the Ventersdorp Eye with any excess water delivered to the Rietspruit Dam and Elandskuil Dam to supply the downstream irrigators. The Schoonspruit Government Water Scheme has a total length of approximately 95.4 km of irrigation canal which supplies the irrigators as well as Ventersdrop Local Municipality.
- Although no detailed condition assessment could be undertaken on the Schoonspruit Government Water Scheme because the canals were operational, a preliminary assessment was however conducted during the site visit that was conducted in May 2011. It was determined that there were significant problems of aquatic weeds and algae growth in the canals affect the hydraulic performance and condition of the canal system.
- In order to ensure that the irrigators receive their scheduled quota as and when required, the Schoonspruit GWS operates the irrigation scheme based on “delivery on request” where each water user (irrigator) must submit a written request on a

weekly basis and the water is delivered to some 616 abstraction points along the canal systems. These procedures are not all formerly documented.

- Irrigation water use in Schoonspruit has ranged from 6.7 million m^3/a in 2001/02 up to 10.28 million m^3/a in 2007/08, with a six-year average of 9.12 million m^3/a. The domestic water use however has shown a steady increase in water consumption, increasing from 1.3 million m^3/a in 2001/02 up to 2.16 million m^3/a, in 2007/08.
- The average total water released into the Schoonspruit Government Water Scheme during the same six year period, was 40.4 million m^3/a, with the range being 31.98 million m^3/a in 2001/02 up to 47.5 million m^3/a in 2005/06.
- An irrigation water balance assessment conducted for Schoonspruit Government Water Scheme indicated that the water losses averaged 29% of the total water released into the Scheme, with the Elandskuil canal system having the highest water losses at 40% and Rietspruit Dam having water losses of 25%. This amounted to total water losses of 11.8 million m^3/a, which was considered to be very high.
- The total water losses were disaggregated to determine the unavoidable and avoidable water losses with a view to establishing the irrigation water delivery BMP for Schoonspruit Government Water Scheme. The total unavoidable water losses was determined to be 3.0 million m^3/a or 7% of the total water released into Scheme.
- Based on the unavoidable water losses, there was significant potential to reduce irrigation water losses and improve irrigation efficiency in the Schoonspruit Government Water Scheme.
- However an assessment of the operational inefficiencies due to over delivery, metering errors, etc. means that approximately 10% of the total releases will unlikely be able to be saved. This translates to 4.06 million m^3/a, which cannot be saved.
- The water losses that can be saved was determined to be 4.69 million m^3/a out of an average total water loss of 11.77 million m^3/a for the Schoonspruit GWS. This was considered to be operational wastage, leakage and spills which could potentially be saved. However some of the water losses were considered to be beneficial as the water is used by downstream users in the Johann Nasser Dam area.
- The irrigation water budget together with discussions with Schoonspruit GWS highlighted that there were number of management issues which included the following:
  (i) Although there are flow measurements, there are not sufficient water measurements at some of the critical points to measure and monitor flows such as at the canal tail ends as well as measurement of water delivered to

other canals. If these measurements were available, the accurate measurements are not being included in the WUEARs.

(ii) Not all the modules of the WAS programme are being utilised to undertake water use efficiency accounting reports. The release module is currently not being used.

(iii) There were no detailed irrigation water budgets being conducted at both scheme and sub-scheme levels as the flow measurements at the canal endpoints and tail water ends as well as at each diversion where flow measurements are being taken was not being included. There was a need to address this in order to clearly determine where and how much water can be considered as water losses.

(iv) The condition of the canal infrastructure was in a very poor state resulting in significant water leakages. This is due to the aquatic weeds and algae growth in the canal system.

- Based on the above water management issues, a number of measures were identified to address the issues with the main management goal being to reduce the high water losses and improve irrigation water use efficiency in the Schoonspruit GWS. These measures were evaluated and prioritised based on the water savings and the average incremental cost (AIC) of implementing the measures.

13.2 Recommendations

13.2.1 Schoonspruit Water Management Plan

A water management plan for the Schoonspruit Government Water Scheme was developed to address the water losses taking place in the scheme and to improve irrigation water management of the scheme. The identified measures for implementation to reduce the water losses from the current 29% to 17% of the total inflow into the irrigation scheme include the following:

(i) Installation of water measurement - This measure has the third most benefit with estimated water savings of 1.41 million m3/a, at an average incremental cost of R0.03 per m3. It is however easier to implement and should be considered a priority as all other measures are dependent on availability of sufficient water measurements in the Schoonspruit Government Water Scheme.

(ii) *Control of canal tail end spills and Chemical management of aquatic weeds and algae growth in canals* - This measure has the second most benefit with estimated water savings of 1.5 million m^3/a, at an average incremental cost of R0.03 per m^3. It should be carried out at the same time as the first intervention measure.

(iii) *Water Accounting System* - This measure is aligned to the installation of water measurement and will provide the system necessary to identify areas where irrigation water management can be improved. The changes in operation of the canals and canal tail ends can result in water savings of approximately 1.41 million m^3/a if no water is allowed at the canal tail ends.

(iv) *Incentive based water pricing structure*- This measure has the lowest benefit with estimated water savings of 0.82 million m^3/a. The average incremental cost to implement this water management measure is likely to be very low as this will be done at national level.

(v) *Refurbishment & resealing* – this intervention measure has a high benefit with an estimated savings of 1.78 million m^3/a. The average incremental cost to implement this measure is likely to be very high.

13.2.2 Financing options for the WMP

All of the Water Conservation and Demand Management measures involve an initial capital investment requirement including the replacement costs over the useful life of the infrastructure. However the financing of the candidate measures should take into account the beneficiaries from water savings made during the implementation of the above identified measures.

Two sources of funding were identified and recommended based on the beneficiaries of the intervention measures. The recommendation is that:

(i) Schoonspruit GWS should look at financing the measures which will benefit and improve the operation and monitoring of irrigation water in the scheme. These measures will also allow Schoonspruit GWS to fulfil it legal requirements in terms of the National Water Act on reporting and efficient management of irrigation water. These include updating the flow measurements, refurbishing the telemetry system and to fully implement the WAS programme.

(ii) The DWA owns the infrastructure in Schoonspruit Government Water Scheme. The refurbishment of the canal infrastructure including management of the aquatic weeds and algae requires significant funding which cannot be met with the maintenance budget of Schoonspruit GWS. As the water savings from the refurbishment of canals will benefit downstream consumers, the financing of the refurbishment of the infrastructure should be undertaken by the DWA. This also includes the implementation of incentive based pricing which will improve the on-farm irrigation efficiency while the savings will benefit downstream users unless Schoonspruit GWS can use the water to expand.

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