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DEVELOPMENT OF RECONCILIATION STRATEGIES FOR LARGE BULK WATER SUPPLY SYSTEMS: ORANGE RIVER

IRRIGATION DEMANDS AND WATER CONSERVATION/WATER DEMAND MANAGEMENT

SEPTEMBER 2014

DEVELOPMENT OF RECONCILIATION STRATEGIES FOR BULK WATER SUPPLY SYSTEMS

ORANGE RIVER

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LIST OF REPORTS

The following reports form part of this study:

Report Title	Report number
Inception Report	P RSA D000/00/18312/1
Literature Review Report	P RSA D000/00/18312/2
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Current and future Water Requirements	P RSA D000/00/18312/4
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DEVELOPMENT OF RECONCILIATION STRATEGIES FOR LARGE BULK WATER SUPPLY SYSTEMS: ORANGE RIVER

Irrigation Demands and

Water Conservation/Water Demand Management (Task8)

And

The Value of Irrigation Water (Task 9)

EXECUTIVE SUMMARY

The Department of Water Affairs (DWA) has identified the need for detailed water resource management strategies as part of their Internal Strategic Perspective (ISP) planning initiative, which recommended studies to identify and formulate intervention measures that will ensure enough water can be made available to supply the water requirements for the next three to four decades.

As part of this process the need for the Reconciliation Strategy Study for the Large Bulk Water Supply Systems in the Orange River was also defined. Given the location of the Orange River System and its interdependencies with other WMAs as well as other countries, various water resource planning and management initiatives compiled during the past few years as well as those currently in progress will form an integral part of the strategy development process.

Since 1994, a significant driver of change in the water balance of the Orange River System was brought about by the storing of water in Katse Dam as the first component of the multi-phase Lesotho Highlands Water Project (LHWP). Currently Phase 1 of the LHWP (consisting of Katse, and Mohale dams, Matsoku Weir and associated conveyance tunnels) transfers 780 million cubic metres per annum via the Liebenbergsvlei River into the Vaal Dam to augment the continuously growing water needs of the Gauteng Province. Phase 2 of the LWHP comprising of Polihali Dam and connecting tunnel to Katse Dam is already in its planning stages. Polihali Dam is expected to be in place by around 2022. Flows that are currently still entering into Gariep and Vanderkloof dams wil then be captured by Polohali Dam, thus reducing the inflow to Gariep and Vanderkloof dams. This will result in a reduction in yield of the Orange River Project (Gariep and Vanderkloof dams) to such an extent that shortages will be experienced in the ORP system. Some sort of yield replacement is then required in the Orange River to correct the yield versus demand imbalance in the ORP system.The objective of the study is to develop a reconciliation strategy for the bulk water resources of the Orange River System, to ensure that sufficient water can be made available to supply the current and future water needs for a 25 year planning horison. This Strategy must be *flexible to accommodate future changes in the actual water requirements and transfers, with the result that the Strategy will evolve over time as part of an on-going planning process.*

Appropriate integration with other planning and management processes as well as cooperation among stakeholders will be key success factors in formulating coherent recommendations and action plans.

The Purpose of this report

This report (Task 8) deals with the Irrigation Demands and Water Conservation and Water Demand Management aspects of the study.

The purpose of the Water Demand component of the report is to determine and understand current and future irrigation demands. Irrigation is by far the largest consumer of the limited water resources of the catchment and is therefore a critical component of the reconciliation strategy.

The purpose of the Water Conservation and Water Demand Management (WC/WDM) component of this report is to evaluate the contribution that irrigation water conservation and water demand management can make towards the reconciliation strategy for the bulk water resources of the Orange River.

Water demand

The irrigated areas and related annual irrigation water demand for the Orange River Basin are estimated as follows:

Catchment	***Field requirement (million m^3/a)***	***Irrigated areas (ha)***
Upper Orange (Reaches 1-14)	*846.0*	*99 647*
Lower Orange (Reaches 15-22)	*818.0*	*63 109*
Molopo	*1.9*	*127*
Lower Orange Tributaries	*19.8*	*1320*
Total Orange	***1684.8***	***164 203***
Eastern Cape	*577.2*	*49 565*
Total RSA	***2262.0***	***213 763***
Lesotho	*20.6*	*2 640*
Namibia Fish River	*47.5*	*2 520*
Namibia Orange River	*35.2*	*2 961*
Total demand	***2365.3***	***221 889***

A more detailed breakdown of the above figures is shown in the following table:

RIVER REACH	***DESCRIPTION***	***IRRIGATION DEMANDS (Mil m³/a)***	***IRRIGATION AREAS (ha)***
1	*Caledon River: U/S Welbedacht Dam*	*40.3*	*9 930*
2	*Caledon River: Welbedacht Dam to Gariep Dam*	*36.5*	*5 835*
3	*U/S Aliwal North D/S Oranjedraai*	*6.6*	*877*
4	*Aliwal N to Gariep Dam*	*52.5*	*8 229*
5	*U/S Aliwal N*	*28.0*	*6 341*
6	*Gariep dam to Vanderkloof dam*	*27.7*	*3 121*
7	*Canals ex Vanderkloof dam*	*195.1*	*17 678*
8	*Scholzburg and Lower Riet IBs*	*50.2*	*4 564*
9	*Vanderkloof-Marks drift*	*187.4*	*17 455*
10	*Krugerdrift dam to Tweerivier gauge - Modder River*	*52.5*	*7 004*
11	*Tierpoort Dam to Kalkfontein Dam: Tierpoort IB*	*8.1*	*1 018*
12	*Kalkfontein Dam to Riet River Settlement:*	*56.7*	*6 187*
14	*Douglas weir to Orange-Vaal Conf. (Orange water)*	*104.3*	*11 410*
15	*Orange - Vaal Confl. to Boegoeberg dam*	*174.0*	*17 236*
16	*Boegoeberg dam to Gifkloof weir*	*161.2*	*10 744*
17	*Gifkloof weir to Neusberg*	*222.8*	*14 855*
18	*Neusberg to Namibian border*	*180.2*	*12 016*
19	*Namibia border to Onseepkans weir*	*28.6*	*1 905*
20	*Onseepkans weir to Vioolsdrift weir*	*33.6*	*2 237*
21	*Vioolsdrift to Orange-Fish Confluence*	*9.0*	*600.0*
22	*Orange-Fish confluence to river mouth*	*8.3*	*553*
Sub-Total	***Upper Orange (reaches 1-14)***	***846***	***99 647***
Sub-Total	***Lower Orange (reaches 15-22)***	***818***	***63 109***
	Molopo	*1.9*	*127*
	Lower Orange Tributaries	*19.8*	*1320*
Total	***Orange River***	***1 685***	***164 203***
	Eastern Cape	*577.2*	*49 565*
Total	***RSA demand***	***2 262***	***213 768***
	Lesotho	*20.6*	*2 640*
	Namibia Fish River	*47.5*	*2 520*
	Namibia main Orange	*35.2*	*2 961*
Total demand		***2 366***	***221 889***

Subsequent to the completion of this report, the Validation & Verification of the Upper Orange Water Management Area Study data for 2010 has been completed. The results of this study, with respect to 2010 validated data is presented in a supplementary report entitled "Supplementary Report on Irrigatin Demands (Task 8) and is included in Appendix A of this report.

Water Conservation and Water Demand Management

The report commences with an overview of irrigation in the Orange River catchment in terms of the nature and condition of irrigation main infrastructure, on-farm technologies being applied by farmers and agronomic practices in the catchment.

Water conservation and water demand management (WC/WDM) is then defined in the context of its interpretation in the study.

The role of institutional structures in WC/WDM is outlined with emphasis on the role of DWA and Water User Associations/Irrigation Boards in promoting and monitoring WC/WDM.

The WC/WDM "best practice" of two leading Water User Associations in the catchment, the Orange Riet Water User Association and the Boegoeberg Water user Associations is described.

The constraints to increased water savings, as perceived by WUAs, IBs and leading farmers are listed and incentives to improve irrigation water use efficiency highlighted.

Specific opportunities for irrigation water savings are then discussed and a broad estimate of the amount of water that could practically be saved through WC/WDM practices over a period of 10 years is presented.

The main conclusions drawn from the study and recommendations made are as follows:

Proposed Interventions

The following key interventions are recommended in order to promote the chances of any significant irrigation water saving in the Orange River catchment by way of water conservation and water demand management.

- *The DWA should "fast-track" the establishment of WUAs and provide consistent support to WUA's through the promotion and review of WMPs and monitoring their implementation. This will have long-term implications to improved water-use efficiency at distributor level and at irrigator level.*
- *Where bulk water reticulation infrastructure on regulated schemes is the responsibility of the DWA, repair and maintenance programmes should be established and funding sought for this purpose. Most irrigation scheme infrastructure is owned by DWA, but is not always being maintained by them. This makes the management of Scheme irrigation infrastructure by the WUA or Irrigation Board difficult. Where infrastructure is owned by IBs or WUAs, they should be encouraged to repair and maintain their bulk infrastructure. Upgrading of canals and storage dams on Schemes with aged infrastructure is probably the single most important initiative to reduce losses and improve water use efficiency.*
- *The installation of efficient measuring devices on all regulated irrigation schemes should become a high priority for DWA and WUA/Irrigation Boards and where possible incentives for farmers to purchase such devices should be sought.*

- *Incentive systems should wherever possible be considered for WUAs and IBs as well as individual farmers to improve water use efficiency and encourage water saving. In the case of irrigators the following options should be addressed by DWA:*
    - *The introduction of sale-by-volume, where effective water measuring devices are available. However, the protection of irrigation water entitlements per farm should be secured.*
    - *Long-term assuredness of supply of irrigation water is an incentive to increase investment in irrigated farming and consequently improve the efficiency of water use in terms of net crop returns per unit of water used and also in terms of job creation and economic "spin off" per unit of water used. This option however does not make a direct impact on water saving.*
- *In the case of water suppliers, the following incentive options should be considered by DWA:*
    - *Promoting water markets: Income from the sale of saved water would be a significant incentive, even though it would not necessarily free-up water for alternative distribution and use.*
    - *Catchment management charges to WUAs could be based on actual annual water distribution to irrigators, rather than to the total area-based allocation to the Scheme.*
- *The purchase of water entitlements (or parts of entitlement) from irrigation farmers by the State, as described in this report, should be considered by DWA.*
- *Unlawful irrigation water use in the catchment should be addressed with more urgency. The irrigation validation and verification of registered use studies are presently underway in the Upper Orange, but the process is complex and slow. Unless the DWA is seen to be identifying this proliferation and taking the necessary regulatory steps to control it, unregistered water use for irrigation will become difficult to reverse.*

Irrigation water savings estimates

Based on the estimates outlined in the report, with a total irrigation water demand of 2 366 million m³/annum, a 10% saving of 237 million m³/a within a 10 year period could be achieved.

However these estimates do not consider the reduction in return flows that such savings would cause, nor the likelihood that savings made by individual farmers, through improved irrigation practices and improved water management, will be used to increase their irrigation areas rather than reduce their overall water allocation.

The estimated savings could consequently be reduced by as much as a further 50 - 60%.

It is recommended that a net saving of about 4 - 5% (95 - 118 million m³ /annum), over a period of 10 years be adopted as a conservative but realistic estimate.

The Value of Irrigation Water

In determining the value of the irrigation water it is important to estimate the regional economic benefits accruing from irrigation water, which include employment creation and the direct, indirect *and induced economic benefits that can be attributed to agricultural production in the study area. A Social Accounting Matrix based model (SAM), which includes the relevant economic multipliers for the various sectors, is used for this purpose. These benefits can then be added to the financial benefits and the real value of the irrigation water can be determined.*

The so-called economic baseline provides the impacts of water usage when the full water allocation is available in the respective sub-regions for variables such as GDP, employment, and income received by households.

To accomplish this, an econometric model was developed with the multipliers synthesised from the representative Social Accounting Matrix (SAM) for the Orange River. The Water Impact Model (WIM) was used for the primary sector irrigation agriculture.

The primary sector feeds the secondary and tertiary sectors but depends on products and services from the latter two sectors to operate efficiently.

The value of the irrigation water and the impact of the sector, in terms of macro-economic indicators, are ultimately expressed in terms of:

GDP - direct, indirect and induced.

Employment - direct, indirect and induced.

Payments to Households - high, medium and low income households.

Production Capital.

A WIM was constructed for the following agro-ecological regions of the South African component of the Orange River:

- *Upper Orange (East), Kraai River upstream of Aliwal North, Orange River upstream of Aliwal North.*
- *Upper Orange (Central), Orange River Gariep Dam to Aliwal North, Caledon River upstream of Welbedacht Dam ,Caledon River Gariep Dam to Welbedacht Dam.*
- *Upper Orange (West), Orange River Vanderkloof Dam to Gariep Dam, Canals ex Vanderkloof Dam, Lower Riet canal/Scholtzburg, Vanderkloof Dam to Douglas (Marksdrift weir), Modder River GWS, Riet River upstream of the Kalkfontein Dam (Tierpoort IB), Riet River downstream from the Kalkfontein Dam (Kalkfontein IB), Douglas weir to Orange Vaal Rivers confluence (Orange Water).*
- *Lower Orange (East), Orange River Marksdrift to Boegoeberg.*
- *Lower Orange (West), Boegoeberg and Upington and Keimoes canals, Boegoeberg to Neusberg river abstraction, Kakamas to Augrabies canals, Neusberg to Augrabies and to Namibian Border abstraction, Namibian Border to Vioolsdrift North and South, Vioolsdrift South canal – Vioolsdrift North and Ausenkjer, Vioolsdrift to Fish River confluence, Alexander Bay.*

Based on certain assumptions described in the report, the cropping pattern and area of each crop for the five regions, and used in the econometric model, are estimated as follows:

Crops	Upper Orange East	Upper Orange Central	Upper Orange West	Lower Orange East	Lower Orange West	Total
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
Maize	1 715	2 813	25 664	4 309	1 698	36 199
Grapes (Table)	-	-	342	-	5 336	5 678
Drybean	-	-	3 422	2 758	1 287	7 467
Pasture/lucerne	10 632	9 141	6 843	1 034	3 768	31 418
Vegetable	686	-	1 369	689	-	2 744
Potato	343	-	4 106	689	-	5 138
Wheat	2 057	2 110	34 219	8 619	3 699	50 704
Deciduous Fruit	1 715	-	-	-	-	1 715
Grapes (Wine)	-	-	-	-	5 839	5 839
Grape (Dry)	-	-	-	-	21 712	21 712
Total	17 148	14 064	75 965	18 098	43 339	168 614

The crop production budget data applied in the Econometric Model are summarised as follows:

Crop	Gross Income (R/ha)	Interest on Working Capital (R/ha)	Variable Cost (R/ha)	Fixed Cost (R/ha)	Net Farm Income (R/ha)
Maize	26 000	797	20784	3 613	4 206
Apples	247 500	4 069	130 413	7 424	42 931
Wheat	17 640	319	13 060	2 622	4 578
Dry beans	17 400	318	12 983	2 613	3 261
Lucerne	24 000	1 569	20 588	4 636	4 641
Potatoes	129 960	2 315	91 696	3 432	32 517
Cabbages	58 725	2 133	41 128	3 594	11 870
Table Grapes	294 373	4 875	170 701	8 861	86 405
Wine Grapes	50 018	2 757	26 945	8 507	11 808
Raisin (Dry Grapes)	86 215	3 475	42 736	7 956	32 048

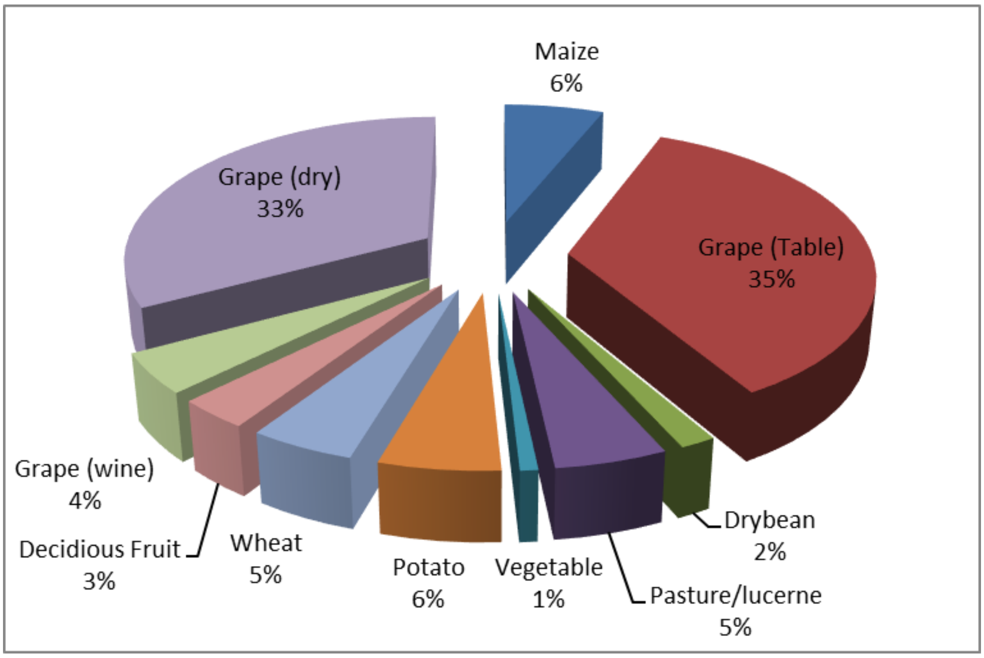
Irrigated agriculture supports in total 34 520 direct jobs and provides payment to low income households of R1 912.1 million per annum. The average payment to low income households is around R 54 000 per household per annum, accepting that the average number of employees per household is two.

Of the 34 520 jobs, it is estimated that 10 097 are permanent employees and 24 423 are seasonal workers. In the following figures the distribution of jobs between the different crops are illustrated as well as the payment contribution to low income households.

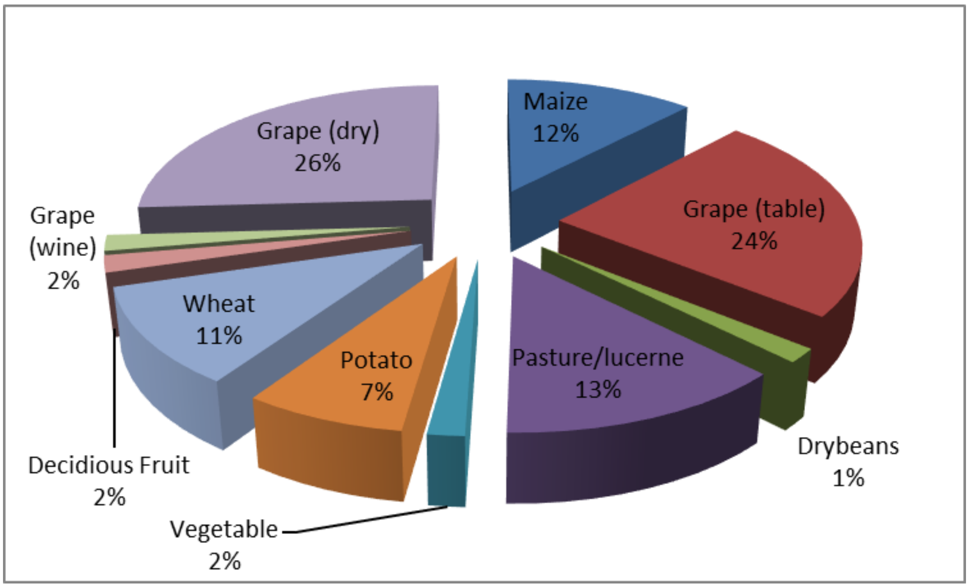
The macro-economic impacts of irrigated agriculture in the Orange River is summarised as follows:

	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
	Direct	**Indirect and Induced**	**Total**	**Direct**	**Indirect and Induced**	**Total**	**Total**	**Total**	**Medium**	**Low**
Maize	343.3	686.4	1029.7	2 116	6 611	8 727	2108.8	858.9	628.7	230.2
Grape (Table)	997.1	793.0	1790.1	12 243	7 047	19 290	2599.4	1223.8	767.4	456.4
Drybean	53.4	83.0	136.4	562	820	1 382	253.9	108.8	78.7	30.1
Pastures	324.5	601.7	926.2	1 752	5 901	7 653	1846.7	740.8	491.7	249.1
Vegetable	45.1	89.1	134.2	282	753	1 035	270.9	119.3	87.4	31.9
Potato	228.7	397.8	626.5	1 889	3 825	5 714	1238.2	484.5	345.0	139.5
Wheat	376.8	626.4	1003.2	1 647	5 436	7 083	1951.9	789.1	580.4	208.7
Deciduous Fruit	81.2	67.5	148.7	1 138	579	1 717	214.5	124.5	88.0	36.5
Grape (Wine)	195.4	68.5	263.9	1 542	597	2 139	239.3	132.9	98.7	34.2
Grape (dry)	1263.2	788.5	2051.7	11 349	6 822	18 171	3433.4	1559.9	1064.4	495.5
Total	**3908.7**	**4201.9**	**8110.6**	**34 520**	**38 391**	**72 911**	**14157.0**	**6142.5**	**4230.4**	**1912.1**

Contribution to employment (numbers)

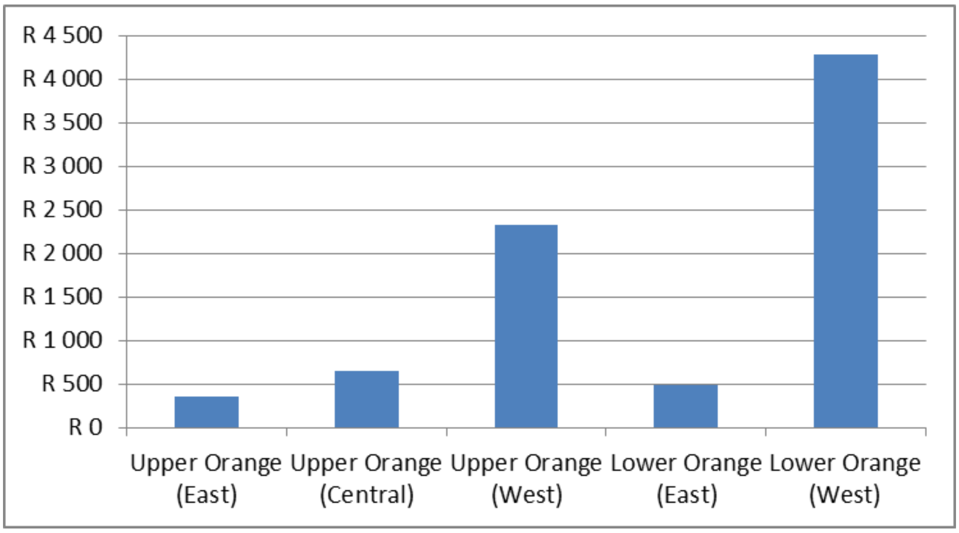


Contribution to low income households (R/annum)



The total GDP contribution, of irrigated agriculture, to the South African economy is estimated at R8 110 million, nearly 5% of the total contribution of Agriculture to the national economy. Of this contribution, R3 908 million applies directly to the irrigation area. The figure below shows the very large contribution of the Lower Orange (West) region compared to the other regions.

Comparison of the GDP contribution (R' million) of the different regions



The capital generated by the irrigation activities is estimated at about R15 900 million.

Conclusion for Irrigation Value

The above analysis shows the value of the irrigation water of the Orange River. It contributes to the growth of the region in terms of GDP, sustains over 72 000 jobs in total throughout the national economy - some within the region and some outside. It also makes a major contribution to poverty *alleviation in terms of payments to low income households and the creation of direct jobs in the area.*

Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River

Irrigation Demands and

Water Conservation/Water Demand Management (Task 8)

and

Value of Irrigation Water (Task 9)

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Development of a Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River

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1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for detailed water resource management strategies as part of their Internal Strategic Perspective (ISP) planning initiative, which recommended studies to identify and formulate intervention measures that will ensure enough water can be made available to supply the water requirements for the next three to four decades.

The DWA Directorate: National Water Resource Planning (NWRP) therefore commenced the strategy development process in 2004 by initially focusing on the water resources supporting the large metropolitan clusters, followed by the systems supplying the smaller urban areas to systematically cover all the municipalities in the country.

As part of this process the need for the Reconciliation Strategy Study for the Large Bulk Water Supply Systems in the Orange River was also defined. Given the location of the Orange River System and its interdependencies with other WMAs as well as other countries (see study area description in **Section 1.3**), various water resource planning and management initiatives compiled during the past few years as well as those currently in progress will form an integral part of the strategy development process.

Major water resource infrastructure in the study area are the Gariep and Vanderkloof dams with associated conveyance conduits supporting large irrigation farming in the provinces of the Free State, Northern Cape and the Eastern Cape - through the Orange-Fish Tunnel. This system is currently almost in balance.

The Caledon-Modder System supplies water to the Mangaung-Bloemfontein urban cluster (largest urban centre in the study area). The 2 200 km long Orange-Senqu River is the lifeline for various industries, mines, towns and communities located along the way until the river discharges into the Atlantic Ocean in the far west at Alexander Bay.

Since 1994, a significant driver of change in the water balance of the Orange River System was brought about by the storing of water in Katse Dam as the first component of the multi-phase Lesotho Highlands Water Project (LHWP). Currently Phase 1 of the LHWP (consisting of Katse, and Mohale dams, Matsoku Weir and associated conveyance tunnels) transfers 780 million cubic metres per annum via the Liebenbergsvlei River into the Vaal Dam to augment the continuously growing water needs of the Gauteng Province. Phase 2 of the LWHP comprising of Polihali Dam and connecting tunnel to Katse Dam is already in its planning stages and is expected to be in place by 2022. Flows that are currently still entering into Gariep and Vanderkloof dams wil then be captured by Polohali Dam, thus reducing the inflow to Gariep and Vanderkloof dams. This will result in a reduction in yield of the Orange River Project (Gariep and Vanderkloof dams) to such an extent that shortages will be experienced in the ORP system. Some sort of yield replacement is then required in the Orange River to correct the yield versus demand imbalance in the ORP system.

The above description illustrates the complex assortment of interdependent water resources and water uses which spans across various international and institutional boundaries that will be considered in the development of the Orange River Reconciliation Strategy.

1.2 MAIN OBJECTIVES OF THE STUDY

The objective of the study is to develop a reconciliation strategy for the bulk water resources of the Orange River System, to ensure that sufficient water can be made available to supply the current and future water needs of all the users up to the year 2040. This Strategy must be flexible to accommodate future changes in the actual water requirements and transfers, with the result that the Strategy will evolve over time as part of an on-going planning process.

Appropriate integration with other planning and management processes, as well as cooperation among stakeholders, will be key success factors in formulating coherent recommendations and action plans.

The outcomes of the Strategy will be specific interventions with particular actions needed to balance the water needs with the availability through the implementation of regulations, demand management measures, as well as infrastructure development options.

1.3 STUDY AREA

As depicted in **Figure A-1** of **Appendix A** (Map of study area), the study will focus on the water resources of the Upper and Lower Orange River Water Management Areas (WMAs), while also considering all the tributary rivers and transfers affecting the water balance of the system. This core area forms part of the Orange-Senqu River Basin, which straddles four International Basin States with the Senqu River originating in the highlands of Lesotho, Botswana in the north eastern part of the Basin, the Fish River in Namibia and the largest area situated in South Africa.

The focus area of the study comprises only the South African portion of the Orange River Basin, excluding the Vaal River Catchment. The Vaal River is an important tributary of the Orange River, but since the Vaal River Reconciliation Strategy has already been developed, the Vaal River Catchment will not form part of the study area. However, strategies developed for the Vaal River System that will have an impact on the Orange River, will be taken into account as well as the impacts of flows from the Vaal into the Orange for selected Integrated Vaal system scenarios.

The Orange River is an international resource, shared by four countries i.e. Lesotho, South Africa, Botswana and Namibia. Any developments, strategies or decisions taken by any one of the countries that will impact on the water availability or quality in South Africa must be taken into account and will form part of this study. The opposite is also applicable. If this strategy plans anything in South Africa that will impact on any of the other countries, this impact must be considered as part of this study in terms of South Africa's international obligations.

The Orange River, the largest river in South Africa, has its origin in the high lying areas of Lesotho. The river drains a total catchment area of about 1 million km^2, runs generally in a westerly direction and finally discharges into the Atlantic Ocean at Alexander Bay.

The Caledon River, forming the north-western boundary of Lesotho with the Republic of South Africa (RSA), is the first major tributary of the Orange River. The Caledon and the Orange (called the Senqu River in Lesotho) rivers have their confluence in the upper reaches of the Gariep Dam.

Other major tributaries into the Orange River are:

- The Kraai River draining from the North Eastern Cape.
- The Vaal River joining the Orange River at Douglas.
- The Ongers and Sak Rivers draining from the northern parts of the Karoo.
- The Molopo and Nossob Rivers in Namibia, Botswana and the Northern Cape Province have not contributed to the Orange River in recorded history as the stream bed is impeded by sand dunes.
- The Fish River draining the southern part of Namibia.

A separate study was also done for the Greater Bloemfontein Area i.e. Water Reconciliation Strategy Study for Large Bulk Water Supply Systems: Greater Bloemfontein Area with it's follow up continuation study currently in process. The recommendations of this strategy and its continuation study will also be taken into account in this study.

Although the Senqu River Catchment in Lesotho does not form part of the focus study area, the development in this catchment impacts directly on the water availability in the study area.

The South African portion of the Orange River Basin is currently divided in two Water Management

Areas, i.e. the Upper and Lower Orange WMAs. The Upper WMA stretches from the headwaters of the Caledon River and Lesotho boundary down to the confluence of the Vaal River and the Lower Orange WMA from this point to the sea. (See **Figure A-1 in Appendix A**). It should be noted that the DWA recently proposed that the two WMAs are managed as a unit.

1.4 PURPOSE OF THE REPORT

1.4.1 Water Demands

The purpose of the Water Demand component of this report is to determine and understand current and future irrigation demands. Irrigation is by far the largest consumer of the limited water resources of the catchment and is therefore a critical component of the reconciliation strategy.

1.4.2 Water Conservation and Water Demand Management (WC/WDM)

The purpose of the Water Conservation and Water Demand Management (WC/WDM) component of this report is to evaluate the contribution that irrigation water conservation water and water demand management can make towards the reconciliation strategy for the bulk water resources of the Orange River.

The irrigation sector is the largest water user in the Orange River catchment, with an estimated requirement of 2 366 million m^3/a comprising 52% of the water requirements within the Upper and Lower Orange catchment and 61% of the water requirements within the Orange River Project. Any percentage reduction in water use in this sector will therefore have a significant effect on the total water requirements within the catchment.

1.4.3 Value of Irrigation Water

The purpose of the Value of Irrigation Water component of this report is to estimate the regional economic benefits accruing from irrigation water, which include employment creation and the direct, indirect and induced economic benefits that can be attributed to agricultural production in the study area.

2 METHODOLOGY

Irrigation is by far the largest consumer of the limited water resources of the catchment and therefore receive detailed evaluation and assessments. These were based on detailed worked already carried out by previous studies, recent data from existing data bases in particular from the current ongoing validation and verification process in the Upper Orange as well as discussions with local DWA officials and Water User Associations/Irrigation Boards to include recent changes and to clarify anomalies when comparing data from different sources.

The findings of this report are therefore based on the following:

- Reports from previous studies (reference has been made to the Task 2 data-base).
- The ORASECOM study which did fairly detailed work to locate irrigation areas using satellite imagery.
- The ORASECOM study on Water Conservation and Water Demand Management which has been referred to extensively for the WC/WDM component of the report. The study which was completed in 2011and included:

  (a) Workshops with regional stakeholders in the irrigation sector including Water User Association and Irrigation Board representatives, leading farmers and DWA representatives and

  (b) Discussions with all the main irrigation Boards and Water User Associations in the Basin during which the WC/WDM practices, issues and views where identified and recorded.
- WARMS database.
- Databases developed during the validation and verification process.
- Discussion with local DWA officials and Water User Associations/Irrigation Boards.
- Transfer volume required for irrigation in the Eastern Cape.
- There are indications of possible unlawful irrigation abstractions along the Orange and its major tributaries. Actual irrigation areas from the Validation and Verification Study as well as satellite imagery identified irrigation areas from the ORASECOM study, have been used to compare with the scheduled irrigation areas, to highlight potential areas of unlawful irrigation water use.

With respect to **Irrigation Water Demands**, a summary database spread-sheet, showing present irrigation water use from various data sources, has been prepared and a consolidated and a revised schedule has been prepared for the Basin.

With respect to **WC/WDM**, the approach has been to identify constraints to increased water savings, the role of Institutional (water management) structures in WC/WDM, the constraints facing irrigators and irrigation water supplies, with respect to water saving and improved water-use efficiency as well as the identification of specific interventions to improve water use efficiency (and consequently tangible water savings) and specific recommendations for their implementation.

A broad estimate of irrigation water savings, that may practically be achieved, has also been made.

With respect to the value of irrigation water, an Economic Baseline Model was firstly used to show the direct local benefits of irrigation water usage such as direct income, employment and income received by households. A Social Accounting Matrix based model (SAM), which includes the relevant economic multipliers for the various sectors, was then used to estimate the regional economic benefits accruing from irrigation water use. These regional benefits were then added to the financial benefits and the overall real value of the irrigation water was determined.

3 IRRIGATION WATER DEMAND

The methodology used to review current and projected irrigation water use is as follows:

Identify previous studies that have been performed.

Identify other additional sources of data.

Identify new or incomplete studies that have information that is available and is reliable.

Review the results of these studies and data sources and summarise them on a data base spread sheet showing present and projected irrigation water use, and current cropping regimes.

Compare the results of the studies and data sources and highlight the differences.

Seek explanations for major differences.

It must be emphasised that this study did not involve any original research or field work other than communicating with certain key local role-players from the DWA and Water User Associations and Irrigation Boards.

3.1 PREVIOUS STUDIES

The following previous **studies** were identified as being pertinent to identifying the irrigation demands:

- Orange River Re-planning Study (ORRS).
- Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan (ORASECOM).
- First Annual State of Water Resources Report (1 April 2010 – 31 March 2011) published by

the Government of the Kingdom of Lesotho in June 2012.

3.2 OTHER DATA SOURCES

Other data sources were also reviewed. These sources are:

- Orange River Project – Annual Operating Analysis Demand Spreadsheet 2012 (WRP 2012).
- WARMS database (WARMS).
- Local knowledge of DWA officials and Water User Associations / Irrigation Boards.

3.3 NEW / INCOMPLETE STUDIES

The NWA makes provision for a qualifying period during which water users had the opportunity to register their existing lawful water use. DWA established the WARMS database to capture the data emanating from the registration process. The qualifying period for registering existing lawful water use came to an end in 1998. The validation process starts by studying satellite imagery from 1998 to identify possible irrigated areas that existed prior to 1998, and studying satellite imagery from 2010 to determine the current situation. The results of the satellite data for 1998 and 2010 is in general an over estimation of the areas under irrigation, as it identifies cropped areas that could possibly be under irrigation. Stakeholder and farmers are then consulted in a two-step consultation process to pare down the satellite data to actual areas under irrigation prior to 1998 and during 2010. Once stakeholders and farmers are in agreement regarding the areas that were under irrigation prior to 1998 and during 2010, then the verification process is started to determine whether the areas are existing lawful use. The verification process is a time consuming process and will take a number of years to complete.

Progress with the V&V UOWMA study is currently at a point where 80-85% of the data for 1998 has been validated. Although not yet verified, we believe the results give estimates of existing lawful use that are more accurate than current estimates. We have therefore extracted estimates from the V&V UOWMA study data to predict current demands in the Upper Orange Catchment.

4 IRRIGATION WATER DEMAND ANALYSIS

Each of the previous studies beginning with the ORRS study used an approach of dividing the Orange River and major tributaries into 22 seperate River Reaches, each with well-defined starting and ending points. We have adopted the same river reaches for this study with some minor modifications to cater for the findings of the ORASECOM study. **Figure 4.1** shows the river reaches for the Upper Orange River Catchment Management Area and **Figure 4.2** the reaches for the Lower Orange River Catchment Management Area.

Table 4.1 shows the total irrigation water volume and irrigated area estimates for the Upper Orange and Lower Orange Catchment Management Areas and cross-border demands:

Table 4.1: Summary of WMA's and cross border demands

Catchment	Field requirement (mill. m^3/a)	Irrigated areas (ha)
Upper Orange (Reaches 1-14)	846.0	99 647
Lower Orange (Reaches 15-22)	818.0	63 109
Molopo	1.9	127
Lower Orange Tributaries	19.8	1320
Total Orange	1684.8	164 203
Eastern Cape	577.2	49 565
Total RSA	2262.0	213 763
Lesotho	20.6	2 640
Namibia Fish River	47.5	2 520
Namibia Orange River	35.2	2 961
Total demand	**2365.3**	**221 889**

Table 4.2 shows the irrigation water volume and irrigated area estimates for each of the 22 River Reaches in the Upper Orange and Lower Orange Catchment Management Areas and cross-border elements of the catchment.

Table 4.3 compares the demands and irrigated area (of the 22 reaches) adopted for each study/database and the proposed demands and areas proposed for this study.

Previous studies and available databases express total water use either on a volumetric basis (million m^3/annum) or an area basis (ha). **Table 4.3** and the complete spreadsheet contained in the CD shows water use on both a volumetric and area basis for each study/database. Where the study/database used volume (million m^3/annum) as basis, the irrigated area was calculated by dividing the volume by the DWA allocation in m^3/ha/annum for that reach. Where the study/database used areas (ha), the volume was calculated by multiplying the area by the DWA allocation in m^3/ha/annum for the reach. For irrigated areas falling outside of the formal schemes, the allocation for the scheme with similar climatic conditions (usually the closest scheme) to the area in question, was used to calculate volumes/area. Data that were obtained from the Validation/Verification study provided both areas and volumes. The volumes from the Validation/Verification study were based on the crop distribution and related crop water requirements determined by using SAPWAT. At this stage on the irrigation related data from the Validation/Verification Study based on the qualifying period (1998) was used. The data representative of the 2010 development level is not yet available. It is however expected that 2010 data should be available for use in the development of the final strategy.

The irrigation areas and related volumes recommended to be used for the purpose of the Orange Reconciliation Study were based mainly on a combination of the Validation/Verification study for the Upper Orange WMA and the latest data from the DWA Upington Regional office for the Lower Orange WMA along the Orange River mainstream.

Table 4.2. Irrigation water volume and irrigated area estimates for each of the 22 River Reaches in the Upper and Lower Orange CMAs and cross-border catchment components

RIVER REACH	DESCRIPTION	IRRIGATION DEMANDS (million m³/a)	IRRIGATION AREAS (ha)
1	Caledon River: U/S Welbedacht Dam	40.3	9 930
2	Caledon River: Welbedacht Dam to Gariep Dam	36.5	5 835
3	U/S Aliwal North D/S Oranjedraai	6.6	877
4	Aliwal N to Gariep Dam	52.5	8 229
5	U/S Aliwal N	28.0	6 341
6	Gariep dam to Vanderkloof dam	27.7	3 121
7	Canals ex Vanderkloof dam	195.1	17 678
8	Scholzburg and Lower Riet IBs	50.2	4 564
9	Vanderkloof-Marks drift	187.4	17 455
10	Krugerdrift dam to Tweerivier gauge - Modder River	52.5	7 004
11	Tierpoort Dam to Kalkfontein Dam: Tierpoort IB	8.1	1 018
12	Kalkfontein Dam to Riet River Settlement: Kalkfontein WUA (canal)	56.7	6 187
14	Douglas weir to Orange-Vaal Conf. (Orange water)	104.3	11 410
15	Orange - Vaal Confl. to Boegoeberg dam	174.0	17 236
16	Boegoeberg dam to Gifkloof weir	161.2	10 744
17	Gifkloof weir to Neusberg	222.8	14 855
18	Neusberg to Namibian border	180.2	12 016
19	Namibia border to Onseepkans weir	28.6	1 905
20	Onseepkans weir to Vioolsdrift weir	33.6	2 237
21	Vioolsdrift to Orange-Fish Confluence	9.0	600.0
22	Orange-Fish confluence to river mouth	8.3	553
Sub-Total	**Upper Orange (reaches 1-14)**	**846**	**99 647**
Sub-Total	**Lower Orange (reaches 15-22)**	**818**	**63 109**
	Molopo	1.9	127
	Lower Orange Tributaries	19.8	1320
Total	**Orange River**	**1 685**	**164 203**
	Eastern Cape	577.2	49 565
Total	**RSA demand**	**2 262**	**213 768**
	Lesotho	20.6	2 640
	Namibia Fish River	47.5	2 520
	Namibia main Orange	35.2	2 961
Total demand		**2 366**	**221 889**

The irrigation within the Lower Orange Tributaries and the Molopo River catchment were obtained from the ORASECOM IWRMP Phase II study, with the Namibian irrigation data from recent information obtained from the current IWRMP Phase III ORASECOM Study. The irrigation assumed for Lesotho was obtained from the "First Annual State of Water Resources Report (1 April 2010 – 31 March 2011)" published by the Government of the Kingdom of Lesotho in June 2012.

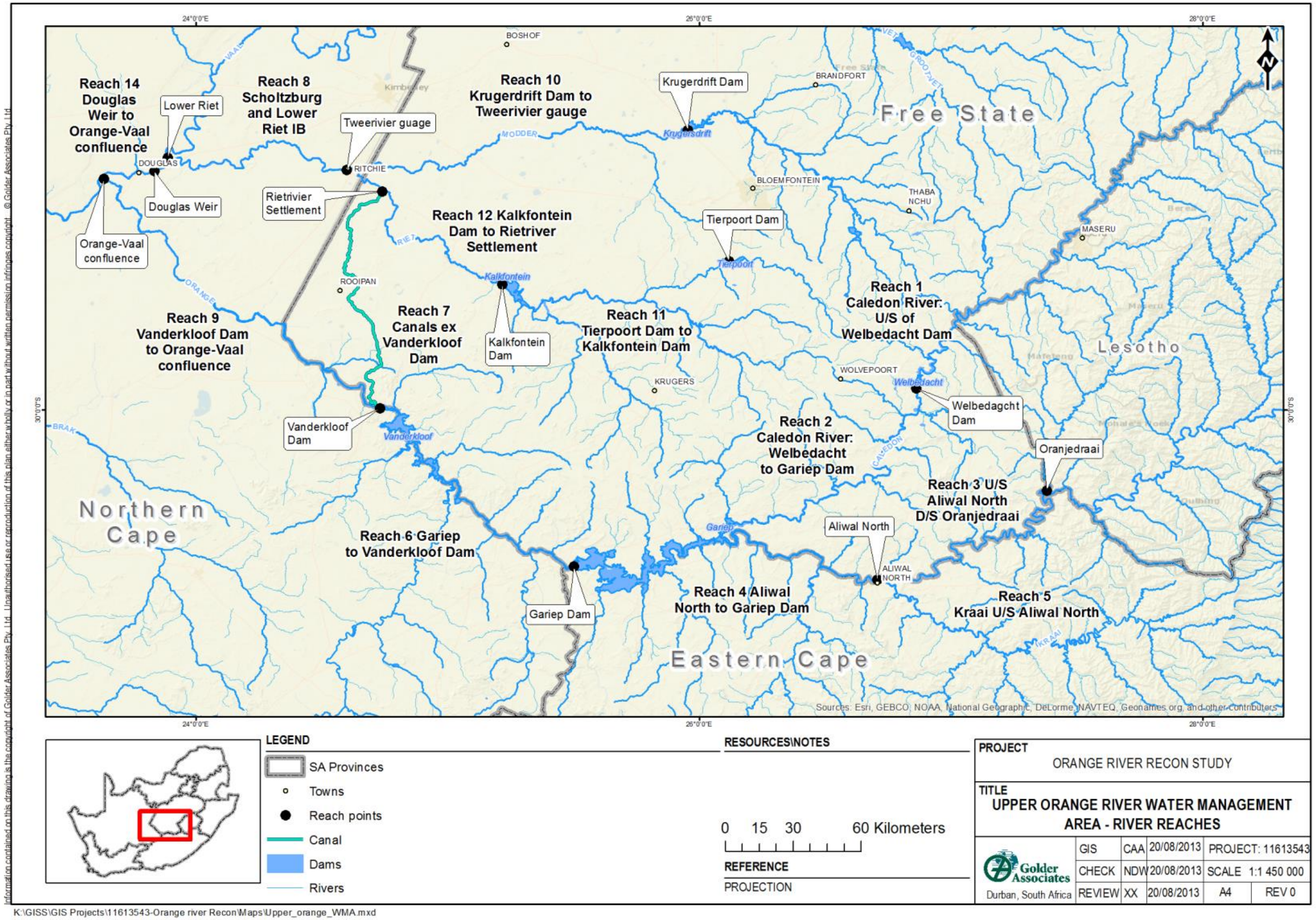


Figure 4.1: Upper Orange River reaches

(Reaches 1-14)

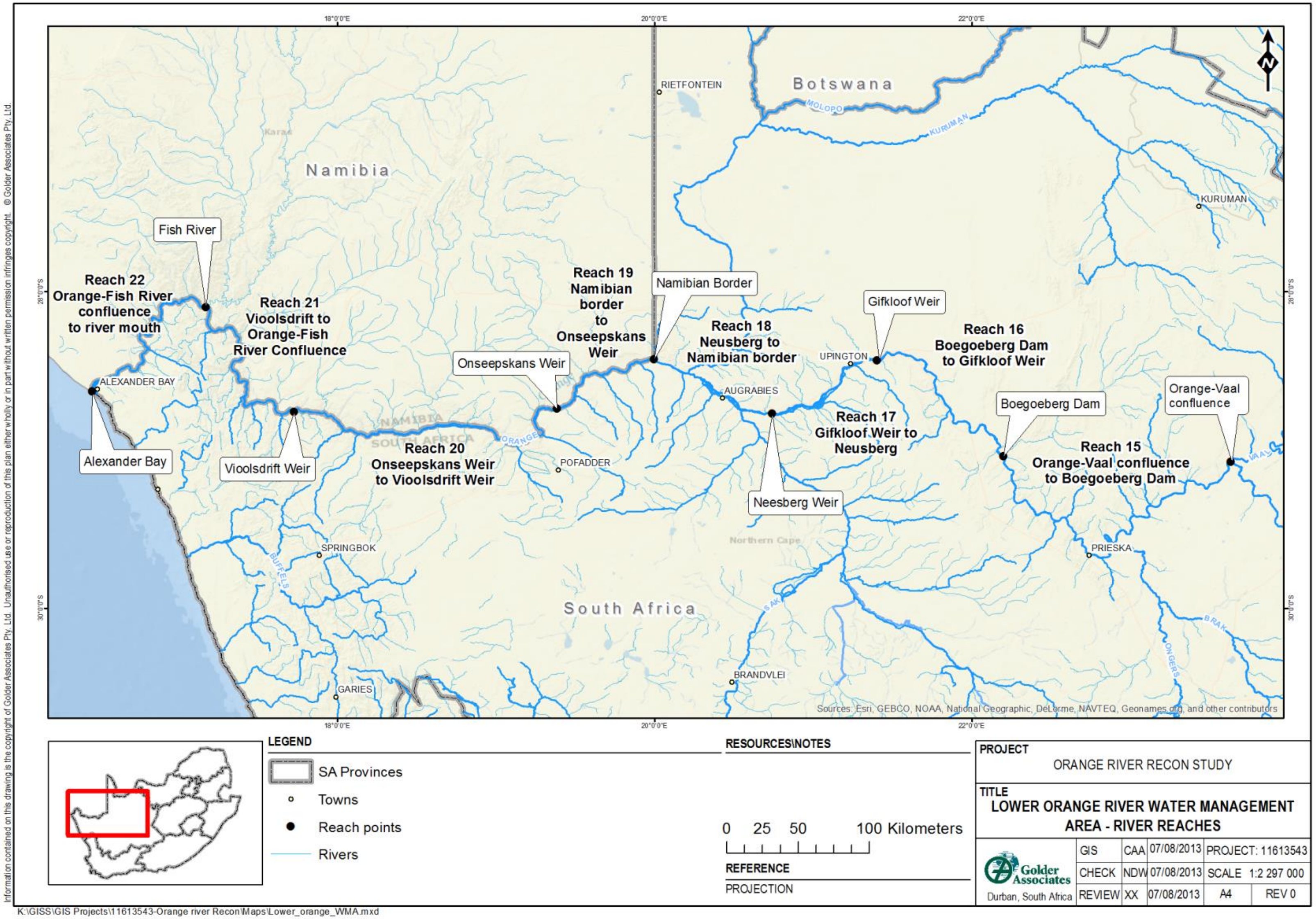


Figure 4.2: Lower Orange River reaches

(Reaches15-22)

Table 4.3: Summary of demands adopted by study/database

REACH NO.	DESCRIPTION OF REACH	WATER ALLOC- ATION (m³/ha/a)	FIELD IRRIGATION REQUIREMENT (mill. M³/a)								IRRIGATED AREAS (ha)							
			WRP (2012)	ORECON Proposed	ORRS		ORASECOM			DWA UPINGTON	WRP (2012)	ORECON Proposed	ORRS		ORASECOM			DWA UPINGTON
					Sched.	Act	WARMS (FROM ORSECOM)	ORRS Sch ha (FROM ORSECOM)	REMOTE SENSING				Scheduled	Act	WARMS (FROM ORSECOM)	ORRS Sch ha (FROM ORSECOM)	REMOTEEN SING	
1	Caledon River: U/S Welbedacht Dam	7 620	71.4	40.3	11.0	28.1	65.1	11.0	25.6		9 364.8	9 930	1 440.0	3 692.0	8 541.2	1 440.0	3 358.6	
2	Caledon River: Welbedacht Dam to Gariep Dam	8 000	18.2	36.5	38.2	27.9	49.1	26.2	25.6		2 275.0	5 835	4 775.1	3 482.0	6 142.6	3 280.4	3 199.3	
3	U/S Aliwal North D/S Oranjedraai	8 000	12.6	6.6	1.9	1.9	8.5	12.6	2.5		1 575.0	877	1 574.6	1 550.0	1 061.6	1 575.0	314.4	
4	Aliwal N to Gariep Dam	8 000	43.3	52.5	20.5	15.5	23.8	20.5	11.7		2 562.5	8 229	2 559.7	1 940.0	2 970.4	2 560.0	1 465.5	
5	Kraai U/S Aliwal N	7 620	11.6	28.0	0.0	0.0	7.4	7.6	5.3		1 524.9	6 341	0.0	0.0	969.5	999.0	699.1	
6	Gariep dam to Vanderkloof dam	11 000	28.4	27.7	25.5	25.5	26.6	26.0	25.8		2 580.9	3 121	2 316.0	2 316.0	2 418.3	2 361.0	2 345.2	
7	Canals ex Vanderkloof dam	11 000	201.7	195.1	191.0	191.0	3.5	191.2	49.2		20 914.9	17 678	17 377.8	17 378.0	322.1	17 378.0	4 474.4	
8	Scholzburg and Lower Riet IBs	9 140	49.4	50.2	41.8	41.8	0.0	0.0	0.0		5 408.1	4 564	4 574.2	4 575.0	0.0	0.0	0.0	
9	Vanderkloof Dam to Orange-Vaal conf:	10000 to11000	170.0	187.4	149.8	149.8	334.0	155.9	301.7		15 845.8	17 455	14 174.1	14 173.0	31 461.5	14 174.0	27 865.3	
10	Krugerdrift dam to Tweerivier gauge - Modder River	8 640	29.4	52.5*	29.1	28.9	197.2	30.8	237.3		3 402.8	7 004	3 364.4	3 340.0	22 823.5	3 564.0	27 470.1	
11	Tierpoort Dam to Kalkfontein Dam: Tierpoort IB	9 000	6.4	8.1*	6.4	6.0	0.0	0.0	0.0		711.1	1 018	708.0	665.0	0.0	0.0	0.0	
12	Kalkfontein Dam to Riet River Settlement: Kalkfontein WUA (canal)	11 000	33.5	56.7*	33.5	33.5	74.7	46.6	58.3		3 510.0	6 187	3 046.3	3 046.0	6 792.6	4 234.0	5 303.2	
14	Douglas weir to Orange-Vaal Conf. (Orange water)	9 140	104.3	104.3	74.2	66.6	98.3	190.7	270.5		11 410.3	11 410	8 113.0	7 285.0	10 755.0	20 869.0	29 594.7	
15	Orange - Vaal Conf to Boegoeberg dam	10 000	176.2	174.0	68.5	68.5	380.4	68.5	173.8	174.0	17 615.0	17 236	6 852.9	6 852.0	38 785.1	6 853.0	17 728.7	17 236.2
16	Boegoeberg dam to Gifkloof weir	15 000	145.2	161.2	129.3	128.7	17.4	129.3	147.1	161.2	9 681.3	10 744	8 623.3	8 578.0	1 158.6	8 623.0	9 806.8	10 813.4
17	Gifkloof weir to Neusberg	15 000	236.8	222.8	197.4	197.4	205.8	197.4	173.0	222.8	15 785.3	14 855	13 162.6	13 163.0	13 723.0	13 163.0	11 535.5	14 855.3
18	Neusberg to Namibian border	15000	168.8	180.2	156.0	156.0	339.4	146.0	494.9	180.2	11 252.0	12 016	10 397.9	10 398.0	27 012.3	9 731.0	36 126.0	12 016.1
19	Namibia border to Onseepkans weir	15000	41.3	28.6	11.0	11.0	23.0	15.7	13.7	28.6	4 275.9	1 905	1 044.9	1 045.0	1 535.0	1 045.0	912.8	1 905.3
20	Onseepkans weir to Vioolsdrift weir	15000	0.0	33.6	12.5	5.3	0.0	0.0	4.8	33.6	0.0	2 237	835.3	351.0	0.0	0.0	317.0	2 237.8
21	Vioolsdrift to Orange-Fish Confluence	15000	9.0	9.0	13.3	10.5	0.0	0.0	0.0	7.5	2 038.0	600.0	883.8	703.3	0.0	0.0	0.0	498.3
22	Orange-Fish confluence to river mouth	15000	11.4	8.3	11.4	11.3	12.7	18.0	7.8	8.3	761.1	553	761.1	750.0	846.3	1 203.0	522.6	552.7
	Sub-Total Upper Orange (Reaches 1-14)		780.3	846	622.7	616.4	888.2	719.1	1 013.6	0.0	83 941.1	99 647	64 023.2	63 442.0	94 258.2	72 434.4	106 089.7	0.0
	Sub-Total Lower Orange (Reaches 15-22)		788.7	818	599.5	588.6	978.8	575.0	1 015.1	816.1	61 408.7	63 109	42 561.8	41 840.3	83 060.3	40 618.0	76 949.4	60 115.1
	Molopo	15000		1.9								127						
	Lower Orange Tributaries	15000	0	19.8								1320						
	Total Orange River		1 569	1 685	1 222.2	1 205.0	1 867.0	1 294.1	2 028.7	816.1	145 349.8	164203	106 585.0	105 282.3	177 318.5	113 052.4	183 039.1	60 115.1
	Eastern Cape		577.2	577.2							49 565	49 565						
	Total RSA demand		2 146	2 262							194 915	213768						
	Lesotho		8.4	20.6							1080	2 640						
	Namibia Fish		47.5	47.5							2 520	2 520						
	Namibia main Orange		44.4	35.2							2 961	2 961						
	Total demand		2 246	2 366							201 476	221889						

V&V UOWMA study have been added for the first time

4.1 IRRIGATION GROWTH PROJECTIONS TO 2040

The bulk of existing irrigation in the Orange River Project in the RSA falls within proclaimed schemes. DWA therefore has control over future growth. Very little irrigation growth within the existing commercial farming areas of the Orange River Project is projected to take place by 2040. The only growth in irrigation is expected to emanate from Government policy to make water allocations available to Resource Poor Farmers (RFPs). The total growth projected for RPF's is 130.9 million cubic meters per annum by 2025 for the development of 12 000ha.

Growth projections for Namibia are centred on the Neckartal Dam development on the Fish River and further development adjacent to the Orange River. The Neckartal Dam development demand is projected to increase to a maximum of 100 million m^3/annum by 2027, while the demand for further development from the Orange River is projected to increase by 22.5 million m^3/annum by 2020. The total expected demand growth for Namibia by 2027 will be 122.5 million m^3/annum.

4.2 DEVELOPMENT LEVEL DATA FOR 2010 FROM V&V UOWMA STUDY

The V&V UOWMA study data for 2010 has been collected but has not yet been processed. Preliminary analysis of this data shows a significant increase in the areas under irrigation from the ORRS data, WRP 2012 data, and the V&V UOWMA 1998 data. The increases are an indicator that unlawful expansion has taken place in the Upper Orange WMA since 1998. The exact extent of this increase can only be determined once the 2010 data has been processed.

4.3 EXPLANATION OF DIFFERENCES BETWEEN STUDIES IN IRRIGATION WATER USE AND IRRIGATION AREAS

As can be seen from **Table 4.3** some river reaches exhibit marked differences between studies/databases in volumes and areas. These differences can be explained as follows:

- The ORRS study concentrated on direct abstraction from the Orange River System either by formal schemes (IBs) or "diffuse irrigation" which was defined in the study as abstraction direct from the river by farmers that were not incorporated within a formal scheme. Irrigation from farm dams and springs was not accounted for.

- Subsequent to the ORRS study the NWA has resulted in the formation of a number of WUA which incorporate and consolidate several IBs into one larger management body. Some of the WUAs have expanded their allocations by either purchasing allocations from elsewhere or by taking up existing water rights under the NWA. The Orange Riet purchased 147 ha from the Eastern Cape, the Orange Vaal purchased 2 945 ha from elsewhere, and Kakamas expanded by 5 289 ha by purchase and taking up existing water rights.

- Only certain areas within the WARMS database have been validated and verified. The balance of WARMS is unvalidated and unverified and in a lot of cases represents farmers attempts to maximise their lawful use under the old Water Act. It is therefore an optimistic estimate for those areas not yet validated and verified.

- The ORASECOM study also used satellite imagery to identify potentially irrigated areas. Satellite imagery uses actively growing vegetation “signatures” to identify areas which are potentially irrigated. The ORASECOM study identifies potentially irrigated areas, including irrigation from smaller tributaries, farm dams; springs and boreholes. Satellite imagery without ground-truthing will generally either, overestimate irrigated areas in high rainfall areas as rain-fed fields are mistaken for irrigated fields, or under estimate irrigated areas in low rainfall areas where certain irrigated fields may be fallow and mistaken for areas not being irrigated. The ORASECOM study exhibits large differences in reaches 7, 8, 9, 10, 14 and 18 from WRP 2012 and ORRS. Diffuse irrigation from tributaries, dams, boreholes and springs are not included in the ORRS and WRP (2012) while ORASECOM does include diffuse irrigation. It is to be expected that ORASECOM will show larger areas under irrigation; however this cannot explain the very large differences in some reaches. It appears that some of the reach boundaries used by the ORASECOM study do not correspond with those used by ORRS and WRP (2012). The differences are highlighted in **Table 4.3** below:

Table 4.3: Differences between ORECONS and ORASECOM in certain Reaches

Reach	Description	ORECONS proposed (ha)	ORASECOM (ha)
7	Canals ex Vanderkloof dam	17 678	4 474
8	Scholtzburg & Lower Riet	4 564	0
9	Vanderkloof to Orange Vaal Confluence	17 455	27 865
10	Krugersdrift Dam Tweerivier gauge – Modder River	7 004	27 865
14	Douglas Weir to Orange Vaal Confluence	11 410	29 594
18	Neusberg to Namibian border	12 016	36 126

The differences can be explained as follows:

- Reach 7: ORECON proposed includes the Riet River Settlement, Vanderkloof Main Canal, Ramah Canal and abstraction directly from the Orange Riet Canal. ORASECOM includes only abstraction direct from the Orange Riet Canal.
- Reach 8: ORASECOM included the figures for this reach into one of the other reaches.
- Reach 9: ORASECOM identified some diffuse irrigation from boreholes, dams and

springs for this reach but it would appear a significant increase in irrigation from the Orange River. Irrigation from the Ramah and Vanderkloof Main canal is also located in this area and is incorrectly in the ORASECOM study added to the irrigation supplied directly from the Orange River.

- Reach 10: ORASECOM identified a very large number of scattered diffuse irrigation between the Riet and Modder Rivers which includes both surface and groundwater irrigated areas. This area is known for large groundwater abstractions of irrigation purposes. The ORECON proposed irrigation however only refers to the irrigated areas using surface water as the resource.

- Reach 14: ORASECOM included irrigation on the Vaal and Riet rivers upstream of the Orange Vaal confluence. The areas on the Vaal are included in the Vaal Reconciliation study and therefore excluded from ORECONS, while areas on the Riet River have been included in Reach 7 for ORECONS

- Reach 18: ORASECOM identified areas of diffuse irrigation in the Brak River (Upper Sak River catchment) as well as the Renoster and Vis Rivers, and a significant area on the river boundaries upstream of the Renoster and Vis confluence. We are of the opinion that these fields are “opportunistic” in nature, meaning that in good rainfall years when there is water in the rivers and farm dams, then farmers will irrigate and in poor rainfall years they will not. The ORECONS proposed irrigation refers only to the irrigation supplied from the main Orange River along Reach 18. The irrigation located in the Sak and Hartbees rivers is included in the ORECONS proposed irrigation under Lower Orange Tributaries.

- Fortunately reaches 9 and 10 are included in the Upper Orange Validation study and accurate figures for these reaches will be available in the near future. The qualifying period data from the V&V study however indicate irrigation areas and demands close to the WRP 2012 demands.

- The ORASECOM study identified 1 456 ha under irrigation in close proximity to the Ongers and Brak Rivers. We are of the opinion that these fields are “opportunistic” in nature, meaning that in good rainfall years when there is water in the rivers, then farmers will irrigate and in poor rainfall years they will not. The Smartt Syndicate irrigation scheme located in this catchment is a good example of the severe shortage of water in this area.

- The Upper Orange Validation and Verification study currently underway uses satellite imagery to identify potentially irrigated areas, which are then validated on the ground, and then verified as existing legal use. The process identifies not only direct abstraction from Orange River but all irrigation in the catchment including irrigation from smaller tributaries, farm dams, springs and boreholes. This process accurately determines the existing legal use, cropping patterns and irrigation system types. The process is slow and time consuming. Approximately 80-85% of the qualifying areas (pre 1998) of the UOWMA has been validated to date but not yet verified. The latest (but still incomplete) validated figures from this study have been used to project future demands and are included as the

ORECONS Proposed requirements for the Upper Orange. This data shows a significant increase in the areas under irrigation from the ORRS data, WRP 2012 data, and the V&V UOWMA 1998 data. The increases are an indicator of probable unlawful irrigation expansion in the Upper Orange WMA since 1998.

- The WARMS database in DWA offices in Upington supports the figures in WRP 2012 being very similar except for reaches 21 and 22 where the figures are lower. This can be explained by the fact that DWA does not account for use in Namibia whereas the WRP 2012 figures do. DWA Upington is showing approximately 12 million m³/a higher demand for reach 18 than WRP 2012.

4.4 CROPPING PATTERNS

The only study containing detailed cropping patterns is the ORRS study. This study was completed in 1998 and the data is now 15 years old. During the ORASECOM study's Best Management Practice task, nine of the larger WUA/IB were visited. One of the questions asked of the WUA/IB management was what the current cropping patterns on the schemes were. In some cases, like the Orange Riet WUA, the data provided was detailed and accurate, while others were based on an estimate. Irrespective of how the cropping patterns were determined, when compared to the ORRS study it is clear that there have been major shifts in cropping patterns between July 1995 and February 2011 when the ORASECOM study was completed. The cropping patterns for the WUA/IB that were visited during the ORASECOM study obviously do not represent the whole of the Orange River. However, it is safe to assume that areas and schemes adjacent to the WUA/IBs visited, especially in the Lower Orange Water Management Area, will exhibit the same trend in shifting of cropping patterns. Accurate information on current cropping patterns is one area that requires further research. The Upper Orange Validation and Verification study currently underway will provide this data for the Upper Orange Water Management Area, while further research is required on the Lower Orange Water Management Area to accurately determine cropping patterns and trends. However, for the purposes of this study, a broad estimate of the present-day cropping patterns has been made, based on data provided by specific WUA's and IB's and regional crop marketing data (Department of Agriculture, Forestry and Marketing (2011). These estimates are outlined in **section 5.1.3** and **section 6**.

4.5 IRRIGATION WATER DEMAND SUPPLEMENTARY REPORT

Subsequent to the completion of this report, the Validation & Verification of the Upper Orange Water Management Area Study data for 2010 has been completed. The results of this study, with respect to 2010 validated data is presented in a supplementary report entitled "Supplementary Report on Irrigatin Demands (Task 8) and is included in **Appendix A** of this report.

5 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

5.1 OVERVIEW OF IRRIGATION IN THE ORANGE RIVER CATCHMENT

5.1.1 Main infrastructure

Irrigation water distribution is controlled from the Gariep Dam and the Vanderkloof Dam as well as from a number of weirs and canal systems along the Orange River. The Vanderkloof canal which runs for over 100 km from Vanderkloof Dam, is a major artery of high-quality Orange River water to the water stressed central region of the catchment towards Kimberley, feeding the Riet/Modder irrigation areas.

Distribution to farmers within schemes is mainly by means of calibrated sluice gates while in-line flow meters with telemetry are used in some schemes in the central region of the basin.

The irrigation distribution infrastructure and particularly the lined open canals are aging and the rehabilitation requirement is widespread. There are a few exceptions such as Kakamas Water User Association where a comprehensive upgrade of bulk infrastructure has taken place.

5.1.2 On-farm Technologies

Centre pivot irrigation now makes up about 80% of all irrigation systems in the catchment and micro-jet and drip irrigation systems are dominant in the orchard and vine crops. Flood irrigation is still practiced widely in the basin particularly on the Lower Orange areas like Boegoeberg, Upington and Kakamas.

The majority of farmers irrigate on the basis of an allocation of irrigation water per ha and technical irrigation scheduling is the exception rather than the rule. These are both aspects which are of critical relevance to water conservation and water demand management in the irrigation sector and will be re-visited several times in this report.

5.1.3 Agronomic Aspects

In the **Upper Orange** portion of the catchment (upstream of the confluence of the Orange and Vaal Rivers - Marksdrift weir) relatively low-value field crops such as maize and wheat and fodder crops like lucerne make up about 90% of all irrigated crops. Higher value field crops like potato, vegetables and certain annual fruit crops such as sweet melon, make up about 7%. The move to higher value orchard and vine crops, which tend to be more water efficient, and provide a significantly higher net financial return per unit of irrigation water, is limited to only about 3% of irrigated crops. This present situation in the Upper Orange is determined by a number of key factors:

- **Assurance of irrigation water supply**: Without a high assurance of supply (in irrigation terms) farmers are hesitant to convert to capital-intensive permanent crops which do not allow any form of flexibility in times when water allocation cuts may be necessary; a case in point being the Kalkfontein WUA where farmers seldom receive their full allocation due to water shortages. Farmers therefore usually prefer to stick with annual crops which reduce risk in times of reduced allocation. The willingness to convert to higher value permanent crops, where there is a high assurance of supply, is demonstrated by the major shift to grape farming in the Lower Orange from Boegoeberg to Vioolsdrift.

There are two reaches, however, which contradict the above statement. Reaches 6 & 9 (downstream of Gariep and downstream of Vanderkloof), are receiving water at very high assurances, yet they are not moving to high income permanent crops. The reason for this could be that the area is less well suited to grapes than the Lower Orange and alternative “higher value” crops appear less financially attractive and agronomically more risky.

- **Cost of water:** The present cost of water usually allows farmers to farm profitably using annual field crops, provided they maintain a reasonably high standard of management and intensive rotation of summer and winter crops. However, their concern is that in the event of a significant increase in the cost of irrigation water (including the cost of pumping where required) profitability is likely to become marginal.

- **High capital cost of establishing orchard and vine crops**: Capital costs of establishing orchards and vines is extremely high (see **Section 6**). This remains one of the main disincentives for a change to export orientated, high-value crops particularly in the present depressed economy.

- **The high-value orchard and vine crops have to be export-orientated for financial viability.** This is often a deterrent to farmers because in a climate of fluctuating exchange rates, export of expensive and management-intensive crops can add to their financial risk.

- **Management intensity:** Successful production of permanent orchard crops has become a complex multifaceted agribusiness requiring good management skills, substantial financial resources and technical skills.

- **Climatic risk:** Add to the intensive agribusiness the potential climatic misfortunes such as hail and unseasonal frosts, it is understandable that the pace of change to such enterprises in the Basin has been relatively slow.

- **Water quality issues:** Deteriorating water quality has become a major concern particularly in the Vaal River system. The rate of change to orchard/vine crops is being affected by water quality because of their generally higher sensitivity to water quality. International marketing standards are putting pressure on fruit exporters to ensure that irrigation water quality meets minimum quality standards. In addition, certain crops such a citrus are highly sensitive to water quality – particularly chloride levels.

In the **Lower Orange** (downstream of Marksdrift weir), rapid evolution to intensive and water-efficient irrigation is taking place. Grape vineyards make up 53% of irrigated crops, maize, wheat and Lucerne make up 45% and other field crops such as potato and vegetables, only 2%. In this region of the catchment and particularly the irrigation area from Boegoeberg Dam to Vioolsdrift, the world-renowned table-grape and raisin industry has blossomed on the basis of favourable climatic conditions, relatively high assurance of supply of irrigation water and the development of sophisticated agri-business operators. In addition, as the industry expands onto the higher-lying ground away from the River, pumping costs (coupled with ever- increasing electricity costs) have become a significant component of crop production costs. This has led to an ever-increasing irrigation efficiency through sophisticated irrigation scheduling.

5.2 DEFINITION OF WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

5.2.1 Water Demand Management

Water demand management may be defined as a management approach to increase the availability of water cost-effectively through more equitable, more efficient and more eco-friendly allocation and usage.

This is chiefly attained through the promotion of sound policy, the application of selected incentives and influencing and regulating the demand, by maximising the participation and defining accountability and responsibility of both political stakeholders and civil society stakeholders.

5.2.2 Water Conservation

Water conservation may be defined as the:

- minimization of loss or waste of water.
- maintenance or improvement of water quality.
- care and protection of water resources.
- efficient and effective use of water.

In the context of the objectives of this study, water conservation and improved water use efficiency should be seen in terms of how they can result in a net saving of water for either future irrigation expansion or alternative sector use.

5.3 THE ROLE OF INSTITUTIONSL STRUCTURES IN WC/WDM

Universally, water resource management policy and strategy is focusing progressively more on decentralized management, operation and maintenance of water delivery through participation by the stakeholders and water users. Also related to this is the practice of focusing water resource management away from the development of new systems and infrastructure to provide more water, to the improved management of existing water resources and the improvement of water use efficiency and water conservation. These improvements are often implemented through Water

Management Plans with a focus on Best Management Practices, which in turn is based on internationally recognised benchmarks for the various water use sectors.

The main benefits of the Water Management Plan approach is that it is structured for stakeholder and water user participation in planning and implementation and it is conducive to ready integration into a broader Water Resource Management Strategy for the Basin area as a whole.

The Water Act provides guidelines for the implementation of water conservation and water demand management in the irrigation sector and the Department of Water Affairs (DWA) has developed (WC/WDM) strategies and guideline documents for agriculture.

The Act requires that WC/WDM be driven primarily by Water User Associations (WUAs).

WUAs are, in turn, required to submit annual business plans, to a catchment management agency, or the DWA in the absence of a catchment management agency.

The development of a Water Management Plan (WMP) by a WUA is central to implementing water conservation and water demand management in the irrigation sector. The WMP sets out benchmarks and best management practices for WC/WDM and a manageable and affordable programme for their implementation by both the water supplier, in the case of controlled- irrigation schemes and their irrigators over time. The water management plan is therefore the primary tool with which the irrigation sector can implement WC/WDM initiatives in controlled irrigation areas.

This approach is strongly supported by all the main WUA's and Irrigation Boards in the Orange River Catchment. There is an appeal by these institutions that DWA should drive the establishment of WUA's to provide the vehicle for improved WC/WDM and the related water savings that will result.

Examples of this are found in the Orange Riet Water User Association and the Boegoeberg Water Users Association which were both identified in an ORASECOM study (February 2011) as leading WUA's with respect to WC/WDM.

The **Orange Riet Water User Association** controls a total of 17 000ha of irrigation (Riet River settlement 7 827ha; Irrigators along canal 4 617ha; Lower Riet 3 873ha; Scholtzburg 646ha and Ritchie settlement 97ha).

The management team maintains a high level of service to irrigators and good control of overall water distribution by means of a computerised telemetry system which is integrated through all levels of water management, from bulk flow measurement to the invoicing of irrigators for water used.

The WUA provides water to 371 irrigators via 314 calibrated sluices and water meters where water is extracted from the river or directly from the canal. Water meters are purchased by the farmer at a subsidized price, and belong to him.

The SAPWAT computer program is currently being used to calculate the crop water requirement and the crop irrigation requirements, which are correlated with the practical irrigation experience in the area, and modified to produce an irrigation benchmark for each crop. Each irrigator's requirements are then projected through the season. The benchmark may be amended each year based on previous season experience.

The water management programme "WAS" is used to manage the water measurements and prepare accounts for irrigators.

Unlawful use of water is monitored using a spot-check system, reported shortages in the canal, telemetric measurement and comparison with benchmark crop water use.

The **Boegoeberg WUA** is an amalgamation of the Boegoeberg GWS, the Gariep IB, the Northern Orange IB, a portion of the Middle Orange Irrigation Area, and the Karos Geelkoppan Water Board and controls a total of 9 200ha under irrigation.

80% of the Scheme is planted to grapes and the majority of the area is still under flood irrigation.

The WUA's best practice examples are similar to the Orange Riet and include the active promotion of laser levelling of flood irrigation areas. 30% of fields have been laser levelled and this trend is on the increase as more farmers realise the financial advantages of laser levelling, being mainly that less labour is required to operate laser levelled fields.

River abstraction is measured by in-line water meters. Water meters are purchased by the farmer and it is his responsibility to maintain them and ensure they are accurate.

The "best practice" initiatives that have the greatest impact on improved water use efficiency on these Schemes are:

- Effective measurement of irrigation water through sluices and water meters and the use of computerised telemetry systems. You can't manage what you can't measure.
- Creating a sense of awareness amongst staff and irrigators about irrigation efficiency and its benefits.
- Preparation of an annual Water Management Plan which allows for a systematic and practically achievable improvement in water management and water-use efficiency.

If other WUA's and Irrigation Boards in the catchment were to improve their WC/WDM practices in line with the above examples, significant improvements in water use efficiency are possible. Support from DWA is required for this to happen in the foreseeable future.

5.4 CONSTRAINTS TO INCREASED WATER SAVINGS

The following main constraints to increased water use efficiency and WC/WDM in general have been identified by the irrigation sector itself in the Orange River Basin and need to be addressed by DWA, WUA's / Irrigation Boards and irrigators as appropriate:

5.4.1 Water allocation method

The practice of allocating water on an "irrigation area" basis and a "standard volume (quota) per unit area" (m^3/ha/a), rather than on a volumetric basis, is a major disincentive for water saving. Water savings, within a given farm allocation, achieved through efficient water management and irrigation scheduling, are frequently applied to an expanded irrigation area, thus negating the opportunity to make an overall saving of irrigation water.

5.4.2 The different statutory requirements of Irrigation Boards and Water User Associations

The different statutory requirements of Irrigation Boards (in terms of old legislation) and Water User Associations (in terms of new legislation) is an obstacle to consistent governance of the irrigation water resources. Until Irrigation Boards are converted to WUAs, these anomalies will continue to impede efforts to improve irrigation efficiency.

5.4.3 DWA support

There appears to be inadequate involvement of the DWA within the catchment in encouraging and auditing WC/WDM. Some WUAs feel that if the audit function was emphasised and performed regularly by DWA, more WUAs would give attention to WC/WDM.

5.4.4 Poor condition of bulk infrastructure

A common challenge facing most WUAs is aging infrastructure. With the exception of Kakamas and possibly Orange Riet, most schemes have been in existence for a very long time and require major rehabilitation work and capital investment to get them back to peak operating condition.

The situation with aging infrastructure is exacerbated in that for a long time prior to WUA's taking over from Government water schemes, there was a general lack of maintenance of Government water scheme infrastructure. Although WUAs are responsible for maintaining infrastructure, ownership of infrastructures vests in the Department of Water Affairs and not in the WUAs. Any capital works such as rehabilitation therefore requires DWA consent and agreement to fund the works. This is further subject to the availability of funds from Government coffers and must compete for funds with pressing demands from other social and development programmes. This makes it difficult to plan ahead.

5.4.5 Inadequate/inappropriate water measuring devices

The lack of accurate water measurement on many Schemes is seen as a major constraint to improved irrigation efficiency. It is difficult to manage and monitor what you cannot measure. Most WUAs have insufficient and/or inaccurate measuring equipment on their main water conveyance systems, making it difficult to measure losses and allocations to irrigators. Ownership issues complicate this. Generally most users in areas served by canals are well measured. The calibrated sluice at farm turnout is ubiquitous.

5.4.6 Lack of incentives to save water.

There are inadequate incentives for **farmers** to save water. There is a perception amongst farmers that if they use less water than their allocation, then in terms of the new Water Act, which no longer recognises a “right” to water, they run the risk of losing a portion of their allocation. The water allocation is attached to the property and determines the value of the property. Any reduction in allocation would devalue the property.

There are inadequate incentives for **WUAs** to save water. Their operational budgets are based on selling a certain volume of water to irrigators. If water is saved, the WUA will have less revenue and may not be able to meet its obligations to member irrigators. Furthermore, the “catchment management charge” to WUAs is based on the total allocation to the Scheme.

There is no incentive for water user associations to improve efficiency when expansion of unregistered irrigation is occurring within the catchment.

5.5 INCENTIVES TO IMPROVE IRRIGATION WATER USE EFFICIENCY

It became clear during our interaction with water supplier and irrigators that any WC/WDM initiatives are unlikely to be effective unless there is a tangible benefit to the supplier and/or the irrigator. Water saving by irrigators is more likely to be made if it makes business sense to do so.

Examples of tangible incentives include:

- A leading table grape farming company in Upington practices high-tech irrigation scheduling and achieves up to 20% savings in irrigation water (12 000m^3/ha/a) compared to standard allocations in the area of 15 000m^3/ha/a. This was achieved not to save water primarily but:

  (a) to satisfy the buyer of his export table grapes who requires documented proof that the minimum amount of water is used in the production of the product; and

  (b) to minimise electricity costs which have become a major production cost in areas where pumping of irrigation water is required.

- Promoting water markets. Income from the sale of saved water would be a significant incentive, even though it would not necessarily free-up water for alternative distribution and use.

- A common practice in the Orange River catchment is for irrigators to apply water savings (gained through careful irrigation scheduling) to additional irrigable land (over and above their allocated areas) thereby increasing their overall irrigation with the same water allocation. This justified form of irrigation efficiency is likely to continue until water allocations are not area (ha)-based but are based on the sale of water per unit volume of water. The application of this form of incentive could be applied by DWA in such a way that the original area-based allocation is not threatened if less water is purchased.

- Long-term assuredness of supply of irrigation water is an incentive to increase investment in irrigated farming and consequently improve the efficiency of water use in terms of net crop returns per unit of water used, and also in terms of job creation and economic "spin off" per unit of water used.

- Catchment management charges to WUA's could be based on actual annual water distribution to irrigators, rather than to the total- area-based allocation to the Scheme.

5.6 SPECIFIC OPPORTUNITIES FOR IRRIGATION WATER SAVINGS

5.6.1 Addressing unregistered irrational water use

- <u>Expansion of unregistered, diffuse irrigation away from the main stream of the Orange River and outside of controlled irrigation areas.</u>

An important finding during the study is that diffuse irrigation, particularly in the Upper Orange, is inadequately measured and monitored by the DWA. Consequently significant areas of unregistered irrigation expansion are taking place. Better control of this expansion would result in significant water savings.

- <u>Expansion of unregistered, irrigation in controlled irrigation areas.</u>

Unregistered water use in the catchment has also been identified by most of the existing WUA's and Irrigation Boards as a significant cause of water "loss". The DWA is aware of the problem and is taking certain steps to address it. However, it would be far more effective when this responsibility falls on WUAs (when they are formed to cover the whole of the Basin) as they will see illegal water use in their area as "stealing their own water".

5.6.2 Accurately measured allocations

The allocation of irrigation water to irrigators on an accurately measured volumetric basis, for which a unit charge applies - as is being applied by the Orange, Riet WUA is an important method of controlling releases accurately and consequently making savings. However, at present, many Irrigation Boards have inadequate water measuring infrastructure and systems in place to implement this approach.

5.6.3 Purchasing water entitlements

Another approach to reduce water use would be for the Minister to levy an additional water use charge on all users of water originating in the Orange River Catchment in terms of Section 57 of the NWA. This levy must be in accordance with the pricing strategy which provides for, inter alia, setting water use charges for achieving the equitable and efficient allocation of water (Section 56 (c) of the NWA). The financial contributions of all the water users would be ring-fenced and used to buy out water entitlements from those water users who are willing to sell, e.g. by tender process. This process can then be continued until the necessary water balance is achieved. Alternatively the purchase of water entitlements can be funded by Government.

Whichever financing strategy is followed, the purchase of water entitlements can lead to financial and social consequences such as irrigated land value reduction, strain on the viability of WUA's and IB's with reduced levee income, and job losses of farm workers. This option must therefore be considered with great caution. Checks and balances need to be built into the process to mitigate these consequences.

The linking of WC/WDM savings to such a selling opportunity is a possible measure that will not necessarily cause economic prejudice and social hardships. It means that a water user, after applying WC/WDM can offer a portion of his/her entitlement representing the amount of water saved, to the water resource authority at an agreed price. This option is attractive in the sense that it can be implemented almost immediately and is not dependent on completion of the entire validation and verification processes. It is only those water users who offer a portion of their water use entitlements for sale whose entitlements must be validated and verified and this can be done on an *ad hoc* basis.

The process is relatively inexpensive, either funding mechanism can be used, and it is easy to implement. However an appropriate policy within the Department of Water Affairs needs to be developed and user guidelines need to be prepared.

5.6.4 Application of irrigation "best practice"

Irrigation "best practice" applies to both the irrigation water supplier (WUA's or IB's in the case of regulated supply) and to individual irrigators.

Best practice for irrigation water suppliers involves the application of:

- The DWA guidelines for drafting and implementing Water Management Plans.
- Application of operating rules & regulations/policies.
- Reference to appropriate Benchmarks for water supply and monitoring.
- Water Auditing: Accounting & Disposal Reporting.
- Operational best management practices including:
    - Effective water allocation measurement and monitoring.
    - Water quality measurement and monitoring;
    - Bulk infrastructure maintenance and repair.
    - Preparation and Implementation of a five-year operating and management plan.

- Technical support/advise to on-farm irrigation management practices.
- Unlawful withdrawal policy implementation.

Best management practices for irrigators include:

On-farm water measurement.

Use of appropriate water-efficient irrigation systems.

Irrigation scheduling to minimise water application in excess of crop water requirements.

Minimising on-farm losses from reticulation systems and storage dams.

The application and effectiveness of the above best practices was investigated in the ORASECOM study on WC/WDM. Examples of best practice at **water supplier** level are given in **section 5.3** above. An example of best practice at **irrigator** level is a 200ha (180ha under irrigation) maize, dry bean, wheat and lucerne producing farm on the Orange, Riet Irrigation Scheme.

Table 5.1: **Crop yield and water use savings**

Crop	Crop yield (t/ha)*		Water use per crop (m^3/ha)*		Water Saving (%)
	Farm.	Scheme	Farm.	Scheme	
Maize	15,0	11,0	5 000	6 000	20
Dry bean	2,5	2,0	3 000	3 500	16
Lucerne	20,0	17,0	11 000	12 750	16

**Actual 2010/2011*

The farm, which uses centre pivots and a solid set sprinkler system, filling the spaces between the centre pivots, uses “state of the art” irrigation scheduling technology and high-level management systems. (Reported in the ORASECOM WC/WDM study – February 2011). Production and irrigation efficiencies compared to the norm for the scheme as a whole are as shown in **Table 5.1**.

These savings illustrate the scope for improvement if the correct irrigation technology and management are applied.

5.7 IRRIGATION WATER SAVING ESTIMATES

The estimates of irrigation water savings are based on WC/WDM initiatives only and do not take into consideration the possible purchase of water entitlement as described above.

Irrigation inefficiencies consist of the following main elements:

Over irrigation *(irrigation water application in excess of crop water requirements).*

Poor in-field irrigation distribution *(some areas in an irrigation field over-irrigated and other areas under-irrigated).*

Inefficient irrigation systems resulting in excessive direct evaporation *(before the irrigation water reaches the soil)*

Leaking bulk-water reticulation systems *(leaking lined canals or unlined canals).*

Leaking farm dams and leaking on-farm water reticulation systems.

The excess water applied due to these inefficiencies is either lost to direct evaporation, to deep percolation into the groundwater system or makes its way back into the catchment river systems as a "return flow". This return flow forms an integral part of the river system's water resources downstream.

Achievable savings in irrigation water, through improved best practice at both distributor level and irrigator level, and the period over which the savings can be achieved are very difficult to estimate for a large and diverse catchment such as the Orange River catchment. The influencing factors, which are extremely complex and interactive - as has been shown in the preceding chapters - include technical elements, institutional and water management elements, legislative issues and perhaps, above all, an incentive factor (or lack thereof) for both irrigation water distributors and irrigators.

Quantitative information from the literature on the impact of WC/WDM initiatives on irrigation water saving at a catchment level is limited and mostly irrelevant to the Orange River situation. Research is focused mainly on modelling return flows and related water quality issues.

Any attempt to quantify practically-achievable savings of irrigation water on an annual basis over a number of years must therefore be broad and largely intuitive.

Interaction and discussion with the leading WUAs and Irrigation Boards throughout the catchment provided a common view that there is a potential for saving up to 15% of total irrigation water over a ten year period through the focused interventions recommended in this report. However a practically achievable saving is unlikely to be more that 60% of this, which is an overall 10% saving.

If the total irrigation water demand is 2 366 million m^3/annum the saving could be 237 million m^3/a within a 10 year period.

However, these estimates do not consider the reduction in return flows that such savings would cause, nor the likelihood that savings made by individual farmers, through improved irrigation practices and improved water management, will be used to increase their irrigation areas rather than reduce their overall water allocation.

The estimated savings could consequently be reduced by as much as a further 50 - 60%.

It is therefore recommended that a net saving of about 4 - 5% (95 - 118 million m^3/a), over a period of 10 years be adopted as a conservative but realistic estimate.

6 VALUE OF IRRIGATION WATER

6.1 INTRODUCTION

In determining the value of irrigation water it is important to estimate the regional economic benefits accrued from irrigation water which must include employment creation and the direct, indirect and induced economic benefits that can be attributed to agricultural production in the study area. A Social Accounting Matrix based econometric model (SAM), which includes the relevant economic multipliers for the various sectors, was used for this purpose. These benefits can then be added to the financial benefits and the real value of the irrigation water can be determined.

6.2 METHODOLOGY AND APPROACH

6.2.1 Approach

6.2.1.1 Structure of the Economy

The so-called economic baseline provides the impacts of water usage when the full water allocation is available in the respective sub-regions for variables such as GDP, employment, and income received by households.

To accomplish this, an econometric model was developed with the multipliers synthesised from the representative Social Accounting Matrix (SAM) for the Orange River. The Water Impact Model (WIM) was used for the primary sector of irrigation agriculture.

A broad schematic representation of the different sectors of the economy is shown in **Figure 6**.1

The primary sector feeds the secondary and tertiary sectors but depends on products and services from the two latter sectors to operate efficiently.

The value of the irrigation water and the impact of the sector, in terms of macro-economic indicators, are then expressed in terms of the following:

GDP - direct, indirect and induced.

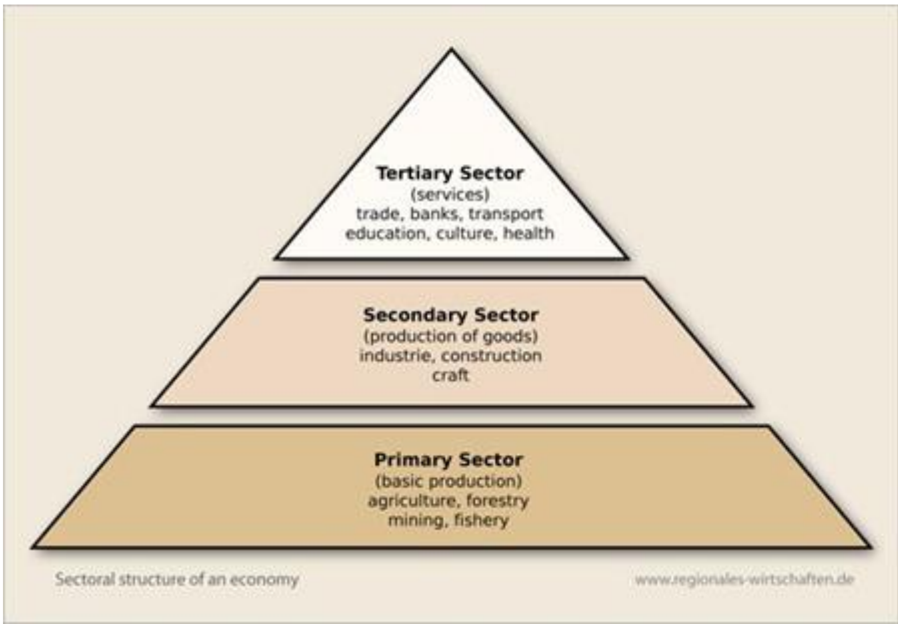
Employment - direct, indirect and induced.

Payments to Households - high, medium and low income households.

Production Capital.

The GDP indicator is an indication of the contribution to economic growth.

Figure 6.1: Schematic Representation of the different Sectors of the Economy



Direct employment and payments to low-income households are an indication of the contribution made to poverty alleviation.

Formally, economists distinguish between direct, indirect and induced economic effects. Indirect and induced effects are sometimes collectively referred to as secondary effects. The total economic impact is the sum of direct, indirect and induced effects within a region. Any of these impacts may be measured in terms of gross output or sales, income, employment or value added.

6.2.2 Impacts

In the following sections, a brief explanation of each of the impacts is provided.

6.2.2.1 Direct Impacts

The direct impacts refer to the effect of the activities that take place in the irrigation agriculture sector. It refers to the income and expenditure that is associated with the everyday operation of each of the components of the relevant activity. For instance, the direct impacts refer to the total production/turnover of the crop production process, the intermediate goods bought by the sector, the salaries and wages paid by the sector and the profits generated by the sector.

6.2.2.2 Indirect Impacts

The indirect impacts refer to economic activities that arise in the sectors that provide inputs to the irrigation agriculture components and other backward linked industries. For example, if the irrigation sector uses steel, the indirect impacts refer to the activity (paying of salaries and wages, and profit generation) that occurs in the steel sector as well as the sectors that, in turn, provide materials to the steel sector.

6.2.2.3 Induced Impacts

Induced impacts refer, *inter alia*, to the economic impacts that result from the payment of salaries and wages to people who are (directly) employed at the various consecutive stages of beneficiation of, for example, the mining and electricity industries. In addition the induced impact also includes the salaries and wages paid by businesses operating in the sectors indirectly linked to these industries through the supply of inputs. These additional salaries and wages lead to an increased demand for various consumable goods that need to be supplied by other sectors of the economy that in turn have to raise their production in tandem with the demand for their products and services.

These induced impacts can then be expressed in terms of their contribution to GDP, employment creation and investment or other useful macro-economic variables.

Added together, the direct, indirect and induced impacts provide the total impact that these industries will have on the South African and regional economies.

6.2.3 Macro-Economic Indicators

In the following paragraphs a short description of the macro-economic indicators calculated to define the value of the irrigation water is provided.

6.2.3.1 Impact on Gross Domestic Product (GDP)

The impact on GDP reflects the magnitude of the value added to the regional and wider economy from activities using the water. Value added is made up of three elements, namely:

Remuneration of employees.

Gross operating surplus (which includes profit and depreciation).

Net indirect taxes.

6.2.3.2 Impact on Capital Utilisation

For an economy to operate at a specific level of activity, investment in capital assets (i.e. buildings, machinery, equipment, etc.) is needed. Capital, together with labour and entrepreneurship, are the basic factors needed for production in an economy.

The effectiveness and efficiency with which these factors are combined influence the overall level of productivity/profitability processes, bearing in mind that productivity is affected by an array of factors of which appropriate technology and skills level of the labour force are two important elements.

6.2.3.3 Impact on Employment Creation

Labour is a key element of the production process. This study determines the number of employment opportunities currently supported by the use of irrigation water. These employment opportunities are broken down into those created directly by the irrigation sector and those created indirectly and those induced throughout the broader economy. Furthermore, a distinction is made between permanent and seasonal labourers.

Impact on Household Income

One of the elements of the value added (i.e. GDP) which results from the irrigation sector is the remuneration of employees, which, in turn affects households income.

The SAM measures the magnitude of changes that occur to both household income and the spending/savings pattern. As such, the results will highlight the impact of irrigation on the low-income households as this can be used as an indicator of the extent to which the irrigation sector contributes to poverty alleviation throughout the economy.

6.2.4 Methodology

6.2.4.1 Water Impact Model (WIM)

The Water Impact Model (WIM) is used in the calculation of the macro-economic indicators. The model, as currently constructed and applied to the irrigation sector, is in the form of a dynamic computerised water entitlement model which can be used to identify and quantify the following indicators:

- Economic benefits also referred to as the economic baseline.
- Maximum possible water reduction.
- Capitalised impact.

To calculate the macro-economic indicators of each of the sub-regions requires identifying and establishing the detailed irrigation crops in terms of the estimated hectares cultivated. Specific crop production budgets were incorporated into the WIM-model and underpinned by the SAM.

A WIM was constructed for the Orange River which included the identified sub-regions listed below:

- Upper Orange (East), Caledon River upstream of Welbedacht Dam, Kraai River upstream of Aliwal North, Orange River upstream of Aliwal North.
- Upper Orange (Central), Orange River Gariep Dam to Aliwal North, Caledon River Gariep Dam to Welbedacht Dam.
- Upper Orange (West), Orange River Vanderkloof Dam to Gariep Dam, Canals ex Vanderkloof Dam, Lower Riet canal/Scholtzburg, Vanderkloof Dam to Douglas (Marksdrift weir), Modder River GWS, Riet River upstream of the Kalkfontein Dam (Tierpoort IB), Riet

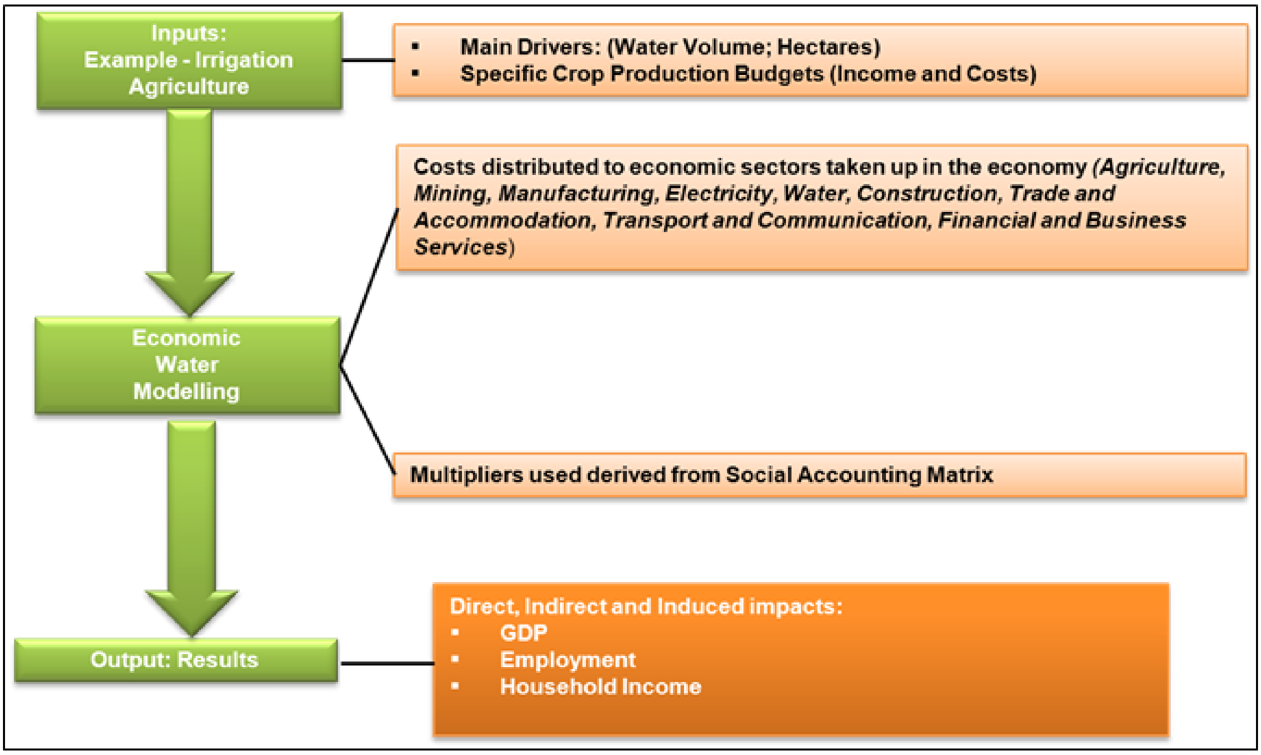
River downstream from the Kalkfontein Dam (Kalkfontein IB), Douglas weir to Orange Vaal Rivers confluence (Orange Water).

- Lower Orange (East), Orange River Marksdrift to Boegoeberg.
- Lower Orange (West), Boegoeberg and Upington and Keimoes canals, Boegoeberg to Neusberg river abstraction, Kakamas to Augrabies canals, Neusberg to Augrabies and to Namibian Border abstraction, Namibian Border to Vioolsdrift North and South, Vioolsdrift South canal – Vioolsdrift North and Ausenkjer, Vioolsdrift to Fish River confluence, Alexander Bay.

The model can accommodate up to twenty different crops.

A schematic representation is provided below in **Figure 6.2** to illustrate the modelling of the WIM-model.

Figure 6.2: Schematic presentation of the Water Impact Model



6.2.4.2 Model Drivers

The so-called drivers of the model are discussed below.

6.2.4.2.1 Crop Enterprise Budgets

The detailed production costs per crop, as shown in **Table 6.1**, are used in the model.

The table also demonstrates the different economic items that are to be calculated:

- Gross Income - (Marketing costs + Variable costs) = Gross Margin,
- Gross Margin - Fixed Costs = Net Farm Income,
- Net Farm Income - (Yield on Capital plus Management Fee) = Net Income.

The pre- harvest costs include the following items:

Land preparation costs.
Seedling and seed costs.
Fertiliser costs.
Agro – chemical costs.
Irrigation water and electricity costs.
Fuel.
Implement Repairs and Maintenance.
Casual Labour.
Etc.

The harvest costs include the following items:

Casual Labour.
Packaging material.
Transport.
Contractor costs if used.
Fuel.
Implement Repairs and Maintenance.
Etc.

The fixed costs refer to cost items that are not dependent on the specific crop that is produced, but form part of the general management of the farm unit. For purposes of this analysis it is estimated in Rand and also converted to Rand value per hectare.

Table 6-1: Crop Enterprise Budget Structure

Gross Income
Costs
Variable Costs
Marketing Costs
Pre Harvest Costs
Harvest Costs
Interest on Working Capital
Gross Margin
Fixed Costs
Depreciation,
Fixed labour
Insurance
Repairs and Maintenance to Fixed Improvements
Administration Costs
Fuel and Electricity
Sundry
Net Farm Income (NFI)

6.2.4.2.2 Cost Items converted to Economic Sectors

The total intermediate inputs and labour cost items are converted to the standard Economic Sectors for use in the Input Output Model as used by Statistics South Africa (Stats SA) (**Table 6.2**).

Table 6-2: **Economic Sector Structure**

Total costs (Intermediate inputs and labour requirements)
- *Agriculture*
- *Mining*
- *Manufacturing*
* *Fuel*
* *Fertilizer*
* *Pharmaceuticals*
* *Other*
- *Electricity*
- *Water*
- *Construction*
- *Trade and accommodation*
- *Transport and communication*
- *Financial and business services*
- *Community services*
- *Salaries and wages: Skilled*
- *Salaries and wages: Semi-Skilled*
- *Salaries and wages: Unskilled*

6.2.4.3 Final Product

The above detail is then accumulated as follows:

(Variable cost + Fixed cost) x hectares = Total costs.

In **Table 6.3**, the format of the multipliers synthesised from the appropriate SAM is presented.

The two structures explained above are than multiplied and the different indicators are calculated.

$$\begin{bmatrix}\text{Economic Structure}\end{bmatrix} \times \begin{bmatrix}\text{Multipliers from SAM}\end{bmatrix} = \text{MACRO – ECONOMIC INDICATORS}$$

(Table 6.2) (Table 6.3)

Table 6-3: **Format of the Multipliers Synthesised from the SAM**

	GDP multiplier	***Labour multiplier***	***Capital multiplier***	***Low-income households***	***Total households***
Intermediate inputs					
Agriculture					
Mining					
Manufacturing					
Electricity					
Water					
Construction					
Trade and accommodation					
Transport and communication					
Financial and business services					
Community services					
Primary inputs					
Salaries and wages: Skilled					
Salaries and wages: Semi-Skilled					
Salaries and wages: Unskilled					
GOS					

6.3 DATA

6.3.1 Data Sources

The following data sources were used:

- The different production regions, irrigated areas and cropping patterns were sourced from the Water Demand section of this report (**Chapter 4**).
- Detailed enterprise production budgets, up to the level of Gross Margins were based on detailed analysis of "best practice" farmers undertaken in the ORASECOM WC/WDM report (2011) and with financial values updated to 2012 costs and prices.
- Fixed costs, were sourced from a project for the Development Bank of Southern Africa, 2012.
- The grape production in the Lower Orange has three sections and the following publications were used to differentiate and determine the correct contribution of each section:
  - Department of Agriculture, Forestry and Fisheries: A Profile of the South African Table Grape Market Value, 2011.
  - South African Wine Industry Information Systems (SAWIS): Marco-economic Impact of the Wine Industry on the South African Economy, 2009
  - Global Agricultural Information Network (GAIN): Raisin Annual – 30 July 2012.

6.3.1.1 Cropping patterns per Region

The following cropping patterns per agro-economic region, expressed as a percentage of total crops grown, were used in the analysis:

- **Upper Orange (East**): Lucerne 35%, Wheat 12%, Fodder/pasture 27%, Potatoes and vegetables 6%, Deciduous fruit 10%. Total physical hectares 17 148, Crop hectares 17 148.
- **Upper Orange (Central):** Fodder/pasture 35%, Lucerne 30%, Maize 20%, and Wheat 15%. Total physical hectares 14 064, Crop hectares 14 064.
- **Upper Orange (West):** Wheat 50%, Maize 35%, Lucerne 6%, Fodder/pasture 4%, Potato and vegetables 8%, Grapes 3%, Other field crops 5%. Total Physical Hectares 68 437, Total crop hectares 75 965.
- **Lower Orange (East):** Wheat 50%, Maize 25%, Lucerne 6%, Potato and vegetables 8%, other field crops 4%. Total physical hectares 17 236, Total crop hectares 18 098.
- **Lower Orange (West**): Grapes 70%, Lucerne 10%, Maize 7%, Wheat 12%, other field crops 2%. Total physical hectares 42 910, Total crop hectares 43 339.

Certain assumptions were necessary in disaggregating the crops:

- In the case of fodder and pastures, they were all included with Lucerne as Lucerne was used as the crop in the model.
- In the case of “Deciduous Fruit” apple production was used.
- In the case of “Other field crops” dry beans was used.
- After analysing some older agricultural census data the following division was used for potato and vegetable crops:
  - Upper Orange (East) – cabbage 4%, potato 2%.
  - Upper Orange (West) – cabbage 2%, potato 6%.
  - Lower Orange (East) – cabbage 4%, potato 4%.

6.3.1.2 Summary of data used in the valuation models

The total irrigated area is 159 795ha, but due to double cropping the total area of crops is 168 614 ha. In Table 6.5 a summary of the financial data used in the model is provided.

Table 6-4 shows the areas of crops per agro-economic region used in the valuation model.

Table 6-4: **Area of crops (ha) per Agro-economic Region**

Crops	Upper Orange East	Upper Orange Central	Upper Orange West	Lower Orange East	Lower Orange West	Total
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
Maize	1 715	2 813	25 664	4 309	1 698	**36 199**
Dry bean	-	-	3 422	2 758	1 287	**7 467**
Pasture/lucerne	10 632	9 141	6 843	1 034	3 768	**31 418**
Winter vegetable (Cabbage)	686	-	1 369	689	-	**2 744**
Potato	343	-	4 106	689	-	**5 138**
Wheat	2 057	2 110	34 219	8 619	3 699	**50 704**
Deciduous fruit (apple)	1 715	-	-	-	-	**1 715**
Grape (Table)	-	-	342	-	5 336	5 678
Grape (Wine)	-	-	-	-	5 839	**5 839**
Grape (Dried)	-	-	-	-	21 712	**21 712**
Total	**17 148**	**14 064**	**75 965**	**18 098**	**43 339**	**168 614**

Table 6-5: **Financial Data used in the WIM Model**

Crop	Gross Income (R/ha)	Interest on Working Capital (R/ha)	Variable Cost (R/ha)	Fixed Cost (R/ha)	Net Farm Income (R/ha)
Maize	26 000	797	20784	3 613	4 206
Apple	247 500	4 069	130 413	7 424	42 931
Wheat	17 640	319	13 060	2 622	4 578
Dry bean	17 400	318	12 983	2 613	3 261
Lucerne	24 000	1 569	20 588	4 636	4 641
Potato	129 960	2 315	91 696	3 432	32 517
Cabbage	58 725	2 133	41 128	3 594	11 870
Grape (Table)	294 373	4 875	170 701	8 861	86 405
Grape (Wine)	50 018	2 757	26 945	8 507	11 808
Grape (Dry)	86 215	3 475	42 736	7 956	32 048

6.4 RESULTS

The output of the valuation model per region and for the Orange River basin (RSA) is summarised below. In the evaluation of the results it must be kept in mind that the calculation of the employment and Household Payments is based on the application of an econometric model and not on surveyed and collected data.

Region 1 - Upper Orange (East)

The GDP contribution of irrigation to the economic growth in the specific region is R151.6 million and to the total South African Economy R349.2 million.

A total of 1 624 direct jobs in the area is supported by irrigated crops, indicating probably a total of about 6 500 (1624 x 4) family members depending on the activities. A further 1 825 indirect and induced jobs are created, some within the region and a number outside.

Irrigation also supports the creation of R614.7 million capital in the economy, a very necessary component for economic growth.

A total of R80.5 million is paid to low income households in the region, which together with the direct employment created, have a very positive impact on poverty alleviation in a very rural area.

Table 6.6: Macro-Economic Indicators for the Upper Orange River (East) (2012 prices)

	GDP (R Mil)			Employment (Number)			Capital (R Mil)	Household Income (R Mil)		
Crops	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Total	Medium	Low
Maize	6.6	13.2	19.8	41	127	168	40.4	16.7	12.3	4.4
Pasture/ lucerne	45.2	83.8	129.0	300	822	1122	257.1	106.5	78.4	28.1
Vegetable	5.5	10.9	16.4	62	93	155	33.3	14.7	11.2	3.5
Potato	6.7	11.6	18.3	55	112	167	36.2	16.0	11.5	4.5
Wheat	6.4	10.6	17.0	28	92	120	33.1	13.4	9.9	3.5
Deciduous Fruit	81.2	67.5	148.7	1138	579	1717	214.5	124.5	88.0	36.5
Total	**151.6**	**197.6**	**349.2**	**1624**	**1825**	**3449**	**614.6**	**291.8**	**211.3**	**80.5**

Region 2 - Upper Orange (Central)

The GDP contribution of irrigation to the economic growth in the specific region is R227.8 million and to the total South African Economy R651.5 million.

A total of 1 432 direct jobs in the area is supported by irrigated crops, indicating probably a total of

5 700 (1432 x 4) family members depending on the activities. A further 4 090 indirect and induced jobs are created, some within the region and others outside.

Irrigation also supports the creation of R1 302.6 million in capital in the economy, a very necessary component for economic growth.

Table 6.7: Macro-Economic Indicators for the Upper Orange River (Central) (2012 prices)

	GDP (R Mil)			Employment (Number)			Capital (R Mil)	Household Income (R Mil)		
Crops	**Direct**	**Indirect and Induced**	**Total**	**Direct**	**Indirect and Induced**	**Total**	**Total**	**Total**	**Medium**	**Low**
Maize	43.8	87.5	131.3	270	843	1113	268.9	110.9	81.6	29.3
Pasture/lucerne	157.4	291.9	449.4	1046	2863	3909	895.9	372.5	223.4	149.1
Wheat	26.6	44.2	70.8	116	384	500	137.7	56.1	41.3	14.7
Total	**227.8**	**423.7**	**651.5**	**1432**	**4090**	**5522**	**1 302.6**	**539.5**	**346.3**	**193.2**

A total of R193.2 million is paid to low income households in the region, which together with the direct employment created have a very positive impact on poverty alleviation in a very sparsely populated rural area.

Region 3 - Upper Orange (West)

The GDP contribution of irrigation to the economic growth in the specific region is R850.5 million and to the total South African Economy R2 330.4 million.

This region contains a very large irrigation area, 68 437ha with the dominant crops being maize and wheat production which are not very labour intensive. The total maize crop area is estimated at 25 664ha and according to the methodology followed, the maize production only employs 1 443 people directly. Wheat is produced on an estimated 34 219ha and only involves 1 105 direct jobs. Potato on the other hand, with a total area of 4 106 hectares, supports 1 507 direct jobs.

In total 5 412 direct jobs are sustained by the irrigation sector with another 13 785 indirect and induced job opportunities totalling 19 197. As far as dependency on the irrigation sector is concerned at least 22 000 people in the region depend on the well-being of the sector.

Table 6.8: Macro-Economic Indicators for the Upper Orange River (West) (2012 prices)

	GDP (R Mil)			Employment (Number)			Capital (R Mil)	Household Income (R Mil)		
Crops	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Total	Medium	Low
Maize	234.0	468.0	702.0	1443	4508	5951	1 437.9	593.0	436.1	156.9
Grapes (Table)	53.7	42.7	96.4	660	380	1040	140.1	66.0	35.0	31.0
Drybean	24.5	38.1	62.6	258	376	634	116.4	47.4	33.6	13.8
Pasture/lucerne	69.1	128.1	197.2	230	1256	1486	393.1	147.7	108.6	39.1
Vegetables	26.3	52.0	78.3	146	439	585	158.0	69.6	50.7	18.9
Potato	190.1	330.7	520.8	1570	3179	4749	1 029.2	398.3	284.7	113.6
Wheat	252.8	420.3	673.1	1105	3647	4752	1 309.6	533.9	392.9	140.0
Total	**850.5**	**1 479.9**	**2 330.4**	**5412**	**13785**	**19197**	**4 584.3**	**1 854.9**	**1 341.6**	**513.3**

In total R513.3 million is paid to low income households, indicating the important role of irrigation in poverty alleviation in the region.

The capital formation is very large at R 4 584 million.

Region 4 - Lower Orange (East)

Table 6.9: Macro-Economic Indicators for the Lower Orange River (East) (2012 prices)

	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
Crop	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Total	Medium	Low
Maize	39.3	78.6	117.9	242	757	999	241.4	92.2	65.9	26.3
Drybean	19.7	30.7	50.4	208	303	511	93.8	41.8	30.7	11.1
Pasture/lucerne	10.4	19.4	29.8	35	190	225	59.4	22.6	16.1	6.5
Vegetable	13.3	26.2	39.5	74	221	295	79.6	35.0	25.5	9.5
Potato	31.9	55.5	87.4	264	534	798	172.8	70.3	48.8	21.5
Wheat	63.7	105.9	169.6	278	919	1197	329.8	134.3	99.0	35.3
Total	**178.3**	**316.3**	**494.6**	**1101**	**2924**	**4025**	**976.8**	**396.2**	**286.0**	**110.2**

The total irrigated crop area is 18 098ha with the dominant crops being maize, 4 309ha, wheat 8 618ha dry beans 2 758ha. None of these crops are very labour intensive. This is reflected in the

1 101 direct jobs created. A further 2 923 indirect and induced jobs make up a total of 4024 jobs sustained by the irrigated crops.

In total R110.2 million is paid to low income households making a significant contribution to rural poverty alleviation in the area.

The total capital formation due to the irrigation sector is around R976 million with the total GDP generated totalling R494 million.

Region 5 - Lower Orange (West)

In the following table the macro-economic indicators for the region is presented.

This region comprises a very large irrigation area, 42 910 hectares, which is the second largest of the five regions analysed. The dominant crops are table grapes for export, wine grapes and raisin production, in total 32 888 hectares. The production process is labour intensive and in total 24 474 direct jobs are sustained by the grape sector alone, projecting a dependency of around 100 000 people.

Table 6.10: Macro-Economic Indicators for the Lower Orange River (West) (2012 prices)

	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
Crops	**Direct**	**Indirect and Induced**	**Total**	**Direct**	**Indirect and Induced**	**Total**	**Total**	**Total**	**Medium**	**Low**
Maize	19.6	39.1	58.7	121	377	497	120.2	45.9	32.8	13.1
Grapes (Table)	943.3	750.3	1 693.6	11583	6667	18250	2 459.3	1 157.9	732.5	425.4
Drybean	9.2	14.3	23.5	97	141	238	43.8	19.5	14.3	5.2
Pasture/lucerne	42.4	78.6	120.9	141	770	911	241.1	91.6	65.3	26.3
Potato	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0
Wheat	27.3	45.4	72.8	119	394	514	141.6	52.3	37.2	15.1
Grapes (Wine)	195.4	68.5	263.9	1542	597	2139	239.3	132.9	98.7	34.2
Grape (Dry)	1 263.2	788.5	2 051.6	11349	6822	18171	3 433.4	1 559.9	1 064.4	495.5
Total	**2 500.4**	**1 784.7**	**4 285.1**	**24952**	**15769**	**40721**	**6 678.6**	**3 060.1**	**2 045.2**	**1 015.0**

A total of 24 952 direct jobs are sustained by all the irrigated crops in the five zones, with an additional 15 769 indirect and induced job opportunities provided by the irrigation industry.

In total R1 015 million is paid to low income households indicating the important role of irrigation to poverty alleviation in the region.

The contribution of R4 285 to the GDP and a capital formation of R6 678 million is a very large and significant contribution from the irrigation industry. The GDP contribution to the region itself is around R2 500 million.

Macro-Economic Indicators for the Total Orange River Irrigation Activities

Irrigation activities supports a total of 34 520 direct jobs and the total payment to low income households is R1 912 million per annum. The average payment to low income households is around R55 000 per household accepting that the average number of employees per household is two.

Of the total of 34 520 direct supported jobs it is estimated that 10 097 are permanent employees and that 24 423 are seasonal workers. It is important to remember when evaluating these numbers that the 24 423 represents full-year opportunities and that the actual number of people involved could be substantially higher.

Table 6.11: Macro-Economic Indicators for the Total Orange River Irrigation Activities (2012 prices)

	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Total	Medium	Low
Maize	343.3	686.4	1029.7	2 116	6 611	8 727	2108.8	858.9	628.7	230.2
Grapes (Table)	997.1	793.0	1790.1	12 243	7 047	19 290	2599.4	1223.8	767.4	456.4
Drybean	53.4	83.0	136.4	562	820	1 382	253.9	108.8	78.7	30.1
Pasture/lucerne	324.5	601.7	926.2	1 752	5 901	7 653	1846.7	740.8	491.7	249.1
Vegetable	45.1	89.1	134.2	282	753	1 035	270.9	119.3	87.4	31.9
Potato	228.7	397.8	626.5	1 889	3 825	5 714	1238.2	484.5	345.0	139.5
Wheat	376.8	626.4	1003.2	1 647	5 436	7 083	1951.9	789.1	580.4	208.7
Deciduous Fruit	81.2	67.5	148.7	1 138	579	1 717	214.5	124.5	88.0	36.5
Grapes (Wine)	195.4	68.5	263.9	1 542	597	2 139	239.3	132.9	98.7	34.2
Grapes (Dry)	1263.2	788.5	2051.7	11 349	6 822	18 171	3433.4	1559.9	1064.4	495.5
Total	**3908.7**	**4201.9**	**8110.6**	**34 520**	**38 391**	**72 911**	**14157.0**	**6142.5**	**4230.4**	**1912.1**

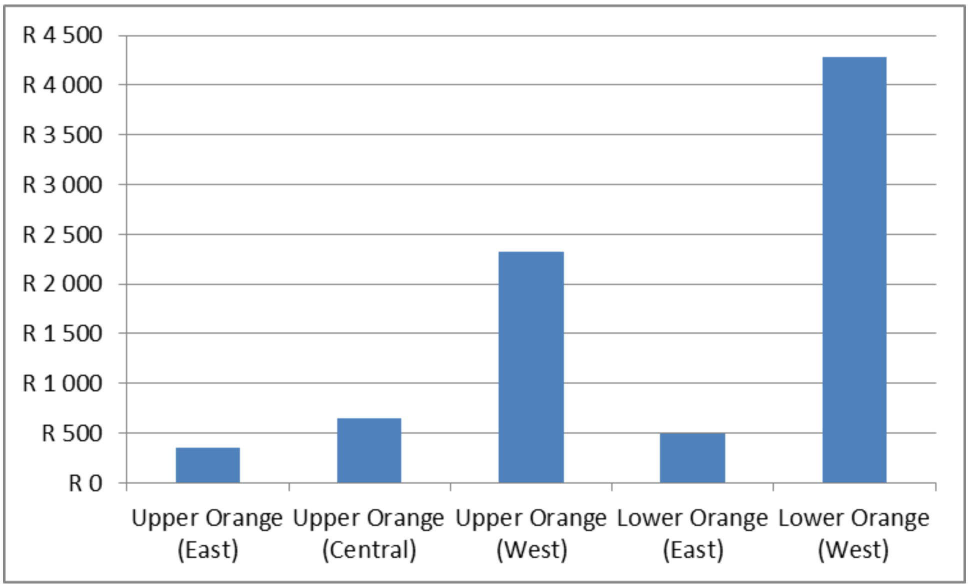
From **Table 6.12** it is clear that the Lower Orange (West) not only sustains the largest number of jobs but is in all macro – economic parameters the most productive region.

Table 6.12: Macro-Economic Indicators for the Total Orange River Irrigation Activities per Region (2012 prices)

	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
Region	**Direct**	**Indirect and Induced**	**Total**	**Direct**	**Indirect and Induced**	**Total**	**Total**	**Total**	**Medium**	**Low**
Upper Orange (East)	151.6	197.6	349.2	1 624	1 824	3 448	614.7	291.9	211.3	80.6
Upper Orange (Central)	227.8	423.7	651.5	1 432	4 090	5 522	1 302.6	539.5	346.3	193.2
Upper Orange (West)	850.6	1 479.8	2 330.5	5412	13785	19197	4 584.3	1 854.9	1 341.7	513.2
Lower Orange (East)	178.3	316.2	494.5	1100	2923	4024	976.8	396.2	286.0	110.2
Lower Orange (West)	2 500.4	1 784.7	4 285.1	24952	15769	40721	6 678.6	3 060.1	2 045.2	1 015.0
Total	**3 908.7**	**4 202.0**	**8 110.7**	**34 521**	**38 391**	**72 912**	**14 156.9**	**6 142.5**	**4 230.4**	**1 912.1**

Figure 6.3 illustrates the difference in total Gross Domestic Product contribution of the five agro-ecological regions to the national economy.

Figure 6.3: Total GDP contribution (R'millions) for the five agro-ecological regions of the Orange River to the Nation l Economy (2012 prices)



The figure shows that the Lower Orange (West) region is the dominant growth generator followed by Upper Orange (West). The other three are much smaller. The total GDP contribution to the South African economy is estimated at R8 110 million of which R3 908 million is in the direct irrigation area.

Figure 6.4 illustrates the distribution of jobs between the different crops over all the agro-economic regions.

Figure 6.4: Employment Opportunities Sustained by the different Crops

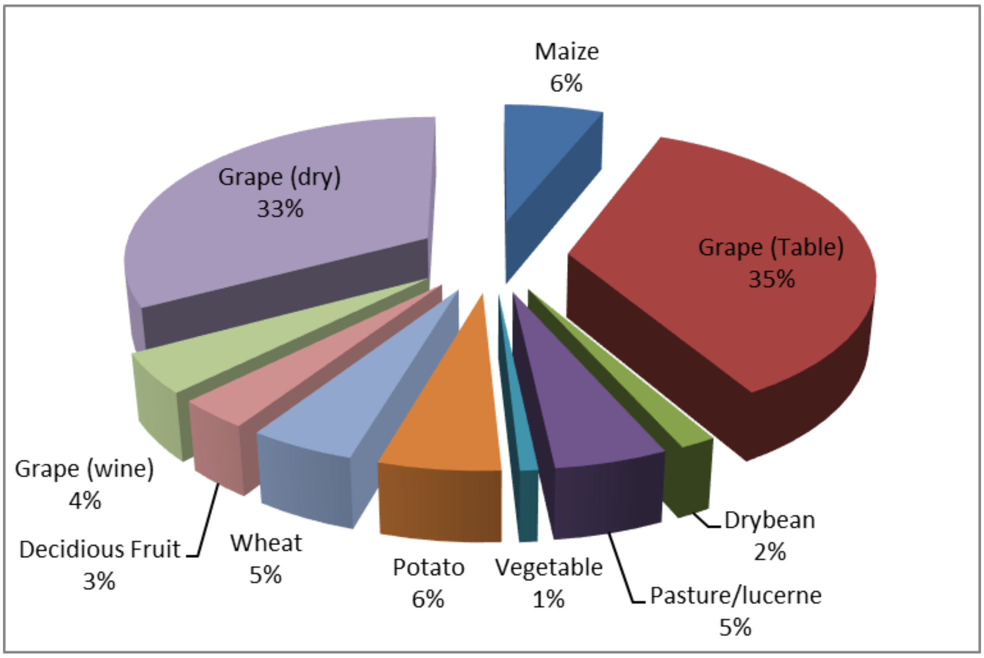
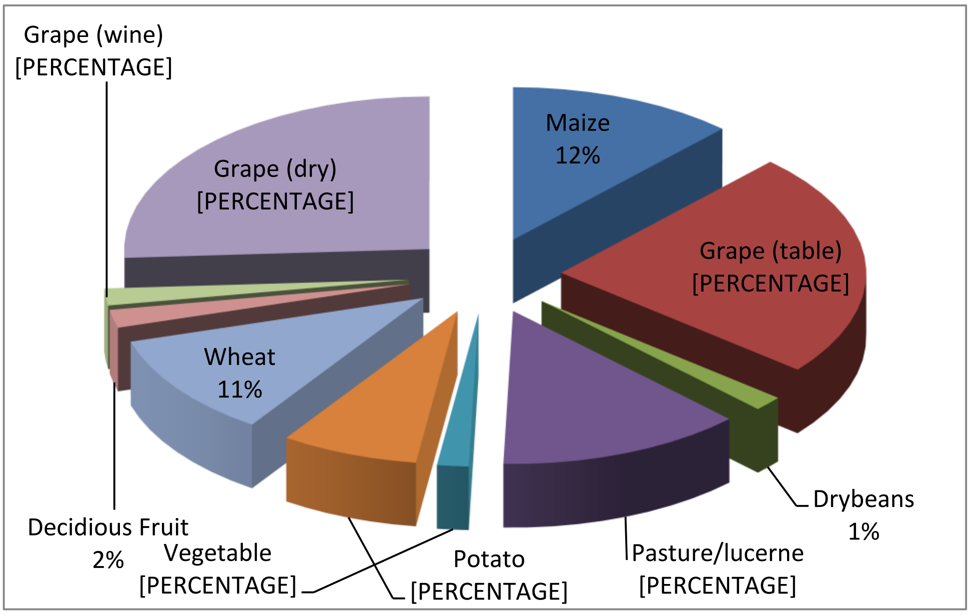


Figure 6.5: Payments to Low Income Households Paid by the different Crops



The two figures show that grapes (dry) (raisins) sustain 33% of the jobs; its contribution to low income households is 26%, an indication that a large number of the employees are seasonal. The grape sector sustains about 72% of the employment and pays 52% of the total payments to low – income households.

The capital generated by the irrigation activities is estimated at about R15 900 million.

The above analysis illustrates the value of Orange River irrigation water and the valuable contribution it makes to the growth of the region in terms of GDP, and job creation - some of which are in the region and some are outside the region. Irrigation also makes a major contribution to poverty alleviation in terms of payments to low income households and the creation of direct employment opportunities in the area.

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Appendix A

Supplimentary report on

Irrigation Demands (Task 8)

(June 2014)

Irrigation Demands (Task 8)

Supplementary Report

(June 2014)

1. Introduction

Subsequent to the completion in August 2013 of the report entitled:

“Development of Reconciliation Strategies for Large Bulk water Supply Systems: Orange River – Irrigation Demands and Water Conservation/Water Demand Management (Task 8) and The Value of Irrigation Water (Task 9)” the Validation & Verification of the Upper Orange Water Management Area Study data for 2010 was completed in May 2014. The results of this study, with respect to 2010 validated data is presented in this supplementary report in order to provide the latest available update on irrigation areas and water use in the Upper Orange River catchment.

2. Supplementary data

Table A1 below provides a comparative summary of irrigation areas and volumes of irrigation water utilized in the Upper Orange River catchment in terms of (a) the Main Report which are shown in **Table 4.2 and 4.3** of the main report completed in August 2013, and (b) the 2010 validation data referred to as “Qualifying_final”, and (c) the so-called “Current” water use which equates to irrigation areas (and estimated water use associated with these area) as observed from satellite imagery and validated on the ground. It is however important to note that the “Current” irrigation areas were not validated on the ground. These “Current” areas have not yet been verified as “lawful” irrigation water use. The “Current” water use may include unregistered unlawful use, groundwater used for irrigation, areas incorrectly identified from satellite imagery as irrigation and irrigation from farm dams which could be opportunistic in nature in that farmers take advantage of wet years when local surface water is available for irrigation.

Note on Table A1:

*Reach 14 was not included in the Validation and Verification study. The main report however includes Reach 14 in the Upper Orange Water Management Area. To enable accurate comparisons to be made between the main report and the validated data the irrigation area and volume for reach 14 in **Table 4.2** of the Main Report have therefore been included in **Table A1** as have the demands for Malopo, Lower Orange Tributaries, Eastern Cape, Lesotho and Namibia.*

Table A1. Summary Comparison of Main Report and Upper Orange Validation study 2014 – Irrigation Areas (ha) and Volumes (mil. m^3/annum)

RIVER REACH	DESCRIPTION	MAIN REPORT (April 2013) IRRIGATION DEMAND		VALIDATION & VERIFICATION STUDY IRRIGATION DEMAND “Qualifying_final”		“Current”	
		VOL (Mil m^3/a)	AREA (ha)	VOL (Mil m^3/a)	AREA (ha)	VOL (Mil m^3/a)	AREA (ha)
1	Caledon River: U/S Welbedacht Dam	40.3	9 930	44.17	9 987	77.38	16 911
2	Caledon River: Welbedacht Dam to Gariep Dam	36.5	5 835	39.10	5 612	48.42	6 863
3	U/S Aliwal North D/S Oranjedraai	6.6	877	9.82	1 330	17.99	2 652
4	Aliwal N to Gariep Dam	52.5	8 229	52.98	7 287	69.62	9 303
5	U/S Aliwal N	28.0	6 341	34.96	7 416	58.61	10 853
6	Gariep dam to Vanderkloof dam	27.7	3 121	29.75	3 246	36.04	3 576
7	Canals ex Vanderkloof dam	195.1	17 678	194.45	17 677	194.45	17 677
8	Scholzburg and Lower Riet IBs	50.2	4 564	50.20	4 564	50.20	4 564
9	Vanderkloof-Marks drift	187.4	17 455	187.00	17 455	187.00	17 455
10	Krugerdrift dam to Tweerivier gauge - Modder River	52.5	7 004	55.44	7 465	80.18	8 909
11	Tierpoort Dam to Kalkfontein Dam:	8.1	1 018	8.63	1 077	15.15	1 888
12	Kalkfontein Dam to Riet River Settlement: Kalkfontein WUA (canal)	56.7	6 187	58.22	6 369	73.94	7 626
14	Douglas weir to Orange-Vaal Conf. (Orange water)	104.3	11 410	104.30	11 410	104.30	11 410
Sub-Total	**Upper Orange (reaches 1-14)**	**846**	**99 647**	**869.02**	**100 896**	**1 031.29**	**119 687**
Sub-Total	**Lower Orange (reaches 15-22) – see table 4.2 & 4.3 of Main Report**	**818**	**63 109**	**818**	**63 109**	**818**	**63 109**
	Malopo	1.9	127	1.9	127	1.9	127
	Lower Orange Tributaries	19.8	1320	19.8	1320	19.8	1320
Total	**Orange River**	**1 685**	**164 203**	**1 708.72**	**165 452**	**1 870.99**	**184 243**
	Eastern Cape	577.2	49 565	577.2	49 565	577.2	49 565
Total	**RSA demand**	**2 262**	**213 768**	**2 285.92**	**215 017**	**2 448.19**	**233 808**
	Lesotho	20.6	2 640	20.6	2 640	20.6	2 640
	Namibia Fish River	47.5	2 520	47.5	2 520	47.5	2 520
	Namibia main Orange	35.2	2 961	35.2	2 961	35.2	2 961
Total demand		**2 366**	**221 889**	**2 389.22**	**223 138**	**2551.49**	**241 929**

Table A2 shows the breakdown of irrigation water use between regulated irrigation schemes and diffuse irrigation in each reach of the Upper Orange. Diffuse irrigation occurs mainly in the secondary catchments.

Table A2: Results of the Validation and Verification Study - Comparison of Main Report and Upper Orange Validation Study 2014 with breakdown between regulated irrigation Schemes and Diffuse Irrigation – Irrigation Areas (ha) and Volumes (mil. m^3/annum)

RIVER REACH	DESCRIPTION	IRRIGATION DEMAND					
		MAIN REPORT (April 2013)		VALIDATION & VERIFICATION STUDY			
				V & V "Qualifying final"		"Current"	
		Area (ha)	Volume (mil m³/a)	Area (ha)	Volume (mil m³/a)	Area (ha)	Volume (mil m³/a)
1	Caledon u/s Welbedacht Dam	9 027	34.83	9 084	38.66	16 008	71.87
	Leeuw River Scheme	903	5.51	903	5.51	903	5.51
sub total		**9 930**	**40.34**	**9 987**	**44.17**	**16 911**	**77.38**
2	Caledon d/s Welbedacht Dam	4 977	31.29	4 755	33.87	6 006	43.19
	Egmont Scheme	857	5.23	857	5.23	857	5.23
sub total		**5 834**	**36.52**	**5 612**	**39.1**	**6 863**	**48.42**
Caledon Sub Total		**15 764**	**76.86**	**15 599**	**83.27**	**23 774**	**125.8**
3	Orange Main Stream	877	6.64	941	7.44	1 222	9.04
	Diffuse			389	2.38	1 430	8.95
sub total		**877**	**6.64**	**1 330**	**9.82**	**2 652**	**17.99**
4	Orange Main Stream	1 344	10.11	1 451	10.90	1 755	12.57
	Stormberg (diffuse)	4 373	27.16	4 770	33.55	6 334	47.21
	Gariep small tributaries (diffuse) (Upper Orange.)	2 513	15.22	1 066	8.53	1 214	9.84
sub total		**8 230**	**52.49**	**7 287**	**52.98**	**9 303**	**69.62**
5	Kraai River (diffuse)	6 341	27.95	7 416	34.96	10 853	58.61
sub total		**6 341**	**27.95**	**7 416**	**34.96**	**10 853**	**58.61**
Upper Orange Sub Total		**15 448**	**87.08**	**16 033**	**97.76**	**22 808**	**146.22**
6	Gariep/Vanderkloof Scheme	2 025	22.27	2 025	22.27	2 025	22.27
	Seekoei & Vanderkloof incremental (diffuse)	1 096	5.46	1 221	7.48	1 551	13.77
sub total		**3 121**	**27.73**	**3 246**	**29.75**	**3 576**	**36.04**
7	Riet River Settlement (7b)	7 769	85.46	7 769	85.46	7 769	85.46
	Orange Riet Canal (7c)	4 637	51.01	4 637	51.01	4 637	51.01
	Ramah+Vanderkloof main Canal	5 271	57.98	5 271	57.98	5 271	57.98
sub total		**17 677**	**194.45**	**17 677**	**194.45**	**17 677**	**194.45**
8	Scholtzburg (8b)	691	7.6	691	7.6	691	7.6
	Lower Riet (8a)	3 873	42.6	3 873	42.6	3 873	42.6
sub total		**4 564**	**50.20**	**4 564**	**50.20**	**4 564**	**50.20**
9	Vanderkloof Scheme	17 455	187	17 455	187	17 455	187

RIVER REACH	DESCRIPTION	IRRIGATION DEMAND					
		MAIN REPORT (April 2013)		VALIDATION & VERIFICATION STUDY			
				V & V "Qualifying final"		"Current"	
		Area (ha)	Volume (mil m³/a)	Area (ha)	Volume (mil m³/a)	Area (ha)	Volume (mil m³/a)
sub total		**17 455**	**187.00**	**17 455**	**187.00**	**17 455**	**187.00**
ORP Upper Orange Sub Total		**42 817**	**459.38**	**42 942.30**	**461.40**	**43 272.30**	**467.69**
10	Diffuse u/s Rustfontein	324	1.26	340	1.32	413	12.76
	Novo Reach (10d)	272	1.24	259	1.20	1 228	9.27
	Diffuse u/s of Mockes	281	1.91	281	1.91	432	3.93
	Diffuse d/s Krugersdrift	115	1.04	115	1.04	140	0.87
	Modder GWS (Krugersdrift)	3 568	29.95	3 568	29.95	3 568	29.95
	Diffuse u/s Krugersdrift	2 443	17.12	2 902	20.02	3 128	23.4
sub total		**7 004**	**52.51**	**7 465**	**55.44**	**8 909**	**80.18**
11	Tierpoort	707	6.36	766	6.89	766	6.89
	Diffuse u/s	311	1.73	311	1.73	1 122	8.26
sub total		**1 018**	**8.10**	**1 077**	**8.63**	**1 888**	**15.15**
12	Kalkfontein Scheme	3 510	38.62	3 510	38.62	3 510	38.62
	Diffuse u/s	2 676	18.13	2 858	19.60	4 115	35.32
sub total		**6 187**	**56.74**	**6 369**	**58.22**	**7 626**	**73.94**
Riet Modder Sub Total		**14 208**	**117.35**	**14 911**	**122.28**	**18 422**	**169.28**
14	**Douglas weir to Orange-Vaal Conf. (Orange water)**	**11 410**	**104.30**	**11 410**	**104.30**	**11 410**	**104.30**
sub total		**11 410**	**104.30**	**11 410**	**104.30**	**11 410**	**104.30**
Grand Total		**99 648**	**844.98**	**100 896**	**869.02**	**119 687**	**1 013.29**
Total Scheme		**62 677**	**643.89**	**62 736**	**644.43**	**62 736**	**644.43**
Total Diffuse		**36 971**	**201.09**	**38 160**	**224.59**	**56 951**	**368.86**

3. Discussion and conclusions

The completed validation data shows that the "qualifying final" irrigation areas and irrigation water use on the **regulated Irrigation Schemes** in the Upper Orange River catchment are essentially unchanged from the August 2013 report figures. The "qualifying_final" for **diffuse irrigation** areas have increased marginally by about 9% on average, with the largest increases occurring in the Kraai River catchment (25%) and upstream of Krugersdrift dam (17%).

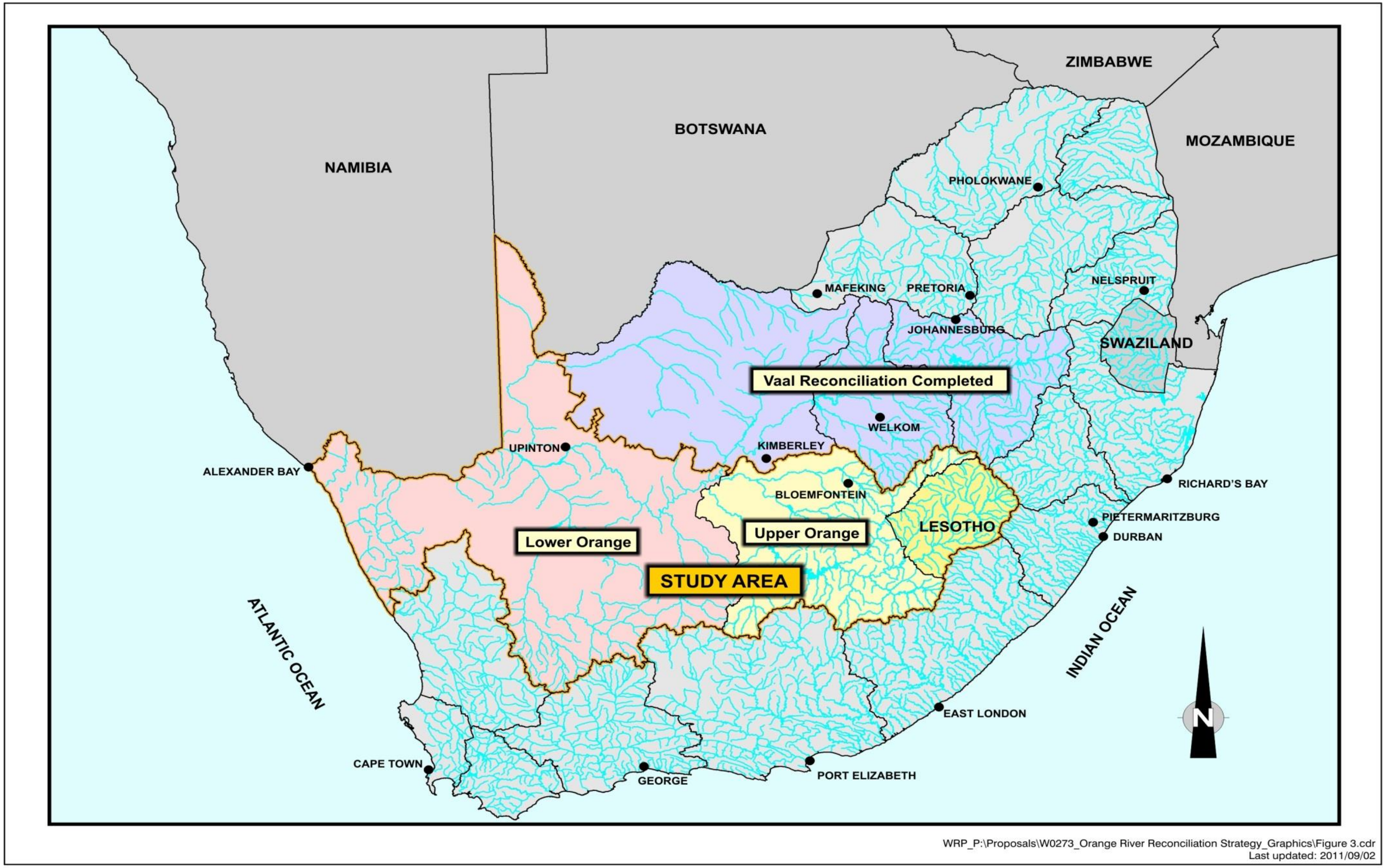
The large variances in **diffuse irrigation** between the "Qualifying_final" irrigation areas and the "Current" areas are however most noteworthy. Over the whole of the Upper Orange, there is an increase of 18 791ha or 43% (43 431ha to 62 222ha) in the area of diffuse irrigation. The main contributing reaches are Reach 1 and 2 (Caledon u/s and d/s of Welbedacht dam) – 8 175 ha; Reach 3 (Orange main stream u/s Aliwal North d/s Oranjedraai – 1 322 ha; Reach 5 (Kraai River)

– 3 437 ha and Reach 10 (Krugerdrift dam to Tweerivier gauge - Modder River) – 1 444 ha.

As indicated earlier, it is possible that this increase may represent opportunistic irrigation in wet years, but in any event the increases are significant and could have a major impact on water availability in the catchment as a whole in the future.

Appendix B

MAPS



DEVELOPMENT OF RECONCILIATION STRATEGIES FOR
LARGE BULK WATER SUPPLY SYSTEMS: ORANGE RIVER: PROPOSAL

Study area locality map