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Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam (WP0485)

Suitable Areas for Agricultural Development Report

August 2019

Department of Water and Sanitation
Directorate: Options Analysis

POST FEASIBILITY BRIDGING STUDY FOR THE PROPOSED BULK CONVEYANCE INFRASTRUCTURE FROM THE RAISED CLANWILLIAM DAM

APPROVAL

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DWS Report Number	:	P WMA 09/E10/00/0417/10
Consultants	:	Aurecon South Africa (Pty) Ltd
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DEPARTMENT OF WATER AND SANITATION

Directorate: Options Analysis

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

SUITABLE AREAS FOR AGRICULTURAL DEVELOPMENT REPORT

August 2019

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Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

Reports produced as part of this project are indicated below.

Bold type indicates this report.

Report Index	Report Number	Report Title
1		Inception Report
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water
6		Existing Infrastructure and Current Agricultural Development Sub-Report
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land
8		Suitable Agricultural Areas and Land Ownership Report
9		Evaluation of Development Options Sub-Report
10	**P WMA 09/E10/00/0417/10**	**Suitable Areas for Agricultural Development**
11		Right Bank Canal Design Sub-Report
12		Conceptual Design Sub-Report
13		Environmental Screening Sub-Report
14		Jan Dissels and Ebenhaeser Schemes Design Sub-Report
15	P WMA 09/E10/00/0417/13	Feasibility Design
16	P WMA 09/E10/00/0417/7	Topographical Surveys
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations
18	P WMA 09/E10/00/0417/9	Soil Survey
19		Financial Viability of Irrigation Farming Sub-Report
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development
21		Right Bank Canal Cost Analysis Sub-Report
22		Socio-Economic Impact Analysis Sub-Report
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Report
25	P WMA 09/E10/00/0417/1	Main Report
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report

Concise Description of the Content of Study Reports

Report Index	Report Number	Report Title and Description of Content
1		Inception The report forms part of the contract and stipulates the scope of work for the study, the contract amount and the contract period. It contains a detailed description of tasks and methodology, a study programme, human resource schedule, budget and deliverables. The Capacity Building and Training Plan has been included.
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the first year of the study, including field-based training, training workshop 1 and mentorship of DWS interns through secondment.
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the second year of the study, including field-based training, training workshop 2 and mentorship of DWS interns through secondment.
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment Provides an analysis of the existing water use and current water allocations in the study area, and addresses ecological water requirements, water use for irrigated agriculture and projections for future use, current domestic and industrial water use and projections for future use, water use for hydropower and water losses in the water supply system.
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water Confirms the volume of additional water available for development, after water has been reserved for the current water uses, as well as making recommendations on how the additional yield should be distributed among water use sectors and water users.
6		Existing Infrastructure and Current Agricultural Development Sub-Report Provides an overview of the extent and general condition of the current bulk water storage and conveyance infrastructure. This report also provides an overview of the locality and extent of the existing agricultural areas determined by reviewing Geographic Information System (GIS) data obtained from various sources.
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land An update of the Sub-Report, providing a refinement of the current agricultural water requirements following evaluation of the current crop types, an assessment of the desirability of diverting releases for downstream irrigators via the Clanwilliam Canal and Jan Dissels River, to meet the summer ecological flows in the lower Jan Dissels River, and presents an Implementation Action Plan with costs.

Report Index	Report Number	Report Title and Description of Content
8		Suitable Agricultural Areas and Land Ownership Sub-Report Description of the collection of information and the preparation undertaken for the analysis of options, which includes a summary of existing irrigated areas and water use, cadastral information, land ownership, environmental sensitivity, soils suitability, water quality considerations and constraints, and the initiation of the process to identify additional areas suitable for irrigation.
9		Evaluation of Development Options Sub-Report Describes the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. This provides the background and an introduction to the discussions at the Options Screening Workshop held in December 2018.
10	P WMA 09/E10/00/0417/10	Suitable Areas for Agricultural Development Describes the supporting information, process followed and the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. Recommends the preferred options to be evaluated at feasibility level.
11		Right Bank Canal Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the new Right Bank canal. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, canal design, surface flow considerations, canal structures, power supply and access roads. Operational considerations and recommendations.
12		Conceptual Design Sub-Report Describes the scheme layouts at a conceptual level and infrastructure components to be designed, alternatives to consider or sub-options, and affected land and infrastructure, as well as the updated recommended schemes for new irrigation development.
13		Environmental Screening Sub-Report Describes and illustrates the opportunities and constraints, and potential ecological risks/impacts and recommendations for the short-listed bulk infrastructure development options at reconnaissance level. Describes relevant legislation that applies to the proposed irrigation developments.
14		Jan Dissels and Ebenhaeser Schemes Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the Jan Dissels and Ebenhaeser schemes. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, intake structures, balancing dams and reservoirs, rising mains and gravity pipelines and trunk mains where relevant, power supply and access roads. Operational considerations and recommendations.

Report Index	Report Number	Report Title and Description of Content
15	P WMA 09/E10/00/0417/13	Feasibility Design Description of the approach to and design of selected bulk infrastructure at feasibility level, with supporting plans and implementation recommendations.
16	P WMA 09/E10/00/0417/7	Topographical Surveys Describes the contour surveys for the proposed identified bulk infrastructure conveyance routes and development areas, the surveying approach, inputs and accuracy, as well as providing the survey information.
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations Presents the findings of geotechnical investigations of the various identified sites, as well as the approach followed, field investigations and testing, laboratory testing, interpretation of findings and geotechnical recommendations.
18	P WMA 09/E10/00/0417/9	Soil Survey Describes the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 to 100 m above river level, between the upper inundation of the raised Clanwilliam Dam and Klawer.
19		Financial Viability of Irrigation Farming Sub-Report Describes the findings of an evaluation of the financial viability of pre-identified crop-mixes, within study sub-regions, and advises on the desirability of specific crops to be grown in these sub-regions. It includes an evaluation of the financial viability of existing irrigation farming or expanding irrigation farming, as well as the identification of factors that may be obstructive for new entrants from historically disadvantaged communities.
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development This report will focus on policy, institutional arrangements, available legal and administrative mechanisms as well as the proposed classes of water users and the needs of each. This would include identifying opportunities for emerging farmers, including grant and other types of Government and private support, and a recommendation on the various options and opportunities that exist to ensure that land reform and water allocation reform will take place through the project implementation.
21		Right Bank Canal Cost Analysis Sub-Report Provides an economic modelling approach to quantify the risk of the failure of the existing main canal and the determination of the economic viability of the construction of the new right bank canal to reduce the risk of water supply failure.
22		Socio-Economic Impact Analysis Sub-Report Describes the socio-economic impact analysis undertaken for the implementation of the new irrigation development schemes, for both the construction and operational phases. This includes a description of the social and economic contributions, the return on capital investment, as well as the findings of a fiscal impact analysis.

Report Index	Report Number	Report Title and Description of Content
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis Synthesis of agricultural economic and socio-economic analyses undertaken, providing an integrated description of agricultural production and farm development and socio-economic impact analysis, as well as the analysis of the right bank canal costs and benefits.
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Describes the scope of the project, the specific configuration of the schemes to be implemented, the required implementation timelines, required institutional arrangements and the required environmental and other approval requirements and mitigation measures, to ensure that the project is ready for implementation.
25	P WMA 09/E10/00/0417/1	Main Report Provides a synthesis of approaches, results and findings from the supporting study tasks and interpretation thereof, culminating in the study recommendations. Provides information in support of the project funding motivation to be provided to National Treasury.
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report Describes the activities undertaken by an independent consultant to evaluate existing HDI Farmers policies and legislative context, identify, map and analyse prospective HDI farmers and potential land for new irrigation, as well as propose a mechanism for the identification and screening of HDI farmers.

Executive Summary

Introduction

This report describes the salient features, costs and impacts of identified potential irrigation development options (see **Table E1**) for new irrigation development in the lower Olifants River, and recommends the preferred options to be evaluated at feasibility level. Following the acceptance of recommendations, the Feasibility Design phase of this study will proceed.

The **process** followed for this task includes the following steps in chronological order:

a) Identification of all potential options, compilation of a Long List of potential options, and first-level screening of the Long List of options,
b) Compilation of a Preliminary Short List of options and qualitative screening of the Preliminary Short List of options
c) Compilation of a Short List of options to be evaluated further,
d) Evaluation and documentation of short-listed options,
e) Holding an Options Workshop with key stakeholders,
f) Preparation of the *Suitable Areas for Agricultural Development Sub- Report* that documents the background and process, and the options presented at the options workshop,
g) Revisiting the screening of options, taking into consideration workshop recommendations,
h) Defining and evaluating new options not previously identified, after considering workshop recommendations,
i) Refining existing options, after considering workshop recommendations,
j) Preparation of the *Suitable Areas for Agricultural Development Report* (this report) inclusive of updated and new options, and with recommendations for feasibility-level evaluation.

The **study area** has been divided into five sub-areas (also referred to as zones) in which the various development options are located, as follows:

- Sub-area 1: Olifants River catchment upstream of Clanwilliam Dam,
- Sub-area 2: Clanwilliam Dam, Olifants River catchment from Clanwilliam Dam up to and including Bulshoek Weir,
- Sub-area 3: Schemes located wholly outside the Olifants River catchment,
- Sub-area 4: Olifants River catchment from Bulshoek Weir to Lutzville,
- Sub-area 5: Olifants River catchment from Klawer to the Coast.

Table E1 │ Summary Options Table

#	Option	Variation	Preferred option?	Brief description of option	Water require-ment (Mm^3/a)	Conveyance losses (Mm^3/a)	River losses (Mm^3/a	Incremental require-ment (Mm^3/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
Sub-area 2 - Clanwilliam Dam and Canal and Jan Dissels catchment													
1	Jan Dissels	-	Yes	Pumping from Clanwilliam Dam. Irrigable area reduced to 148ha following environmental screening. Potential for 7.5ha plots, consisting of currently irrigated land as well as greenfields. Land between the Clanwilliam Dam and the Jan Dissels River is municipal property. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam. Existing water allocation of 0.49 million m^3/a.	1.36	0.00	0.00	0.87	13.9	23.1	-	1.47	**Sensitivity: Medium:** Small ESA 1 and ESA 2 corridors occur within the natural areas of the study sites. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised. **Recommendation:** The Jan Dissels River flows to the south of the irrigation fields and it is advised to limit development outside of the 1:100 year floodline of the river. The proposed site would require detailed site assessment by freshwater and botanical specialists.
2	Abstraction from Clanwilliam Dam	-	Yes	Pumping water directly from the lake of the Clanwilliam Dam, at two abstraction points. The abstraction points will be affected by the rise/fall of the water level. Irrigable area 549ha. Potential for 7.5ha plots. Potential power supply from a new hydropower plant at the raised Clanwilliam dam. Existing water allocation of 0.29 million m^3/a. Privately-owned land.	5.06	0.00	0.00	4.77	38.3	73.7	-	1.26	**Sensitivity: Medium:** Most remaining natural areas are mapped as ESA 1 and ESA 2 corridors near watercourses. Adjacent wetland areas should be buffered by a specialist. The most northern part of the site falls within a climate change adaptation corridor and should be avoided for new developments. The north western section also falls within an upland-lowland interface, which supports important ecological functions. **Recommendations:** Avoid as far as possible the upland-lowland interface and climate change adaptation corridors. The proposed site would require detailed site assessment by freshwater and botanical specialists.
Sub-area 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir													
3	Transfer of lower Jan Dissels River scheduled allocations to Olifants River	-	Yes	Moving existing allocations of 3 irrigators in the lower Jan Dissels River to the Olifants River, to improve the ecological condition of the lower section of the Jan Dissels River.	1.0	0.00	0	1.0	0	-	-	-	**Sensitivity: Medium:** All remaining natural areas within the proposed site are mapped as ESA 1 with the Jan Dissels River, Olifants River and other smaller watercourse corridors mapped as CBA 1 and ESA 2. **Recommendation:** All CBA 1 areas should be avoided and the ESA 1 and ESA 2 areas would require detailed site assessment by freshwater and botanical specialists. All development should also be located outside of the 1:100 year floodline of the Olifants and Jan Dissels rivers and other tributaries in the area.
4	Pumping from Olifants River: Zandrug	-	Yes	Water pumped from the Olifants River at three abstraction points. Located between Clanwilliam Dam and Bulshoek Weir to the east of the N7. The land is privately-owned. Irrigable area of 1,219ha. Potential for 7.5ha plots for a portion of the area located closest to Clanwilliam town. Existing water allocation of 2.55 million m^3/a.	11.24	0.00	0.56	8.89	84.6	144.1	-	1.11	**Sensitivity: High:** All remaining natural areas within the proposed site are mapped as ESA 1 and CBA 1, with all watercourse corridors mapped as ESA 2. The remaining natural vegetation across the bottom third of the site is mapped as Leipoldtville Sand Fynbos, which is classified as an Endangered ecosystem. **Recommendation:** All CBA 1 and natural vegetation areas should be avoided, and the ESA 1 and ESA 2 areas would require detailed site assessment by freshwater and botanical specialists. All development should also be located outside of the 1:100 year floodline of the Olifants and Jan Dissels rivers and other tributaries in the area.

#	Option	Variation	Preferred option?	Brief description of option	Water requirement (Mm^3/a)	Conveyance losses (Mm^3/a)	River losses (Mm^3/a	Incremental requirement (Mm^3/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
5	Pumping from Bulshoek Weir	-	Yes	Water pumped from Bulshoek Weir at three abstraction points. Located between Clanwilliam Dam and Bulshoek Weir. Irrigable area of 354ha. Potential power supply from a new hydropower plant at the enlarged dam. The land is privately-owned. Existing water allocation of 0.33 million m^3/a.	3.26	0.00	0.16	2.93	33.3	57.6	-	1.52	**Sensitivity: Medium:** All watercourse corridors within the proposed site are mapped as ESA 1 for watercourse protection and a very small section in the most western section across an existing pivot irrigation field. An area is mapped as an upland-lowland interface across the western half of the entire site. The remaining natural vegetation across the western boundaries as well is the most southern portion of the site is mapped as Leipoldtville Sand Fynbos, which is classified as an Endangered ecosystem. **Recommendation:** The proposed site would require detailed site assessment by freshwater and botanical specialists to confirm the areas to be excluded as an upland-lowland interface and those containing endangered vegetation or species of concern. Provide a buffer for all wetlands and watercourses.
Sub-area 3 - Options Located Outside the Olifants River Valley													
6a	Jakkals River Irrigation Scheme (JRIS) & Graafwater	*Inter-basin transfer to Jakkals River for abstraction*	No	Sandveld Investment & Development Co. Ltd (SANID) Water identified four farms as possible irrigation areas and a supply pipeline route. Water will be pumped from Clanwilliam Dam to the Jakkals River, from where it is abstracted for the JRIS (3,187ha irrigable area) and Graafwater. Pumping head of 563m.	10.27	0.31	5.13	10.27	544.38	1,196.07	-	10.05	**Sensitivity: High:** The pipeline follows the road much of the route, but the eastern section includes areas of CBA1. The pipeline also transects ESA1 and ESA2 areas, mostly in the west and includes watercourses and wetland areas. Option 7a mostly transects an area mapped as CBA 1. This area is very sensitive and should be avoided as far as practicably possible. **Recommendation:** Avoid CBA1 area as far as practicable and apply site specific mitigation if not possible. Botanical and freshwater specialist assessments should be undertaken for the route and associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. Site rehabilitation & maintenance would be very important along the pipeline corridors.
6b		*Direct pipeline*	No	Pipeline scheme alternative from Clanwilliam Dam along the R364 road. Pumping head of 467m.	10.27	0.31	0.00	10.27	488.1	907.8	-	6.79	
7	Provision of water to coastal towns	-	No	Supply coastal municipalities (Lamberts Bay and Elands Bay) with water to augment their domestic supply. Water will be pumped from Clanwilliam Dam along the R364 road and then gravitated along the coast to Lamberts Bay and Elands Bay. Pumping head of 384m.	0.37	0.01	0.00	0.37	86.7	92.6	-	21.61	**Sensitivity: High:** The pipeline transects numerous CBA1 areas along the proposed route and transects CBA2 areas in small areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line. **Mitigation:** Avoid CBA1 areas as far as practicable and apply site specific mitigation if not possible. Botanical and freshwater specialist assessments should be undertaken for the route and associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. Site rehabilitation and maintenance would be very important along the pipeline corridors. Consultation with Steenboksfontein Private Nature Reserve is recommended.

#	Option	Variation	Preferred option?	Brief description of option	Water require-ment (Mm³/a)	Conveyance losses (Mm³/a)	River losses (Mm³/a	Incremental require-ment (Mm³/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
8	Combined JRIS & supply to Graafwater, Lamberts Bay & Elands Bay	-	No	Pipeline scheme along the R364, pumped from Clanwilliam Dam and distribution to the JRIS, Graafwater Lamberts Bay & Elands Bay. Pumping head of 474m.	10.63	0.32	0.00	10.63	565.9	904.7	-	7.34	**Sensitivity: High:** The pipeline transects numerous CBA1 (Terrestrial) and CBA2 areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line. **Recommendation:** Avoid CBA1 areas as far as practicable and apply site specific mitigation if not possible. Botanical and freshwater specialist assessments should be undertaken for the route and associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. Site rehabilitation and maintenance would be very important along the pipeline corridors. Consultation with Steenboksfontein Private Nature Reserve is recommended.
Sub-area 4 - Olifants River below Bulshoek Weir to Trawal													
9	Release at Bulshoek and pump from river: Zypherfontein 1	-	No	Water released from Bulshoek Weir down the Olifants River and pumped to the scheme on the right bank, above the Doring River confluence. Irrigable area of 888ha. The land is privately-owned.	7.94	0.00	2.30	7.94	65.1	127.2	-	1.38	**Sensitivity: Medium:** CBA1 occurs adjacent to the south western border of the site along the Olifants river. All watercourse corridors across the site is mapped as ESA1 and ESA2 for watercourse protection. The north eastern section of the study area is also classified as an upland-lowland interface and should be regarded as requiring specialist input. **Recommendation:** The site should be assessed from a botanical and freshwater perspective as well as to provide input into the possible impact on the upland-lowland interface area. Development should also be limited to areas outside the 1:100 year floodline of the Olifants River.
10	Release at Bulshoek and pump from river: Trawal	-	No	Water released from Bulshoek Weir down the Olifants River and pumped to the scheme on the left bank, above the Doring River confluence. Irrigable area of 695ha. The land is privately-owned.	6.64	0.00	1.92	6.64	56.3	105.8	-	1.38	**Sensitivity: Medium:** All watercourse corridors across the site is mapped as ESA1 and ESA2. There is also a small wetland section on the north western side of the site. **Recommendation:** The site should be assessed from a botanical and freshwater perspective. Development should also be limited to areas outside the 1:100 year floodline of the Olifants River.
11	Release at Bulshoek and pump from river: Zypherfontein 2	-	No	Water released from Bulshoek Weir down the Olifants River and pumped to the scheme on the right bank, above the Doring River confluence. Irrigable area of 658ha. The land is privately-owned.	6.28	0.00	1.82	6.28	58.4	104.6	-	1.44	**Sensitivity: Medium:** CBA1 occurs adjacent to the south western border of the site along the Olifants river as well as to the north along the Doring River. All watercourse corridors across the site is mapped as ESA1 and ESA2. The north eastern section of the study area is also classified as an upland-lowland interface. **Recommendation:** The site should be assessed from a botanical and freshwater perspective to buffer watercourses and wetland areas as well as to provide input into the possible impact on the upland-lowland interface area. Development should also be limited to areas outside the 1:100 year floodlines of the Olifants and Doring rivers.

#	Option	Variation	Preferred option?	Brief description of option	Water requirement (Mm³/a)	Conveyance losses (Mm³/a)	River losses (Mm³/a	Incremental requirement (Mm³/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
12	Release at Bulshoek and pump from river: Melkboom	-	No	Water released from Bulshoek Weir down the Olifants River and pumped to the scheme on the right bank, just below the Doring River confluence. Irrigable area of 333ha. The land is privately-owned.	3.45	0.00	1.00	3.45	38.0	67.6	-	1.69	**Sensitivity: Medium:** CBA1 occurs adjacent to the north and north eastern border of the site. All watercourse corridors across the site is mapped as ESA1 and ESA2 for watercourse protection. **Recommendation:** The site should be assessed from a botanical and freshwater perspective to buffer watercourses and determine mitigation measures for avoiding sensitive ecological corridors.
13	Combined Areas # 10-11-12 Zypherfontein 1-2 & Trawal	*Pipeline with branches*	No	Water supplied by pipeline from Bulshoek Weir to the Zypherfontein 1-2 and Trawal areas. Irrigable area of 2,241ha.	21.40	0.00	1.07	21.40	529.9	726.4	-	2.93	**Sensitivity: Medium:** as per the ecological descriptions of Schemes 10, 11 and 12. **Recommendation:** As per the recommendations for Schemes 10, 11 and 12.
14a	Combined Areas # 10-12-13 Zypherfontein 1-2 & Melkboom	*Raised BH canal, pipeline, high-level canal*	No	Water supplied from Bulshoek Weir to the Zypherfontein 1-2 and Melkboom areas, via a raised Lower Olifants canal, pipeline and syphon crossing the Olifants River, and a new high-level canal supplying these areas under gravity. Irrigable area of 1,878ha.	17.93	1.79	0.90	17.93	274.8	366.0	-	1.76	**Sensitivity: Medium:** As per the ecological descriptions of Schemes 10, 12, and 13. **Recommendation:** As per the recommendations for Schemes 10, 12 and 13.
14b		*Raised & lined BH canal, pipeline, high-level canal*	No	Water supplied from Bulshoek Weir to the Zypherfontein 1-2 and Melkboom areas, via a raised and lined Lower Olifants canal, pipeline and syphon crossing the Olifants River, and a new high-level canal supplying these areas under gravity. Irrigable area of 1,878ha.	17.93	1.79	0.90	17.93	305.1	412.8	256.2	1.99	**Sensitivity: Medium:** As per the ecological descriptions of Schemes 10, 12 and 13. **Recommendation:** As per the recommendations for Schemes 10, 12 and 13.
15	New Right Bank canal	-	Yes	Raise and line short section of Trawal canal below Bulshoek Weir, syphon through Olifants river and a new right bank canal section to replace the existing Trawal canal section to meet all existing irrigation plus new irrigation in Zypherfontein 1-2, Trawal and Melkboom areas. New irrigable area of 2,574ha. Privately-owned land.	24.31	2.46	1.23	24.31	361.4	518.6	508.7	1.82	**Sensitivity: Medium:** The riparian zone of the Doring River is mapped as a CBA 1 with smaller ESA1 areas; however there are no mapped threatened ecosystems along the new canal route. **Mitigation:** Use existing disturbed areas as far as possible. Mitigation measures should be advised by a freshwater ecologist to promote watercourse protection. Refer to the mitigation of the relevant areas (areas 9, 10, 11 and 12) discussed above.
Sub-area 5 - Olifants River from Klawer to the Coast													
16	Release at Bulshoek and pump from river: Klawer	-	No	Water released downstream from Bulshoek Weir and pumped from the lower Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. 12 million m³ balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality. New irrigable area of 1,449ha.	14.67	0.00	6.16	14.67	464.8	591.1	-	3.48	**Sensitivity: High:** A very small pocket of CBA1 remains in the centre of the reduced area. Watercourses occurring along the south eastern section of the site have been designated as ESA1 and ESA2 areas. The eastern half of the site falls into the Knersvlakte protected area expansion under the NPAES programme. **Recommendation:** Avoid CBA areas and watercourse corridors. These areas would require freshwater and botanical specialist inputs. Avoid NPAES areas.

#	Option	Variation	Preferred option?	Brief description of option	Water require-ment (Mm³/a)	Conveyance losses (Mm³/a)	River losses (Mm³/a	Incremental require-ment (Mm³/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
17	Release at Bulshoek and pump from river: Aties Karoo	-	No	Water released downstream from Bulshoek Weir and pumped from the lower Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. 4.3 million m³ balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality. New irrigable area of 4,500ha evaluated.	45.56	0.00	20.50	45.56	647.7	1,032.1	-	1.97	**Sensitivity**: **Medium:** ESA1 and ESA2 features occur across the site along watercourse corridors. Smaller sections along the eastern boundary of the site falls into the Knersvlakte protected area expansion in terms of the NPAES. **Recommendation**: Avoid watercourse corridors. These areas would require freshwater and botanical specialist inputs. Avoid NPAES areas.
18	Release at Bulshoek and pump from river: Ebenhaeser New	-	No	Water released downstream from Bulshoek Weir and pumped from the lower Olifants River to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. 15.7 million m³ balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality. New irrigable area of 4,500ha evaluated.	45.56	0.00	23.24	45.56	924.9	1,378.7	-	2.84	**Sensitivity**: **Medium:** ESA1 and ESA2 features occur across the site along watercourse corridors mainly. The most western section of the site however falls within an ESA1 which is classified as a climate change corridor. A small section to the south east falls within the Knersvlakte protected area expansion in terms of the NPAES. **Recommendation**: Avoid the ESA1 area to the west, as well as the NPAES focus area to the south east of the study area. All watercourse corridors should be buffered. Development should be limited to outside the 1:100 year floodline of the streams in the study area.
19	Release at Bulshoek and pump from river: Lutzville 2	-	No	Water released downstream from Bulshoek Weir and pumped from the lower Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. 19.2 million m³ balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality. New irrigable area of 4,145ha.	41.97	0.00	21.40	41.97	1,058.4	1,378.7	-	2.84	**Sensitivity**: **Medium:** ESA1 and ESA2 features occur across the site along watercourse corridors mainly. **Recommendation**: All watercourse corridors should be buffered by a specialist and avoided as far as possible. Development should be limited to outside the 1:100 year floodline of the streams in the study area.
20a	Use of spare capacity in Naauwkoes canal section Release at Bulshoek Weir and pump into start of Naauwkoes canal section	*Naauwkoes canal section – Klawer, with canal lining*	No	Pump from river into start of Naauwkoes (zone 5) canal section. Irrigate full Klawer irrigation area on the right bank from Naauwkoes canal. New irrigable area of 1,449ha.	14.67	1.47	4.25	14.67	249.2	316.2	199.3	1.86	**Sensitivity**: **High:** The whole area where the pipeline is located is mapped as a CBA 1 and ESA2 along the river riparian zone. It also falls within the floodplain of the Olifants River. The area of abstraction from the canal to transfer to a dam is partially mapped as ESA 1 and ESA 2 for watercourse protection. **Recommendation**: A freshwater ecologist would have to undertake site assessments. Proper rehabilitation of the pipeline routes would be very important as well as post-construction monitoring and invasive alien vegetation removal.
20b		*Naauwkoes canal section – Klawer scaled-down*	Yes	Pump from river into start of Naauwkoes (zone 5) canal section. Irrigate reduced Klawer irrigation area on the right bank from Naauwkoes canal. New irrigable area of 818ha.	8.28	0.83	2.40	8.28	82.7	142.6	-	1.49	
21a	Use of spare capacity in Naauwkoes/ Vredendal canal sections Release at Bulshoek Weir and pump into start of Naauwkoes canal section	*Naauwkoes/ Vredendal canal sections – Coastal 1, with canal lining*	No	Pump from river into start of Naauwkoes (zone 5) canal section. Irrigate full Coastal 1 irrigation area on the left bank from Vredendal canal. New irrigable area of 2,235ha.	22.63	2.26	6.56	2.63	573.6	786.2	568.5	3.01	**Sensitivity**: **Low:** ESA1 and ESA2 features occur across the site along the watercourse corridors. **Recommendation**: ESA1 and ESA2 areas along watercourse corridors should be avoided as far as possible. Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.
21b		*Naauwkoes/ Vredendal canal sections – Coastal 1 scaled-down*	Yes	Pump from river into start of Naauwkoes (zone 5) canal section. Irrigate reduced Coastal 1 irrigation area on the left bank from Vredendal canal. New irrigable area of 818ha.	8.28	0.83	2.40	8.28	72.3	144.6	-	1.51	
21c		*Naauwkoes/ Vredendal canal sections – Coastal 1 scaled-down Post RB-Canal*	Yes	Convey via future right-bank canal and irrigate reduced Coastal 1 irrigation area on the left bank from Vredendal canal. New irrigable area of 818ha.	8.28	0.83	0.41	8.28	53.70	93.2	-	0.97	

#	Option	Variation	Preferred option?	Brief description of option	Water require-ment (Mm^3/a)	Conveyance losses (Mm^3/a)	River losses (Mm^3/a	Incremental require-ment (Mm^3/a	HD Farmers Capital cost (R million)	TOTAL NPV HD Farmers (R million)	TOTAL NPV Betterm'nts (R million)	URV (8%)	Environmental impacts
21D		*Naauwkoes/ Vredendal canal sections – Coastal 1 scaled-down 2*	Yes	Pump from river into start of Naauwkoes (zone 5) canal section. Irrigate reduced Coastal 1 irrigation area on the left bank from Vredendal canal. New irrigable area of 450ha.	4.56	0.46	1.32	4.56	38.8	74.3	-	1.41	
22a	Use of spare capacity in Naauwkoes/ Vredendal canal sections Release at Bulshoek Weir and pump into start of Naauwkoes canal section	*Naauwkoes/ Vredendal canal sections – Ebenhaeser Restitution & Augmentation*	Yes	Pump from river into start of Naauwkoes (zone 5) canal section. Divert at end of Vredendal canal section and pump to Ebenhaeser. Irrigate Ebenhaeser restitution area and augment Ebenhaeser community scheme. New irrigable area of 400ha.	6.05	0.40	1.17	4.05	120.2	158.9	-	3.39	**Sensitivity: Medium:** Small sections of the entire development footprint of the abstraction from the river, as well as the proposed new plots fall within areas mapped as CBA1, ESA1 and ESA2. The entire area is mapped as Namaqualand Strandveld which is classified as Least Threatened (LT). On the western side of the proposed new plots at Ebenhaeser is an area which falls within a CBA 1 which is approximately 70 ha in extent. This area is also bordered by a wetland and estuarine environments to the west, north and south. **Recommendation:** A freshwater and estuarine ecologist as well as a botanical specialist would have to be consulted and site assessments undertaken to determine the impact of the proposed developments on the natural environment. Proper rehabilitation of the pipeline routes would be very important as well as post-construction monitoring and invasive alien vegetation removal.
22b		*Naauwkoes/ Vredendal canal sections – Ebenhaeser Restitution & Augmentation Post RB-Canal*	Yes	Convey via future right-bank canal and divert at end of Vredendal canal section and pump to Ebenhaeser. Irrigate Ebenhaeser restitution area and augment Ebenhaeser community scheme. New irrigable area of 400ha.	6.05	0.40	0.20	4.05	111.2	142.5	-	3.04	
Sub-areas 4 and 5: LORGWS (Bulshoek) Canal													
23	Replace LORGWS Canal with a pipeline with increased capacity	-	No	Supply existing irrigation plus new irrigation via a pipeline that fully replaces the existing Lower Olifants canal, with increased capacities to accommodate increased use from the Bulshoek main canal and portions of the left bank and right bank canals. New irrigable area of 6,257ha.	60.51	1.82	3.03	60.51	2,949.1	3,446.9	4,691.2	5.34	**Sensitivity**: **Medium:** The sensitivity would depend on whether the pipeline would fall within the same footprint of the current canal or whether new areas will be disturbed, and where these areas would be. If the canal footprint is used, then the sensitivity would be low for the route, but the associated footprint of construction camps, roads, stockpile areas, turning circles, etc. could be medium or high, depending on location. There is also a section with endangered vegetation along Options 5 and 6. Work within the regulated area of a watercourse or wetland would have to be authorised by DWS and freshwater specialist inputs would be required. **Recommendation**: Follow roads / existing canal where possible. Avoid CBA1 areas and threatened ecosystems. The pipeline route should be planned together with a botanical and freshwater specialist. The heritage value of the canal should also be determined by including Heritage Western Cape in the planning process.
24	Increase capacity of LORGWS canal and other betterments	-	No	Raise the Bulshoek main canal and left bank canal up to the start of the Naauwkoes connection and supply existing irrigators as well as new irrigation areas Zypherfontein 1-2, Trawal Melkboom and Coastal 1. New irrigable area of 6,257ha.	60.51	1.82	3.03	60.51	945.3	1173.8	814.5	1.92	**Sensitivity**: **Low:** Assuming existing canals used. **Recommendation**: Use existing footprint as far as possible. If any natural areas or watercourses would be affected, then specialist input would be required. The heritage value of the canal should also be determined.

Comparative Evaluation and Screening

The following screening criteria were identified and applied for the comparative evaluation of options:

- Scheme location and size,
- Water loss percentage / irrigable area,
- Net present value (NPV),
- Unit reference value (URV) and URV adjusted for the water loss factor,
- Opportunity costs,
- Environmental impacts,
- Risks,
- Social aspects and impacts,
- Practical implementation.

The following screening approach has been adopted, to identify the preferred irrigation development options:

1) Develop combinations of development options, hereafter called "Suites" up to the limit of 61.1 million m^3/a (= water requirements + losses).
2) Identify screening criteria and apply to the Suite of options.
3) Propose phases of development and associated budgeting implications.
4) Compare alternatives and recommend the preferred Suite.
5) Make recommendations for feasibility-level analysis and further issues to address.

Recommendation of Options

Three implementation alternatives (suites) have been assessed to illustrate the combinations of options. It is deduced, from the different phasing options, that Phasing Suite 3 offers the opportunity to irrigate the largest area (6 062 ha) when compared to the other phasing options. The development cost per hectare is marginally more expensive than that of Phasing Suite 1 (the lowest capital cost suite). Phasing Suite 3 further offers the unique opportunity to, in part, address the most significant risk currently posed to the Lower Olifants River Government Water Scheme (LORGWS), namely the very poor structural integrity of the canal system. This suite of options includes replacement of the main (Trawal) canal section with a new right bank canal, from Bulshoek Weir up to 'Verdeling', where the canal splits. This betterment would also offer the opportunity to lessen the restriction to flow in the main canal.

The following irrigation development options are recommended for feasibility design evaluation, based on the comparative evaluation and screening of identified options, to a total of 61.1 million m^3/a:

1) Option 1: Jan Dissels; pumping from Clanwilliam Dam.
2) Option 2: Clanwilliam; pumping from Clanwilliam Dam.
3) Option 4: Zandrug; pumping from the Olifants River.
4) Option 5: Bulshoek; pumping from Bulshoek Weir.
5) Option 15: Right Bank Canal; replacing the existing Trawal section of the Lower Olifants canal with increased capacity, supplying four new irrigation development areas (Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom) in the Trawal area, and any increased downstream supply.
6) Options 20/21/22: Use of spare capacity in the Naauwkoes/Vredendal canal sections, supplying a combination of the restitution farms to be allocated to Ebenhaeser farmers, augmenting the existing Ebenhaeser community scheme, and potentially supplying a scaled-down Coastal 1 area near Vredendal (or possibly a scaled-down Klawer area), depending on the confirmation of spare capacities in canal sections.

In addition, the following option is recommended, from the 25% portion of the additional yield from the raised Clanwilliam Dam for improving the assurance of supply of existing users:

7) Option 3: Transfer of Jan Dissels River Water Use Authorisations to the Olifants River.

All the recommended options, with perhaps the exception of the Bulshoek option (Option 5), provides significant opportunity for the development of small (assumed 7.5 ha) plots, being located reasonably close to towns., These options also provide the opportunity to support a restitution scheme or an existing HDI scheme (Ebenhaeser).

The development phases as shown in Table 18.1, or a variation thereof, are recommended as the preferred options. This should be revisited following the Feasibility Design of the preferred options.

The options located closest to the Clanwilliam Dam, especially those options located upstream of the Bulshoek Weir, are the most attractive options, as water can be provided for irrigation at low costs with limited losses.

While a rigorous process has been followed to identify the preferred development options, there is a possibility that some private landowners, whose lands do not fall within the current identified scheme areas, may be interested in HDI development schemes. Such, likely smaller in extent, HDI schemes could still apply for additional water through the application process for water authorisations, if such schemes are deemed feasible. This should be encouraged especially in the area between Clanwilliam Dam ans Bulshoek Weir.

While it is evident that many existing land owners are interested in HDI irrigation development schemes, there still seems to be significant uncertainty among them, until the completion of the raising of the dam is more certain, and cost implications (tariffs) are better understood.

Considering the current level of knowledge of planned HDI developments, the development of such schemes is more likely to be a combination of private development (one or more farms per venture), and community supply, specifically the Ebenhaeser restitution farms and some augmentation of the irrigation at Ebenhaeser. The requirement for the development of one or more government irrigation scheme may only become clear with greater clarity of the likely uptake by existing land owners committed to HDI developments.

At this stage, options that can be designed as part of this study are the Jan Dissels option (in close cooperation with the Augsberg Agricultural School), the Right Bank canal, and the Ebenhaeser option. The remainder of the options will likely be private developments. It is expected that private land owners will incrementally apply for HDI development schemes along with their HDI partners.

It may be a requirement that land should also be made available to commercial black irrigators who do not wish to enter in a joint-venture arrangement with existing landowners, i.e. the development of a government water scheme. It is noted that the preferred irrigation options above Bulshoek Weir are so interwoven with existing irrigated areas, as well as land that can be more intensely farmed with permanent crops, that these options do not lend themselves well to development as government water schemes.

Should there be a need to identify and design a government water scheme at this stage, the four irrigation areas located in the Trawal area, namely Zypherfontein 1 and Zypherfontein 2, Trawal and Melkboom, (or portions thereof) should rather be considered, as these options contain large tracts of undeveloped land in private ownership. Certain portions of these areas could be supplied by gravity from a new Right Bank main canal, but, for most of these areas, water would need to be pumped from the new canal. Since this land is privately-owned, an option will be for government to acquire the land. It is therefore proposed that, as part of Option 15, an irrigation development option, or options, in the Trawal area be examined that can be developed as a government water scheme.

Further issues to address

Issues to address during feasibility design are the following:

- Revisit the spare flow capacities in the Naauwkoes and Vredendal canal sections, given the discrepancies between statements made by LORWUA officials and the spare capacity seemingly indicated by the evaluation of historical flows.
- Undertake an assessment of the risk associated with increasing the flow in the existing Naauwkoes and Vredendal canal sections.

- Refine the irrigable areas with information supplied by farmers and confirmation of the slopes. For the options not taken to the feasibility design stage, such information should be summarised for potential future use.
- Determine the actual water requirements of the Ebenhaeser restitution farms. This will be a process that should consider existing crops, irrigation methods and other relevant factors. To be on an equal footing with existing farmers, the original allocation of 12 200 m^3/ha may need to be used for calculations. While only some farms have been handed over, the requirements of future farms to be handed over also need to be considered.
- Evaluate the requirement for additional water supply to the Ebenhaeser community.
- Consider that most of the preferred options cover large areas that vary significantly in elevation, and that supplying new irrigation in the lower-lying areas will be less costly, and therefore more attractive than to supply the full option areas. This could be unpacked further, perhaps in a phased approach.
- Apart from the recommended options, it is likely that small feasible BEE schemes, especially for the expansion of existing farms, could eventually be submitted by existing farmers as part of licence applications. This should be kept in mind as an alternative to developing the most expensive land for irrigation, within the recommended options.
- The splitting of capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators) should be revisited, to ensure equity. This should preferably include a risk analysis of the current distribution system versus an upgraded one, and include economic and social implications of system failures, and the likelihood of these occurring over an economic period. In addition, the legal obligations on DWS to ensure that the infrastructure remains functional should be clarified.
- The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations. Options analysis has confirmed that the ecological impact and environmental issues relating to new development significantly influence and limit the scope of development options. Dialogue around these issues should take place between departments as soon as possible. While a detailed botanical assessment of the potential development areas will provide insight, this has not been allowed for in this study.
- In order to obtain greater clarity on funding options, it is suggested that DWS arrange a meeting with National Treasury to discuss implementation approaches. For this purpose, it will be necessary to have information at hand regarding economic and job creation implications of new investment, as well as the risks towards the economy and labour of

potential canal failures if betterments are not undertaken. These will be determined during the Socio-Economic Impact Analysis phase of this Bridging Study.

- Adequate information is available for the following reports to be produced, using the layouts and costs of the preferred suite of options and the identified impacts:
  - Socio-Economic Impact Analysis Sub-Report
  - Agricultural Production and Farm Development Report
  - Socio-Economic Impact Analysis Report
- The topographic and geotechnical surveys should proceed for:
  - Option 1 Jan Dissels, following finalisation of the option area,
  - New Right Bank canal, which forms part of Option 15,
  - Option 22 Ebenhaeser restitution and expansion,
  - Potentially for an irrigation area to be identified for a government water scheme in the Trawal area.

  Options 1 and 22 should be better defined before these activities can proceed. The topographic survey for the New Right Bank canal can immediately proceed, likely using Light Detection and Ranging (LIDAR). The geotechnical survey can follow once the route of the new canal section has been confirmed.

Table E2 | Phasing of Options

Option #	Scheme name	Zone	Incremental requirement + losses (Mm³/a)*	Phase A	Phase B	Phase C
1	Jan Dissels	2	**0.87**	**0.87**		
2	Clanwilliam	2	**4.77**	**4.77**		
3	Transfer of lower JD irrigators	2				
4	Zandrug	2	**9.25**	**9.25**		
5	Bulshoek	2	**3.10**	**3.10**		
9	Zypherfontein 1	4				
10	Trawal	4				
11	Zypherfontein 2	4				
12	Melkboom	4				
14b	Options 9-11-12 (8km raised & lined canal)	4				
15	New Right Bank canal & areas 9-10-11-12	4	**28.25**		**28.25**	
21c	Coastal 1 small (818ha) Post-RB Canal ***	5	**9.52**			**9.52**
21d	Naauwkoes/Vred canal sections - Coastal 1 scaled-down 2 (450ha)	5				
22a	Naauk/Vred canal sections - Ebenhaeser restitution & expansion	5	**5.63**	**5.63**		
22b	Ebenhaeser rest & expansion loss reduction Post-RB canal ***	5	**-0.97**		**-0.97**	
	Water Requirements + Losses (Mm³/a)		**66.79**	29.28	27.99	9.52
	Incremental Water Requirements + Losses (Mm³/a)		**61.13**	23.62	27.99	9.52
	Water Requirements (Mm³/a)		**59.56**	26.97	24.31	8.28
	Incremental Water Requirements (Mm³/a)		**53.90**	21.31	24.31	8.28
	Losses (Mm³/a)		**7.23**	2.30	3.69	1.24
	Water Loss %		**12%**	9%	15%	15%
	Water Loss Fraction		**0.12**	0.09	0.15	0.15
	Hectares of new irrigation		**6,062**	2,670	2,574	818
	Phase % of (Req. + Losses)		**100%**	44%	42%	14%
	Development Capital Cost (R million)		**R689**	R273	R361	R54
	Betterment Capital Cost (R million)		**R514**	R0	R514	R0
	Total Capital Cost (incl. Betterments) (R million)		**R1,203**	R273	R875	R54
	Development NPV Cost (R million)		**R1,017**	R405	R519	R93
	Betterment NPV Cost (R million)		**R509**	R0	R509	R0
	Total NPV Cost (incl. Betterments) (R million)		**R1,526**	R405	R1,027	R93
	Development Capital Cost apportionment by Phase & Suite (%)		**100%**	40%	52%	8%
	Development NPV Cost apportionment by Phase & Suite (%)		**100%**	40%	51%	9%
	Development NPV Cost per hectare (R 1,000/ha)		**R168**	R152	R201	R114
	JD allocation moved to Olifants River		**1.00**	1.00		

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Acronyms

CBA	Critical biodiversity area
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DMS	Dissolved major salts
regionECiw	Electrical conductivity for irrigation water
ESA	Ecological Support Areas
FOS	Factor of safety
GIS	Geographical information system
GWS	Government water scheme
HDPE	High density polyethylene
IRR	Internal Rate of Return
LIDAR	Light Detection and Ranging
LORGWS	Lower Olifants River Government Water Scheme
LORWUA	Lower Olifants River Water User Association
ONAs	Other Natural Areas
MAR	Mean annual runoff
NFEPA	National Freshwater Ecosystem Priority Areas
NPAES	National Protected Area Expansion Strategy
NPV	Net present value
PA	Protected Areas
P&G	Preliminary and General
SAD	South African Dried Fruit Association
SAR	Sodium Adsorption Ratio
TDS	Total Dissolved Solids
uPVC	Unplasticised polyvinyl chloride
URV	Unit Reference Value
VAT	Value added tax
WCDoA	Western Cape Department of Agriculture (Provincial)
WUA	Water User Association

1 Introduction

1.1 Study objectives

The objective of the *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam* is to provide recommendations on the bulk conveyance infrastructure options (new developments/upgrading/rehabilitation) required for the equitable distribution of the existing and additional water from the raised Clanwilliam Dam, after investigation of:

- The existing water allocation and projections for the supply area,
- New areas for agricultural development,
- Options for the required conveyance infrastructure,
- Appropriate farming models and cost of irrigation water.

1.2 Report Objectives

This report describes the options analysis phase of this study, for the selection of suitable areas for agricultural development, with additional water made available by raising Clanwilliam Dam by 13 m. The report more specifically addresses the following:

a) A summary of current bulk water infrastructure,
b) Existing irrigation development,
c) Soil suitability,
d) Crop water requirements and farm sizes,
e) Environmental considerations,
f) Water quality considerations and constraints,
g) Options analysis process,
h) Reconnaissance-level design,
i) Features and costs of irrigation development options,
j) Comparative evaluation and screening of options,
k) Recommendations of options to evaluate further.

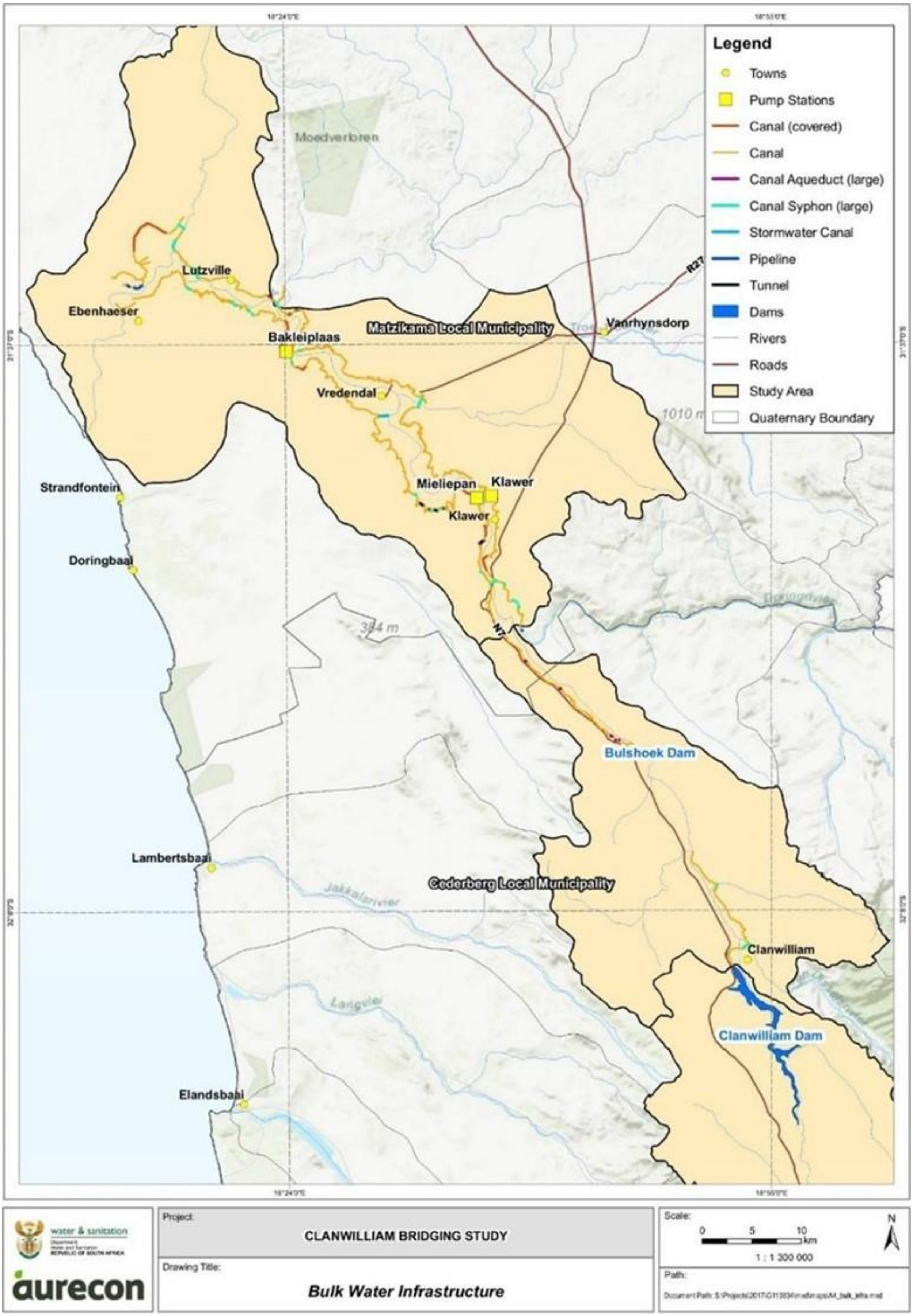


Figure 1.1 │ Study Area and Bulk Water Infrastructure

1.3 Background to the Project

The Clanwilliam Dam is situated in the Olifants River near the town of Clanwilliam in the Olifants/Doorn River Catchment Management Area in the Western Cape. The dam requires remedial work for dam safety reasons, which offers the opportunity to increase the yield at the same time by raising the dam and enlarging the storage capacity. Water use in the region is predominantly for irrigated agriculture. **Figure 1.1** shows the study area and provides an overview of the existing conveyance infrastructure discussed in this report.

A feasibility study was completed in 2008, which concluded that the raising of Clanwilliam Dam and further associated agricultural development, is economically viable and socially desirable. The feasibility study recommended the raising of the full supply level of the existing Clanwilliam Dam by 13 m, to augment the water supply to the existing scheduled irrigation area, towns and industrial use, as well as to provide additional water for new irrigation areas to establish historically-disadvantaged farmers, as well as supply other local water users.

The environmental authorisation for the raising of Clanwilliam Dam is effective from February 2010 and the project was approved by the then Minister of Water and Environmental Affairs as a Government Water Works in August 2010. The implementation of this project is currently in the construction stage, which commenced in October 2018.

The Clanwilliam Dam Raising Feasibility Study Report titled '*Irrigation Development and Water Distribution Options'* provided reconnaissance-level information on the potential areas for new irrigation development and some water distribution options, but more detailed investigations are required.

Once the various water distribution options and associated bulk water infrastructure have been determined at a higher level of confidence, the feasibility design and costing will be done, and the project will be made implementation-ready.

1.4 Content of this Report

Chapter 1: Introduction (this Chapter): introduces and provides background to the options evaluation process.

Chapter 2: Existing Bulk Water Infrastructure: describes the existing bulk water infrastructure for the storage, distribution and use of water from Clanwilliam Dam.

Chapter 3: Existing Irrigation and Land Ownership: describes existing irrigation areas and corresponding water requirements by crop and sub-area, and land ownership.

Chapter 4: Soil Suitability: provides information of existing information on soil suitability and the extended soil survey undertaken.

Chapter 5: Crop Water Requirements and Farm Sizes: explains the determination of crop water requirements for future irrigation schemes for planning purposes and how farm sizes will be considered.

Chapter 6: Environmentally Sensitive Areas: provides a review of the key environmental considerations for the proposed irrigation development options in the study area.

Chapter 7: Water Quality Considerations and Constraints: provides an overview of water quality monitoring in the study area, and the water quality requirements of irrigation farmers.

Chapter 8: Options Analysis Process and Screening: provides an explanation of the process followed in the identification and screening of options, the identified options and options screened out, as well as the selected short-list of options to consider.

Chapter 9: Evaluation Process: describes the technical, ecological, socio-economic, water quality and other considerations of the reconnaissance-level design of the irrigation development schemes.

Chapter 10: Zone 2, Clanwilliam Dam and Jan Dissels River: describes the options relating to abstraction directly from Clanwilliam Dam, and the options in the Jan Dissels catchment.

Chapter 11: Zone 2, Clanwilliam Dam to Bulshoek Weir: describes the options for abstraction from the Olifants River between Clanwilliam Dam up to and including Bulshoek Weir.

Chapter 12: Zone 3, Options Located Outside the Olifants River Valley: describes the options that are not located in the Olifants River valley.

Chapter 13: Zone 4, Olifants River from Bulshoek Weir to Trawal: describes the options for abstraction from the Olifants River below Bulshoek Weir up to Trawal.

Chapter 14: Zone 5, Olifants River from Klawer to Coast: describes the options for abstraction from the Olifants River from Klawer to the Coast.

Chapter 15: Zones 4 and 5, LORGWS (Bulshoek) Canal: describes the options relating to increased irrigation from the LORGWS canal.

Chapter 16: Meetings with Land Owners and Communities: describes the meetings that were held with land owners and communities, to discuss study findings and to obtain clarity on an implementation approach.

Chapter 17: Comparative Evaluation and Screening of Options: provides a comparative evaluation of the features and costs of the short-listed options, proposes screening parameters.

Chapter 18: Recommendations: provides recommendations on the selection of irrigation schemes to evaluate further at feasibility level, as well as providing supporting recommendations.

2 Existing Bulk Water Infrastructure

2.1 Clanwilliam Dam

The Clanwilliam Dam was originally constructed in 1935, with a capacity of 69.86 million m^3. The Dam was raised in 1962 by 6.1 m to increase the capacity to 128 million m^3. The current live storage capacity is 122 million m^3. The mean annual runoff (MAR) at the dam is currently 360 million m^3. The dam currently supplies approximately 11 000 ha of scheduled water downstream of the dam. There are 318 ha scheduled allocations from the dam basin.

Due to proposed betterments to improve the safety of the dam wall, the opportunity to raise the dam was investigated. The Feasibility Study, concluded in 2008, found that a 13 m dam raising would be economically viable as a substantial increase in yield from the dam of 70 million m^3 (based on the increase in firm yield) could be achieved, thereby increasing the current storage volume to 344 million m^3, i.e. nearly a 1 MAR capacity dam.

2.2 Clanwilliam Canal

The Clanwilliam Canal, approximately 18 km in length, originates at the Clanwilliam Dam wall (**Figure 2.1**), passes through Clanwilliam town and crosses the Jan Dissels River.

In the Clanwilliam scheme, there are 564 ha scheduled allocations from the Clanwilliam Canal and 665 ha allocated from the Olifants River. The peak application rate by water users from the canal is 0.83 ℓ/s/ha, thus the maximum canal capacity required is 1685 m^3/h. The maximum carrying capacity of the canal is estimated at 1700 m^3/h (0.47 m^3/s), which means that during peak periods the canal runs at close to full capacity. Canal losses are estimated as 20%.

Figure 2.1 | Start of the Clanwilliam Canal

2.3 Olifants River (Vanrhynsdorp) Government Water Scheme

The Olifants River (Vanrhynsdorp) Government Water Scheme (ORGWS), which forms the backbone of the local economy, consists of the canal system fed from Bulshoek Weir with water released from the Clanwilliam Dam. The canal system (the Lower Olifants Canal) supplies irrigation, industrial, and domestic water to the Matzikama Municipality for the following towns and communities: Vredendal, Klawer, Lutzville, Koekenaap, Ebenhaeser, Papendorp, Strandfontein, Doring Bay and Vanrhynsdorp. The Tronox Mine at Brand-se-Baai and its smelter near Koekenaap are also supplied with water from the canal system.

2.4 Bulshoek Weir

The Bulshoek Weir was constructed across the Olifants River, about 26 km downstream of Clanwilliam town. The weir, with a capacity of 5.754 million m^3, together with a system of unlined canals, comprised the irrigation scheme for 8 500 ha of land along the Olifants River, Vanrhynsdorp District, which was completed in 1923. The weir's catchment area is 2 679 km^2 in extent. The Bulshoek Weir is a stone-masonry gravity structure (**Figure 2.2**). A series of connected arches and buttresses supporting a bridge deck and a gantry for the spillway gate hoists make up the dam wall. Sixteen gates are positioned between the buttresses on top of the ogee-shaped crests.

The dam is operated at close to its full supply capacity to divert water into the irrigation canal. Seepage through and under the Bulshoek Weir is pumped back into the canal supplying water to the LORWUA during dry periods.

Figure 2.2 | Bulshoek Weir

2.5 Lower Olifants Canal

Downstream of the Bulshoek Weir, water is diverted into the Lower Olifants Canal (**Figure 2.3**) which is the main conveyance system in the Olifants River (Vanrhynsdorp) Government Water Scheme (GWS). The canals and tunnels were mainly constructed during the 1930s.

Figure 2.3 | The Lower Olifants Canal

The canal runs on the left bank (western side) of the Olifants River for approximately 21 km, before it divides, with one portion crossing the river with a siphon to a right bank canal with a small section of the canal running in an upstream direction along the right bank (**Figure 2.4**). The canals continue towards Lutzville, becoming gradually smaller downstream. Water is abstracted at numerous points along the canal (approximately 600 off-takes). Secondary canals distribute water from near Lutzville towards the coast. The lead time for water to travel in the canal from the Bulshoek Weir to the last point at Ebenhaeser is about three days. The total length of the canal system is approximately 237 km (LORWUA, 2004).

2.6 Ebenhaeser Community Irrigation Project

The LORGWS also provides water to the Ebenhaeser community irrigation project. The LORWUA operates and maintains the canal system up to the Ebenhaeser balancing dam. From there on, there is a canal to the Ebenhaeser community, which is operated and maintained by the community itself. The water is currently distributed with open furrows and canal systems without a formal administrative dividing system in place.

The LORWUA supplies water to Ebenhaeser at the Parshall measuring gauge at the start of the Ebenhaeser channel. The water supplied is subject to the water allocation Ebenhaeser is entitled to, as well as to any restrictions applicable to the entire LORWUA distribution system. Flows are continuously and automatically monitored at the measuring gauge.

The Ebenhaeser Pumped Scheme, which is under construction, consists of a reservoir supplied by pumping from the balancing dam, and a pipe network, to provide the 257 ha of water rights to 153 plots (1.68 ha each). This scheme will also provide a commercial farmer with 8.6 ha of irrigation area with pressurised irrigation water.

At a public meeting on 12 February 2018, the Ebenhaeser farmers claimed that they are not receiving their scheduled water allocations due to operational mismanagement by the LORWUA, i.e. no policing and monitoring of water abstraction along the canal is implemented. Several of the Ebenhaeser farmers criticised the LORWUA for its perceived lack of control over the water allocations. However, these views contrast with those of some DWS and WCDoA staff who have commented that there are some management challenges in the way the Ebenhaeser farmers operate their internal water distribution. It is expected that the pressurised water supply system currently being constructed will resolve these delivery challenges.

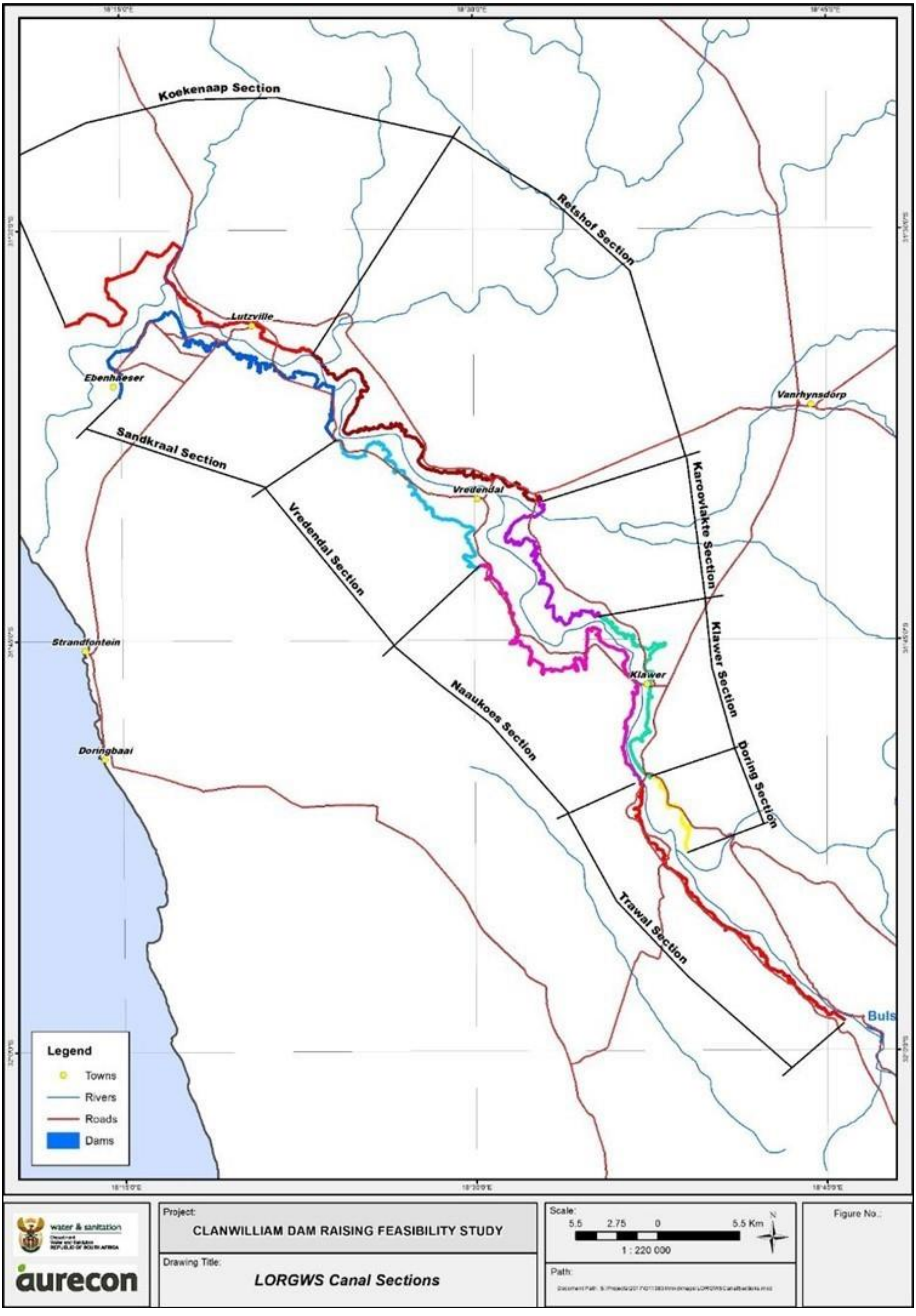


Figure 2.4 │ The Lower Olifants Canal sections

3 Existing Irrigation and Land Ownership

3.1 Locality and Extent of the Current Agricultural Areas

The study area was originally, during the Clanwilliam Dam Raising Feasibility Study, split into three sub-areas for easy reference. To be able to better distinguish between potential irrigation development options and their characteristics, the study area has subsequently been divided into five sub-areas (also referred to as zones), as follows:

- Sub-area 1: Olifants River catchment upstream of Clanwilliam Dam.
- Sub-area 2: Clanwilliam Dam, and the Olifants River catchment from Clanwilliam Dam to and including Bulshoek Weir,
- Sub-area 3: Schemes located wholly outside the Olifants River catchment,
- Sub-area 4: Olifants River catchment from Bulshoek Weir to Lutzville,
- Sub-area 5: Olifants River catchment from Klawer to the Coast.

It is important to note that the potential for further agricultural development will be determined by the factors as shown in **Table 3.1**.

Table 3.1 | Factors determining potential for agricultural development

Factor	Description
Soils	Selected irrigable soils potential classes and their slope (Medium-Low to High potential)
Locality and height differential	The locality and height differential of potential irrigable areas relative to abstraction points from dams, weirs, canals or rivers
Water losses	Conveyance or other water losses
Scale	Extent of the potential agricultural areas
Locality relative to towns	Locality relative to towns for the targeted HDI grouping to minimise travelling costs and allow them to stay in towns
Access to existing infrastructure	Access to existing infrastructure which will be upgraded or constructed
Affordable pumping cost	Affordable pumping cost within the proximity of other available infrastructure such as roads, markets, etc.

The following information presents the existing situation for the study area before any of these screening filters have been applied.

To assess the extent of existing irrigation in the Olifants River catchment, the agricultural areas have been divided into three categories, namely:

1. Cultivated irrigated areas,
2. Cultivated dry-land areas, and
3. Uncultivated or dry/arid areas.

Figure 3.1 on the following page shows the location of the existing agricultural areas.

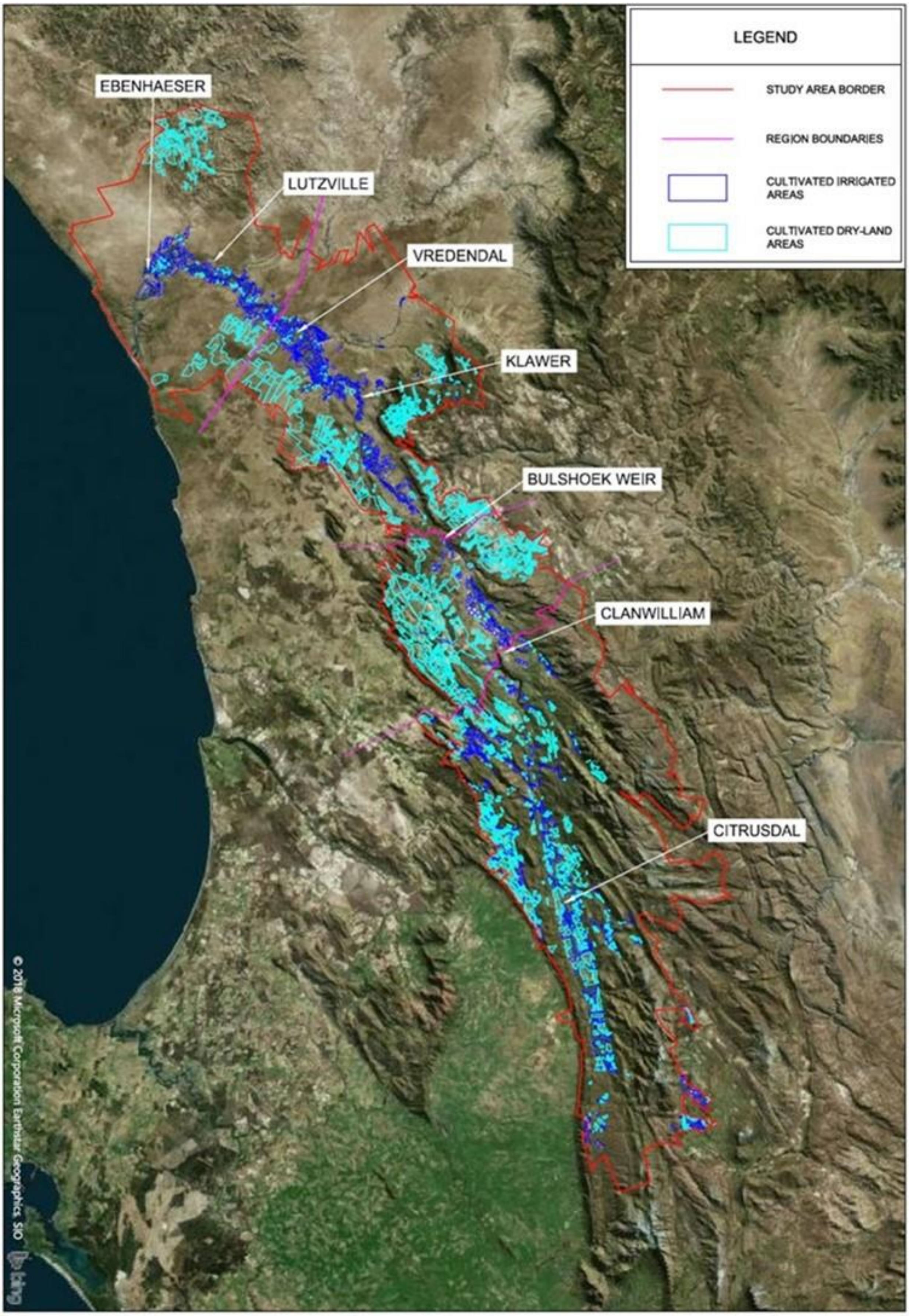


Figure 3.1 │ Existing agricultural land use

The study area boundary shown in **Figure 3.1** was defined in the '*Feasibility Study for the Raising of Clanwilliam Dam'* (DWAF, 2008), as the extent of the Olifants River catchment.

The existing agricultural land use areas, obtained from the National Department of Environmental Affairs (2013-2014) and updated with Bing Imagery (2016-2017) are summarised in **Table 3.2**.

Table 3.2 | Existing agricultural areas by sub-area

Sub-area	Cultivated Irrigated (ha)	Cultivated Dryland (ha)	Uncultivated, Dry/Arid (ha)	Total (ha)
Sub-area 1	12 000	16 000	225 000	253 000
Sub-area 2	2 900	22 000	45 200	70 100
Sub-area 3	8 500	21 000	115 600	145 100
Sub-area 4	7 300	10 200	103 100	120 000
Total	**30 700**	**69 200**	**488 900**	**588 800**

3.2 Existing Agricultural Areas and Water Requirements

This sub-section describes the crop types in the existing agricultural areas, the crop irrigation quotas and the irrigation water requirements.

Figure 3.2 shows the distribution of crop types according to the Cape Farm Mapper Crop Census (2013) data.

Table 3.3 summarises the existing developed areas per crop type in each of the three sub-areas, downstream of the Clanwilliam Dam.

Table 3.4 shows the crop irrigation quotas relevant to each crop type in each of the four sub-areas, as described in the '*Financial Viability of Irrigation Farming*' sub-report.

By applying the crop water requirements indicated in **Table 3.4** to the crop areas shown in **Table 3.3**, the total agricultural water requirements for each crop type per sub-area could be determined, as summarised in **Table 3.5** (three sub-areas downstream of Clanwilliam Dam) and in **Table 3.6** (sub-area upstream of Clanwilliam Dam). The Irrigation Board quota used by the LORWUA, not mentioned in the table, is 12 200 m^3/ha.

The total agricultural water use for the area downstream of the Clanwilliam Dam (i.e. Sub-area 2, Sub-area 3 and Sub-area 4) is approximately 142 million m^3 for 14 500 ha, which is similar to the irrigation water usage of 140 million m^3 determined in the '*Water Requirements Assessment Report* (*P WMA 09/E10/00/0417/5*) of this study. The total agricultural water use for all sub-areas is 231 million m^3/a.

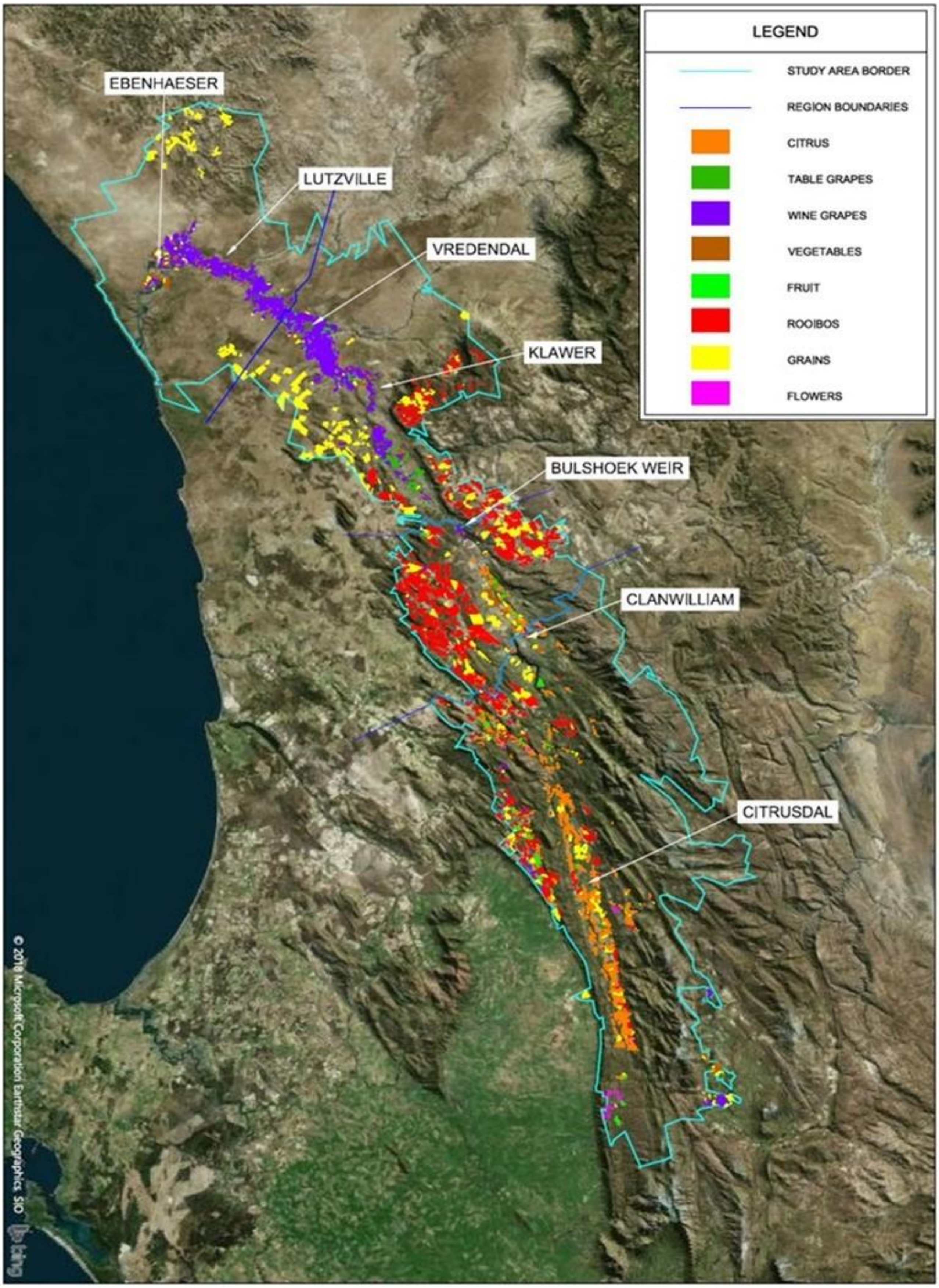


Figure 3.2 │ Cape Farm Mapper Crop Census Data

Table 3.3 | Existing irrigation areas downstream of Clanwilliam Dam by crop and sub-area (ha)

Crop type	Sub-area 2	Sub-area 4	Sub-area 5	Total (downstream)
Citrus	650	0	0	**650**
Table grapes	189	812	23	**1 024**
Wine grapes	228	6 189	4 784	**11 201**
Vegetables	500	373	597	**1 470**
Other fruit	50	145	5	**200**
Total	**1 616**	**7 519**	**5 409**	**14 545**

Table 3.4 | Current irrigation quotas by crop and sub-area (m^3/ha)

Crop type	Sub-area 1	Sub-area 2	Sub-area 4	Sub-area 5
Citrus	10 000	11 000	11 000	11 000
Table grapes	10 110	11 340	11 340	12 390
Wine grapes	8 500	9 500	9 500	9 500
Vegetables	8 213	9 281	9 281	9 281
Other fruit	9 000	9 900	9 900	9 900

Table 3.5 | Irrigation requirements downstream of Clanwilliam Dam by crop and sub-area (million m^3/a)

Crop type	Sub-area 2	Sub-area 4	Sub-area 5	Total (downstream)
Citrus	7.15	0.00	0.00	**7.15**
Table grapes	2.14	9.21	0.28	**11.63**
Wine grapes	2.16	58.79	45.45	**106.40**
Vegetables	4.64	3.47	5.54	**13.64**
Other fruit	0.50	1.43	0.05	**1.98**
Total	**16.59**	**72.90**	**51.32**	**140.81**

Table 3.6 | Irrigation requirements upstream of Clanwilliam Dam by crop and sub-area (million m^3/a)

Crop Type	Area (ha)	Irrigation requirements (million m^3/a)
	Sub-area 1	Sub-area 1
Citrus	6 757	67.57
Table grapes	4	0.04
Wine grapes	877	7.46
Vegetables	386	3.17
Other fruit	1 055	9.49
Total	**9 080**	**87.74**

The total agricultural water requirement by crop type, both upstream and downstream of Clanwilliam Dam, is shown in **Table 3.7**.

Table 3.7 | Total Irrigation requirements by crop and sub-area (million m^3/a)

Crop type	Sub-area 1	Sub-areas 2, 4, 5	Total
Citrus	67.57	7.15	**74.72**
Table grapes	0.04	11.63	**11.67**
Wine grapes	7.46	106.40	**113.86**
Vegetables	3.17	13.64	**16.82**
Other fruit	9.49	1.98	**11.47**
Total	**87.74**	**140.81**	**228.55**

3.3 Land ownership

Land ownership by government and privately-owned land were identified as indicated in **Table 3.8**. The land ownership details (name, address, contact details, etc.) have also been recorded for each property in the study area. **Table 3.8** summarises the ownership for each sub-area in the study area. The government-owned properties do not include the urban/town areas such as Citrusdal, Vredendal, Klawer and Ebenhaeser, but only properties up to such town borders.

Table 3.8 │ Property ownership by sub-area

Sub-area	Government-owned (ha)	Privately-owned (ha)
Sub-area 1	82 600	170 500
Sub-area 2	900	69 100
Sub-area 4	40 800	91 800
Sub-area 5	2 200	130 900
Total	**126 500**	**462 300**

From **Table 3.8**, it is evident that only 22% of land within the study area is government-owned, with 78% being privately-owned land.

Furthermore, the majority of the 82 600 ha of government-owned properties in Sub-area 1 is located in the upper regions of the Cederberg Mountains, consisting of steep slopes and possibly critical biodiversity areas. Only a limited area of government-owned land can therefore be considered for the development of new irrigation areas.

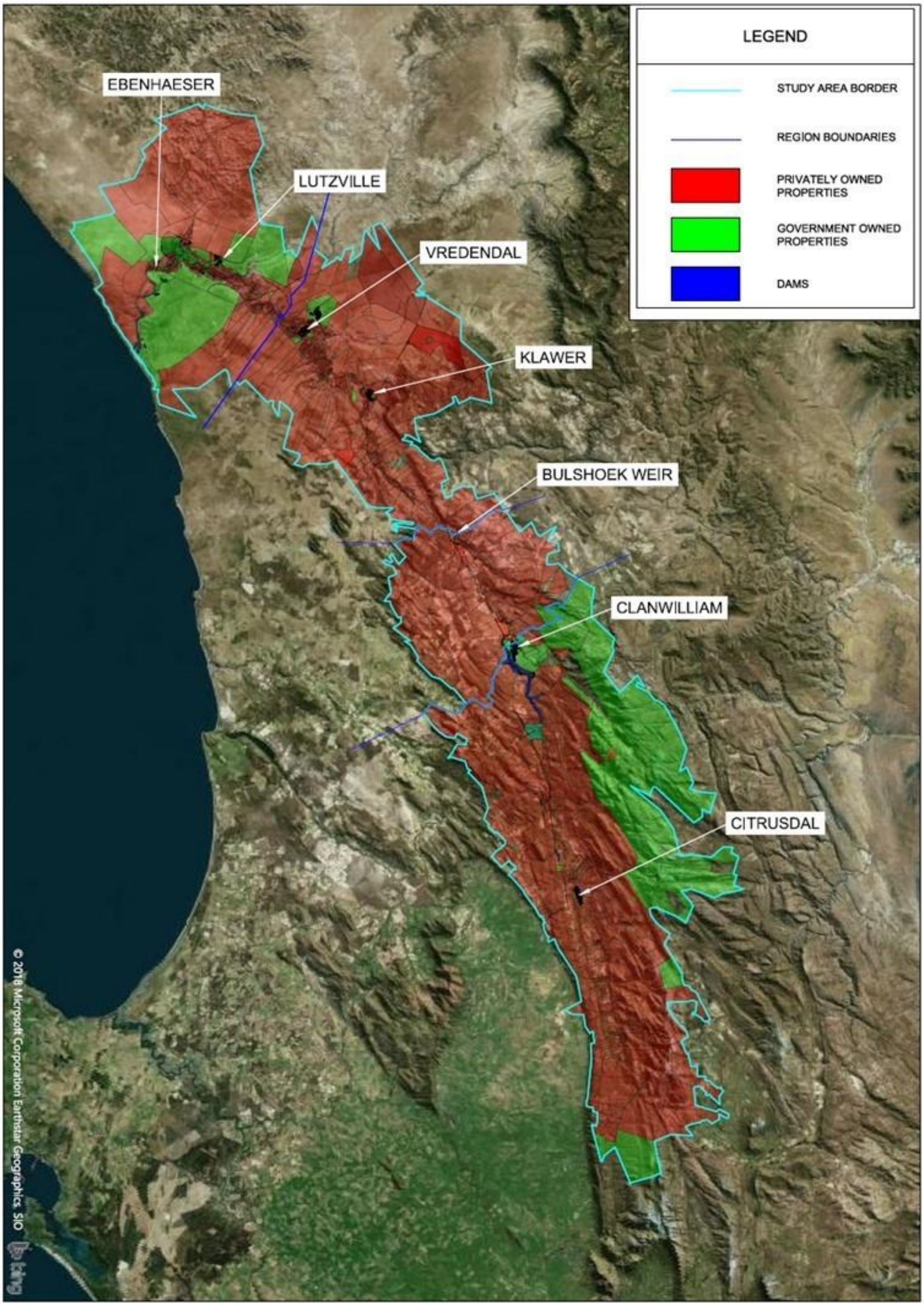


Figure 3.3 | Land ownership in the study area

4 Soil Suitability

4.1 Clanwilliam Dam Raising Feasibility Study Soil Survey

The '*Soils, Water Requirements and Crops'* Report (DWAF, 2004), prepared as part of the *Feasibility Study for the Raising of Clanwilliam Dam*, included mapping of soils in the Olifants River valley upstream of Bulshoek Weir, to a lateral extent of about 60 m above the level of the river or existing canals. The evaluation dealt with the soil types, soil suitability and amelioration measures of the surveyed area from Keerom to the Coast and incorporated previous soil surveys undertaken.

Soils in the Olifants River Basin have a variety of naturally occurring soil properties that restrict the ability of plant roots to develop and absorb water and nutrients. These include physical and morphological (e.g. low clay content, cemented hardpans, surface crusting and hard-setting, dense and/or strongly structured subsoil clay layers, wetness, weathering rock and wind erosion) as well as chemical (e.g. acidity; free carbonates and alkalinity, and salinity) limitations.

An expert system approach was used to evaluate the potential of the different soil complexes in the production of annual and perennial crops. Due to the variation in a particular property that might be encountered within a particular soil sub-group, the limitation degree was qualified as ranges. Five classes were used to rate the potential and recommendation of soil sub-groups for irrigated crop production (for annual and perennial crops before and after amelioration of subsoil limitations), as shown in **Table 4.1**.

Table 4.1 | Classes used to evaluate the potential and recommendation of soils for different crop types

Potential	Recommendation for irrigated crop production	Percentage of maximum potential
Low	Not recommended	≤ 40%
Medium-low	Marginally recommended	> 40% - ≤ 50%
Medium	Conditionally recommended	> 50% - ≤ 60%
Medium-high	Recommended	> 60% - ≤ 80%
High	Highly recommended	>80%

The total surface areas for the five potential suitability classes of soil types over the Olifants River Basin (Keerom to the Coast) for annual tuberous and non-tuberous crops, and perennial crops, before and after amelioration of soil limitations, are shown in **Table 4.2** and **Table 4.3**. Tuberous crops include crops such as potatoes, onions, sweet potatoes, and carrots; usually not requiring hardpan amelioration. Non-tuberous crops include crops such as tomatoes, pumpkin, and beans, usually requiring hardpan amelioration. Perennial crops refer mainly to dry, wine and table grapes, and citrus. The spatial distribution over the area from Keerom to Bulshoek Weir and Bulshoek Weir to the Coast is presented in **Table 4.2** and **Table 4.3** respectively.

Table 4.2 | Surface Area of the potential suitability of soil - Keerom to Bulshoek Weir

Potential class	Annual tuberous crops (ha)	Annual non-tuberous crops (ha)	Perennial crops	
			Before amelioration (ha)	After amelioration (ha)
Low	11 536	10 774	18 077	8 099
Medium-low	7 718	7 303	9 660	11 063
Medium	476	7 463	1 196	8 575
Medium-high	9 930	4 118	726	1 922
High	0	0	0	0
Total area (ha)	**29 659**			

Table 4.3 | Surface Area of the potential suitability of soil - Bulshoek Weir to Coast

Potential class	Annual tuberous crops (ha)	Annual non-tuberous crops (ha)	Perennial crops	
			Before amelioration (ha)	After amelioration (ha)
Low	83 054	33 457	86 701	83 054
Medium-low	812	5 194	17 418	812
Medium	24 264	21 089	29 118	24 264
Medium-high	34 464	82 854	9 356	34 464
High	0	0	0	0
Total area (ha)	**142 594**			

The information included in **Table 4.2** and **Table 4.3** is also shown in the Potential Rating Soil Maps that were prepared for the production of the various crops.

4.1.1 Soil Suitability from Keerom to Bulshoek Weir

Based on these evaluations, about 2 000 ha were recommended for perennial crops (e.g. citrus and wine grapes) in the southern section of the catchment from Keerom to Bulshoek Weir. Another 19 000 ha were marginally and conditionally recommended if subsoil limitations are properly ameliorated. About 8 600 ha of this class has a potential rating that is near the upper limit of the conditionally recommended class. The main limitations in this class are wetness and shallow underlying weathering rock combined with low clay content. These limitations are relatively easy to ameliorate and is economically feasible. With judicious irrigation practices approximately 10 000 ha can be used for economically viable production of citrus and wine grapes. Within the lateral extent of the survey approximately 10 000 ha is available in the Keerom to Bulshoek section for any combination of irrigated annual (tuberous and non-tuberous) and perennial (citrus, wine grapes, mangos) production.

4.1.2 Soil Suitability from Bulshoek Weir to the Coast

The soils in the surveyed area from Bulshoek Weir to the Coast differ greatly from those in the southern section in terms of the dominant limitation(s). Deep, well-drained red sandy soils can be highly recommended for irrigated tuberous and non-tuberous crops without any subsoil amelioration measures. However, these soils are only conditionally recommended for perennial crops due to the very sandy nature and risk of sandblasting of crops. Non-tuberous crops are conditionally recommended, while perennial crops are recommended on these soils after amelioration of subsoil limitation. In this section there is approximately 105 000 ha that can be recommended for production of perennial crops after amelioration of subsoil limitations, in particular hardpans, and if provision is made for leaching and drainage to remove soluble salts from saline environments. Most of the areas recommended for perennial crops can also be used for irrigated non-tuberous annual crop production.

4.2 Extending the extent of the soil survey

Considering that both the Clanwilliam WUA and LORWUA already have significant developments above the river and existing canals, it was decided to extend, as part of this study, the soil survey to cover the lateral extent of 100 m above the level of the river or existing canals. The findings are described in the *Soil Survey Report* (P WMA 09/E10/00/0417/9). The evaluation deals with the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 m to 100 m above river level between Clanwilliam Dam and Klawer.

This 60 m to 100 m zone was identified and added to the existing survey area that was completed in 2012 (during the Clanwilliam Dam Raising Feasibility Study) which covered the area up to 60 m above river level. The objectives, scope of work and terms of reference for this survey were briefly as follows:

- Expansion of the soil suitability for irrigated crop production, from the existing extent of mapping undertaken, as part of the Clanwilliam Dam Raising Feasibility Study, to a height of 100 m above either river, dam or canal level.
- The methodology followed to update the maps is the same as the methodology as described in the Soils, Water Requirements and Crops Report produced for the Clanwilliam Dam Raising Feasibility Study.
- Carrying out pit profiling and logging the profile information using a GPS.
- Appending the additional soil map units within the defined area to the soil map shapefile.
- Providing all GIS data in a geodatabase and maps.

The 2012 soil map legend was used for the 2018 survey. As this survey was also a reconnaissance soil survey, the legend stayed the same, except for any new soil-terrain units that were identified. This was done to make sure that the new areas would join up smoothly with the existing (2012) boundaries and that information on soil suitability and other soil-related interpretations are the same for both reports.

The same methodology that was used and explained in the 2012 report was also used to map the soils for the 2018 survey areas.

Firstly, the 2012 soil boundaries were plotted on the latest Google Earth background with 5 m contour lines also visible. Two separate and independent visits were made to the survey area. The first visit was for the soil-scientists to familiarise themselves with the earlier (2012) soil-terrain units and, with limited field work, to prepare a first draft of soil-terrain units of the new areas using the 2012 legend. This first draft map was thereafter taken to the field on a second round to prepare the final map.

For the second visit to the area the following procedure was used:

- Based on soil properties and variation in soil types and terrain form, uniform soil-terrain units were delineated during the field excursion on the draft map that covered the 2018 survey area.
- During the field excursion soil observations were made at all available soil exposures such as road cuts and drainage trenches, and a hand auger was used for additional observations. It was not necessary to use a mechanical digger to make extra soil pits for observation purposes.
- In a few cases none of the existing map units could accommodate a newly delineated area. In those cases, new map units were created and defined in terms of terrain type and dominant soils.

It was decided to retain the relatively simple two-level legend that consisted of an upper level of soil groups and a second level of soil sub-groups used in the 2012 report. Twelve soil groups were defined based on two or more of the following properties: general soil type, soil colour, texture of the topsoil, soil depth, drainage, terrain position. An identification letter symbol (A to L) was given for each soil group. The legend covers the soils from Keerom to the coast, used for the 2012 survey. The soil groups mapped and defined for the 2018 survey included 33 of the 2012 soil groups. Another seven subgroups, under the soil complexes upper level, were identified and described.

A combined soil map legend for the new survey area was defined and used for the soil maps.

Hereafter the soil suitability for irrigated crops was determined for the same crops mentioned in the 2012 report. Soil limitations were identified as for the 2012 report. An additional non-soil limitation (namely slope) was added. Slope influences the cultivation of land and is therefore regulated by the "Conservation of Agricultural Resources (Act, 43 of 1983) Regulations". Total areas (ha) of the three slope classes that occur within the 60 m – 100 m above river level 2018 mapping area (totalling 10 332 ha) were determined as 4 951 ha (0 – 12 % class), 2 850 ha (12 – 20%) and 2 531 ha (>20 % class). The >20 % slopes therefore covers about 25 % of the total survey area. Further details about slopes are given in electronic map form.

Five classes were used to rate the potential and recommendation of soil sub-groups for irrigated crop production (see **Table 4.4** below). Due to the negative effect, indirect and direct, of free lime on growth and production, soils with calcareous horizons were rated one unit lower than non-calcareous soils with similar properties. Although it was difficult to accommodate salinity in these evaluations, soil sub-groups with a very high salinity were downgraded compared to similar non-saline soils.

Table 4.4 │ Soil Potential Classes

Soil potential	Recommendation for irrigated crop production	Percent of maximum potential
Low (L)	Not recommended (NR)	≤ 40%
Medium-Low (ML)	Marginally recommended (MR)	> 40% - ≤ 50%
Medium (M)	Conditionally recommended (CR)	> 50% - ≤ 60%
Medium-High (MH)	Recommended (RE)	> 60% - ≤ 80%
High (H)	Highly recommended (HR)	>80%

The information given in **Table 4.4** above was applied to each soil sub-group identified to derive a "*potential of soil units for irrigated annual and perennial crop production*". Thereafter a table summarising the surface areas of the five potential suitability and recommended classes was compiled (**Table 4.5**), indicating the surface area of five potential suitability classes for the production of tuberous and non-tuberous crops and perennial crops, before and after amelioration of subsoil limitations, in four main areas, in the Olifants River Basin from Clanwilliam Dam to Klawer, between 60 m to 100 m above river level.

Table 4.5 | Soil suitability areas

Potential class and recommendation	Annual tuberous crops (ha) 1)	Annual non-tuberous crops (ha) 2)	Perennial crops 3)	
			Before amelioration (ha)	After amelioration (ha)
Low	8457	7 132	9 259	5 729
Medium-low	802	1 010	973	2 280
Medium	100	1 693	20	1 107
Medium-high	973	497	80	1 217
High	0	0	0	0
Total area (ha)	**10 332**			

1) *This includes crops such as potatoes, onions, sweet potatoes, and carrot; usually without hardpan amelioration.*
2) *This includes crops such as tomatoes, pumpkin, and bean; usually after hardpan amelioration.*
3) *This refers mainly to dry, wine and table grapes and citrus.*

From Table 4.5 most of the soil classes identified fall within the *Not Recommended* category, for soils with Low potential. Recommendations have been made for amelioration measures per soil sub-group.

An example of one of these maps has been included below (**Figure 4.1**).

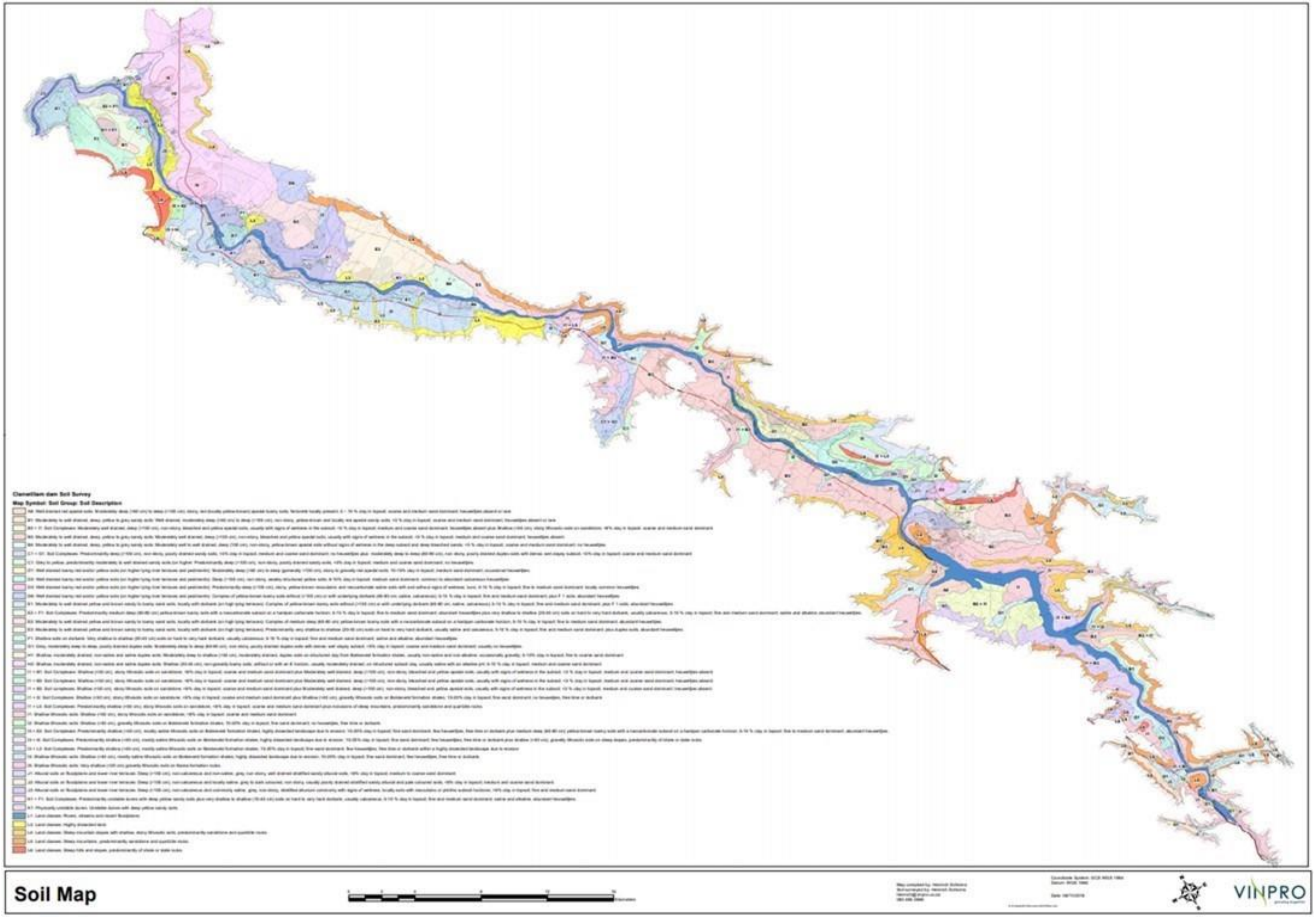


Figure 4.1 │ Example of Potential Rating of soil map units

5 Crop Water Requirements and Farm Sizes

Crop mixes and irrigation zones are described in the *Financial Viability of Irrigation Farming Sub-Report* (DWS, 2018) of this study. **Table 3.3** shows a summary of the identified crops per irrigation sub-area. The minimum viable commercial farm size was also investigated.

5.1 Evaluation of Suitable Crops

The criteria used for selecting crops to evaluate within this study are as follows:

- Crops which are well suited to the climate and soils enabling high yields and good quality to be produced; and
- Crops which are tried and tested in the area and already grown on a large scale commercially. Crops grown on a smaller scale with limited economic contribution to the region were therefore not selected.

Based on the above criteria the following crops were selected for this study:

1. Table grapes;
2. Citrus;
3. Raisins;
4. Wine grapes;
5. Tomatoes with brassica seed in rotation; and
6. Potatoes with wheat, in rotation.

5.1.1 Table Grapes

The bulk of South Africa's table grapes are exported. The Olifants River table grape producing area falls into a relatively early production window in the South African season, directly after the early areas, such as Limpopo and the Orange River. A shortage of water has resulted in limited expansion in the Olifants River area to date. As a result, there is still a relative shortage of table grapes during this production window, providing a good opportunity for future expansion in the Olifants River area.

5.1.2 Citrus

Citrus is the largest export fruit commodity in South Africa and the industry has performed well in recent years resulting in consistent growth in new plantings. Citrus volumes were down in the 2017 season, mainly due to a drop in the volume of oranges resulting from the drought in the Limpopo region and due to fruit drop in the Eastern Cape. Soft citrus and lemon volumes are set to grow considerably in the coming years because of new plantings and South Africa will need to grow its export markets for these crops.

5.1.3 Wine Grapes

Both the local and export markets play an important role in the South African wine industry. There is currently a shortage of bulk wine on a global level due to adverse weather conditions in the main wine producing countries. It is anticipated that the South African price for bulk wine will therefore increase by up to 20%, providing some relief to growers, although this is cyclical in nature.

5.1.4 Raisins

Global raisin production for 2017/2018 is also expected to decrease by 2% as modest gains in China are offset by lower output in Turkey, USA and Iran. Because of reduced supply, total stocks are expected to plunge 22% to 84 000 tons, an 8-year low. This also poses an opportunity for raisin exports from South Africa and indications from the South African Dried Fruit Association (SAD) are that the supply is expected to remain short in the world market for the foreseeable future.

5.1.5 Potatoes

The South African potato market is comprised of The National Fresh Produce Markets, processing, informal trade, retail and export, with the bulk of the volume sold in the local market. Slightly more than two thirds of the national crop is marketed in the formal market sector. South African production has increased by 35% in a decade from 2005 to 2015, to 248 million 10 kg bags. At the same time the number of producers has decreased, due to increased yields and an increase in the number of hectares per farmer.

Refer to **Table 5.1** for crop types recommended for each sub-area.

Table 5.1 | Identified Irrigation Sub-areas and Suitable Crops (DWS, 2018)

Sub-area	Location	Suitable Crops
1	Citrusdal	• Citrus (oranges & soft citrus)
2	From Clanwilliam Dam Wall to Bulshoek Weir (including Jan Dissels River)	• Citrus (oranges & soft citrus) • Table grapes • Potatoes / wheat in rotation
3	Jakkalsvlei / Graafwater	• Potatoes • Grazing
4	From Bulshoek Weir to Trawal	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation
5	From Trawal to the Coast	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation

A summary of proposed crop water use requirements for each geographical area is shown below in **Table 5.2**. The table includes the irrigation efficiency factor for each crop type.

Table 5.2 | Summary of existing crop water use requirements per geographical area

Sub-area	Crop	Water use (m^3/ha/a)			Proposed volume (m^3/ha/a)
		Source	Efficiency factor	Volume	
1 – Citrusdal	Citrus		90%	13 280	10 000
		V&V	90%	10 000	
		DOA	90%	14 310	
		DWS	90%	13 002	
2 – Clanwilliam	Citrus	2004 Feasibility	90%	14 100	11 000
		Jan Dissels study	90%	8000 (micro)	
		V&V	90%	11 000	
		DWS	90%	14 901	
	Table grapes	Jan Dissels study	90%	9000 (micro)	11 340
		V&V	90%	11 340	
		DWS	90%	12 417	
	Potatoes	2004 Feasibility	85%	5490	10 080
		DWS	80%	7440 / 10 811	
		V&V	80%	10 080	
3 – Jakkalsvlei / Graafwater	Potatoes	V&V	80%	10 080	10 080 Note that the value for Clanwilliam will also be used apply to the Jakkalsvlei / Graafwater area)
4 – Bulshoek to Trawal (quat E10K)	Table grapes	V&V	90%	11 340	11 340
	Wine grapes / raisins	V&V	90%	9500	9500
	Tomatoes	No data	-	-	It is recommended to use the V&V figure of 9281, which is the generic quota for vegetables

Sub-area	Crop	Water use (m³/ha/a)			Proposed volume (m³/ha/a)
		Source	Efficiency factor	Volume	
	Vegetables (general)	V&V	80%	9281	9281
	Brassica	No data	-	-	Recommended to use Zone 5 figures of either 5030 or 2080, depending on season (as available from the DOA data)
5 – Klawer to Coast (quats E33G and E33H)	Table grapes	V&V	90%	12 390 (Vredendal)	12 390
		DOA	90%	4560 (Vredendal)	
			90%	5320 (Lutzville)	
		DWS	90%	12 128 (Klawer)	
			90%	11 959 (Lutzville)	
	Wine grapes / raisins	2004 feasibility	95%	9650 (Klawer)	9500
			95%	9080 (Lutzville)	
		V&V	90%	9500	
		DOA	90%	7110 (Lutzville)	
			90%	5960 (Vredendal)	
		DWS	90%	10 669 (Klawer)	
			90%	10 551 (Lutzville)	
	Tomatoes (processing)	2004 feasibility	95%	6930 (Klawer, Dec)	Recommended V&V value of 9281 for vegetables
			95%	6340 (Lutzville, Dec)	
	Tomatoes (table)	2004 feasibility	95%	8410 (Klawer, Dec)	
			95%	9340 (Klawer, Sep)	
			95%	7740 (Lutzville, Dec)	
			95%	8760 (Lutzville, Sep)	
		DOA	80%	2830 (Vredendal, Mar)	

Sub-area	Crop	Water use (m^3/ha/a)			Proposed volume (m^3/ha/a)
		Source	Efficiency factor	Volume	
	Tomatoes (unspecified)		80%	4710 (Vredendal, Jun)	
			80%	8800 (Vredendal, Sep)	
			80%	8180 (Vredendal, Nov)	
			80%	3700 (Lutzville, Mar)	
			80%	6110 (Lutzville, Jun)	
			80%	10 390 (Lutzville, Sep)	
			80%	9980 (Lutzville, Nov)	
		DWS	80%	11 276 (Lutzville, Sep)	
	Vegetables	V&V	80%	9281	9281
	Brassica	DOA	80%	4000 (Vredendal, Feb)	Recommended to use maximum volumes – either 5030 or 2080, depending on season
			80%	2080 (Vredendal, Apr)	
			80%	5030 (Lutzville, Feb)	
			80%	2660 (Lutzville, Apr)	

5.2 Crop Water Requirements for Planning Purposes

The calculation of the aggregated water use requirements per crop is explained in this section. The aggregate crop water requirement for sub-area / sub-area is required for the evaluation of irrigation development options.

The extent of the main crops that are currently irrigated in the study area were identified. These crops are indicated in **Table 5.3** below. Note that Sub-area 3 was included with Sub-area 2 for calculation purposes (sub-areas are defined in **Table 5.1**).

Table 5.3 | Main irrigated crops grown in the study area

Crop	Area (ha)			
	Sub-area 1	Sub-areas 2 & 3	Sub-area 4	Sub-area 5
Citrus	6 757	650	0	0
Table Grapes	4	189	812	23
Wine Grapes	877	228	6 189	4 784
Vegetables	386	500	373	597
Fruit	1 055	50	145	5
Total	9 080	1 616	7 519	5 409

Source: GIS data obtained from Department of Agriculture

Further to calculating the crop water requirements, the net crop water use requirements were calculated, by removing the irrigation efficiency factors (90% for permanent crops and 80% for annual crops). The net crop water use requirements (per ha per annum) are shown in

for the identified crops.

Table 5.4 | Net crop water use requirements

Crop	Net crop water use (m^3/ha/a)			
	Sub-area 1	Sub-areas 2 & 3	Sub-area 4	Sub-area 5
Citrus	9 000	9 900	9 900	9 900
Table Grapes	9 099	10 206	10 206	11 151
Wine Grapes	7 650	8 550	8 550	8 550
Vegetables	6 570	7 425	7 425	7 425
Fruit	8 100	8 910	8 910	8 910

The percentage (%) breakdown of identified crops that are planted in each zone was then calculated. Please refer to **Table 5.5** for the percentage breakdown of identified crops per zone.

Table 5.5 | Percentage breakdown of identified crops per zone

Crop	Area (ha)			
	Sub-area 1	Sub-areas 2 & 3	Sub-area 4	Sub-area 5
Citrus	74.42	40.21	0.00	0.00
Table Grapes	0.05	11.68	10.80	0.42
Wine Grapes	9.66	14.08	82.31	88.45
Vegetables	4.26	30.93	4.97	11.03
Fruit	11.62	3.09	1.93	0.10

Lastly, the weighted average of the crop percentages per zone in **Table 5.5** and the net crop water use requirements in

were used to calculate the aggregate crop water requirements. **Table 5.6** indicates the final aggregate net crop water use requirements per zone, to be used for planning purposes.

Table 5.6 | Aggregate crop water use requirements

Sub-area	Aggregate water use (m^3/ha/a)
1	8 662
2 & 3	8 949
4	8 680
5	8 437

It was agreed that the extent of losses would be addressed for each option during the options analysis process. Losses have thus not been included in the water use requirement values.

5.3 Farm Sizes in the Options Analysis Context

5.3.1 Minimum Viable Farm Sizes

The minimum viable farm size (for the identified crop types) for an existing farm was calculated, as well as the minimum viable farm size for a new black-owned farm where the land was provided at no cost. The minimum viable farm sizes resulting from the financial evaluations done for the *Financial Viability of Irrigation Farm Sub-Report* (DWS, 2018) are presented in **Table 5.7**.

Table 5.7 | Minimum Viable Farm Sizes (DWS, 2018)

Crop	Existing Commercial (ha)	New Black Owned (ha)
Citrus	22	90 (@IRR 8%)
Table Grapes	16	46
Wine Grapes	Not currently viable	Not currently viable
Raisins	68/12[1]	26
Tomatoes/Brassica seed - commercial	27	41
Tomatoes/Brassica seed - Small scale production	6	6

Notes:

1 For raisins, the 68 ha minimum viable size relates to the current average study group yield of 22 tons/ha and the 12 ha minimum viable size is calculated at a potential yield of 50 tons/ha based on top varieties and best practice.

5.3.2 Approach to farm sizes

While viable minimum farm sizes were determined for new farms and the expansion of existing farms, this was not a consideration in the Options Analysis phase of this project, i.e. the identification and evaluation of irrigation schemes, to make use of additional water from a raised Clanwilliam Dam. These potential schemes tend to be a mixture of potential farm expansion and development of new land, and identified schemes typically cross several farms. Once the more feasible irrigation options have been identified, the farm sizes and models will be revisited again.

Smaller plot sizes of 6ha (with a total area of 7.5ha) have been considered during the options analysis, and the potential irrigation schemes, located closer to towns, have been identified. The sizes of these plots will be revisited during the feasibility design. The Department of Agriculture, Forestry and Fisheries (DAFF) has recommended that about 10% of the additional irrigation area be considered for these plots.

6 Environmentally Sensitive Areas

This section of the report provides a review of key environmental considerations for the proposed distribution options in the study area. This focuses on aspects of the natural environment which could potentially be affected by the proposed distribution options. The analysis is indicative of the key environmental factors considered, with the aim of presenting the potential environmental constraints to be considered for the realisation of the project.

6.1 Western Cape Biodiversity Spatial Plan

The Western Cape Biodiversity Spatial Plan (2017) identifies Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs), per Municipality in the Western Cape, which require safeguarding to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services, from a terrestrial and aquatic perspective. It also identifies Protected Areas (PAs) and Other Natural Areas (ONAs) in each Municipality.

6.1.1 Critical Biodiversity Areas and Ecological Support Areas

Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) are terrestrial and freshwater areas that have been mapped as being important for conserving biodiversity patterns and ecological processes. More specifically, CBAs are areas that are required to meet biodiversity targets for species, ecosystems or ecological processes and infrastructure. According to the 2017 Western Cape Biodiversity Spatial Plan, CBAs are areas considered to be of high biodiversity and ecological value and therefore should be kept in a natural or near-natural state, with no further loss of habitat or species. Degraded areas should be rehabilitated to natural or near-natural condition and only low-impact, biodiversity-sensitive land uses are appropriate. The mapped CBAs have been categorised into those areas that are likely to be in a natural condition (CBA1) and those that are potentially degraded or represent secondary vegetation (CBA2).

Figure 6.1 shows the Critical Biodiversity Areas and Ecological Support Areas for the study area.

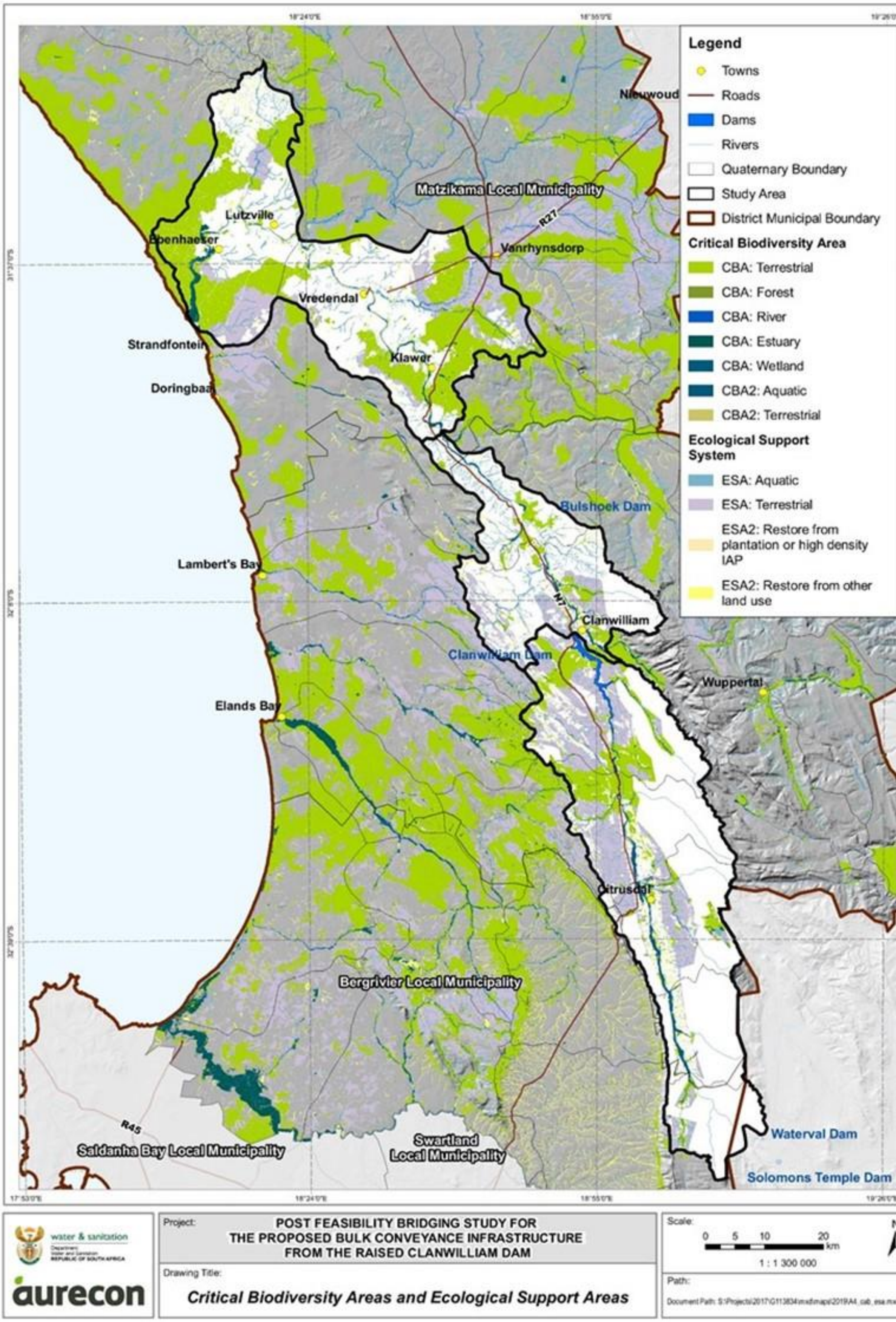


Figure 6.1 │ Critical Biodiversity Areas and Ecological Support Areas

ESAs are areas that are not considered essential for meeting biodiversity targets; however, they do play an important role in supporting the functioning of Protected Areas and/or CBAs. They create a vital link to the delivery of ecosystem services by supporting landscape connectivity, encompassing the ecological infrastructure from which ecosystem goods and services flow, and strengthening resilience to climate change. ESAs include features such as regional climate adaptation corridors, water source and recharge areas, riparian habitat surrounding rivers or wetlands, and endangered vegetation. Similarly, ESAs are also categorised into two categories, namely those that are still likely to be functional (i.e. in a natural, near-natural or moderately degraded condition) (ESA 1), and those that are severely degraded or have no natural cover remaining and therefore require restoration (ESA2). It is important to note that ESAs need to be maintained in at least a functional and often natural state, to support the purpose for which they were identified, but some limited habitat loss may be acceptable subject to an authorisation process.

There are very few areas mapped as CBA2 areas for the study area. The aquatic CBA areas cannot be identified because of the scale**.** There are no predominant ESA2 areas for the study area, as they are all small and at a very fine scale.

6.1.2 Protected Areas

The Rondeberg Oord Private Nature Reserve is a private nature reserve located near the Bulshoek Weir. It is a Protected Area that is recognised in terms of the National Environmental Management: Protected Areas Act (NEMPAA), Act 57 of 2003. In addition, the Ramskop Nature Reserve is located on the eastern bank of the Clanwilliam Dam. It is a local nature reserve that is also recognised in terms of the NEMPAA, Act 57 of 2003.

The Elandsbay State Forest is near to and north of Elands Bay. It is a nature reserve that is recognised in terms of the NEMPAA, Act 57 of 2003. Other nearby protected areas are the Steenboksfontein Private Nature Reserve and Aan de Klipheuvel, which is a contract nature reserve.

The Lutzville Conservation Area is a nature reserve that is located near the proposed coastal WODRIS irrigation area, near Ebenhaeser. It is a Protected Area that is recognised in terms of the NEMPAA, Act 57 of 2003.

Protected areas are shown in **Figure 6.2**.

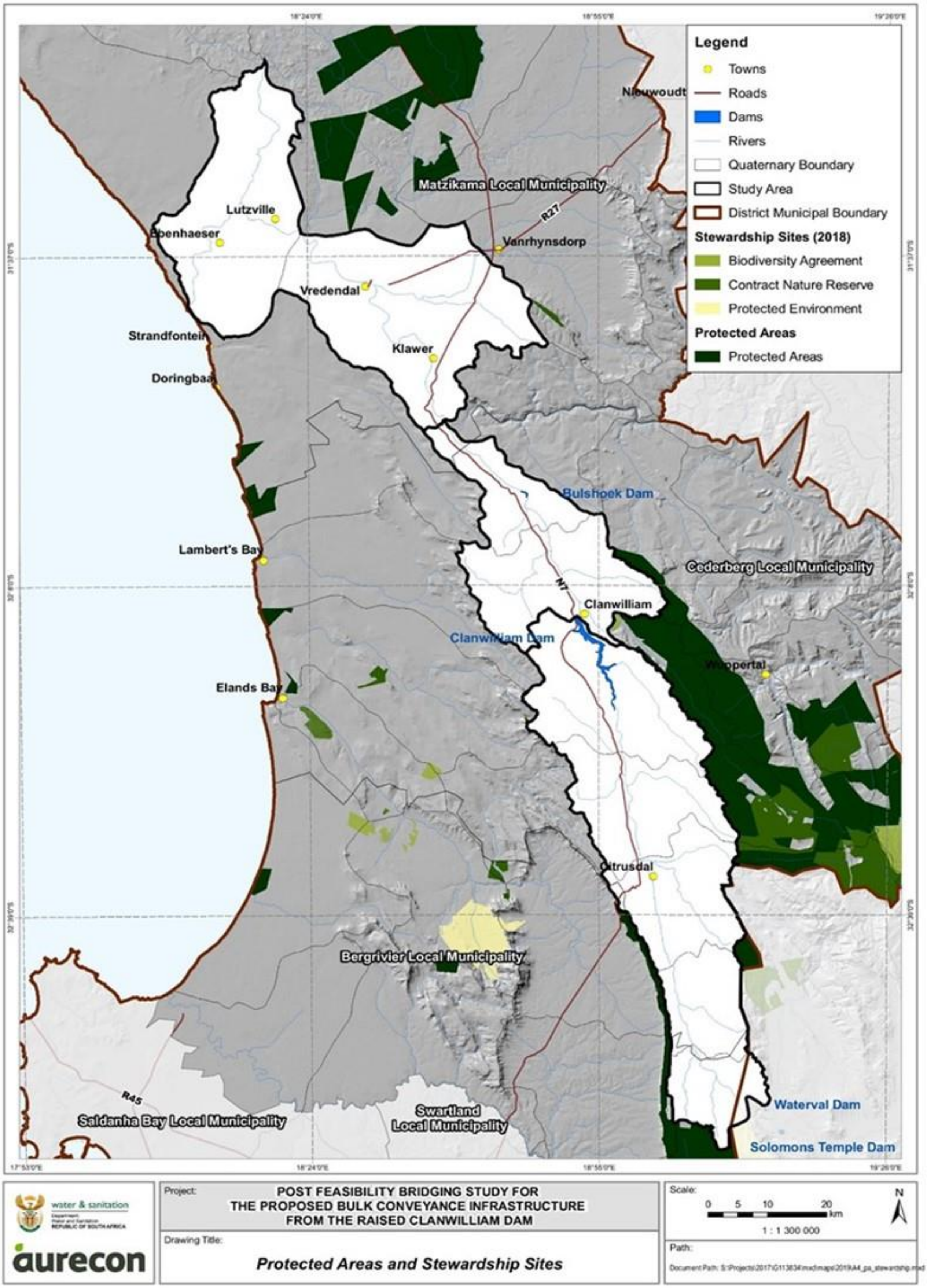


Figure 6.2 │ Protected Areas and Stewardship sites

6.1.3 Other Natural Areas

Other Natural Areas (ONAs) are areas that have not been identified as a priority in the 2017 Western Cape Biodiversity Spatial Plan, but they retain most of their natural character and perform a range of biodiversity and ecological infrastructure functions. These areas are still an important part of the natural ecosystem and should be managed or utilised in a manner that minimises habitat and species loss and ensures ecosystem functionality.

Figure 6.2 shows the ONAs mapped for the study area.

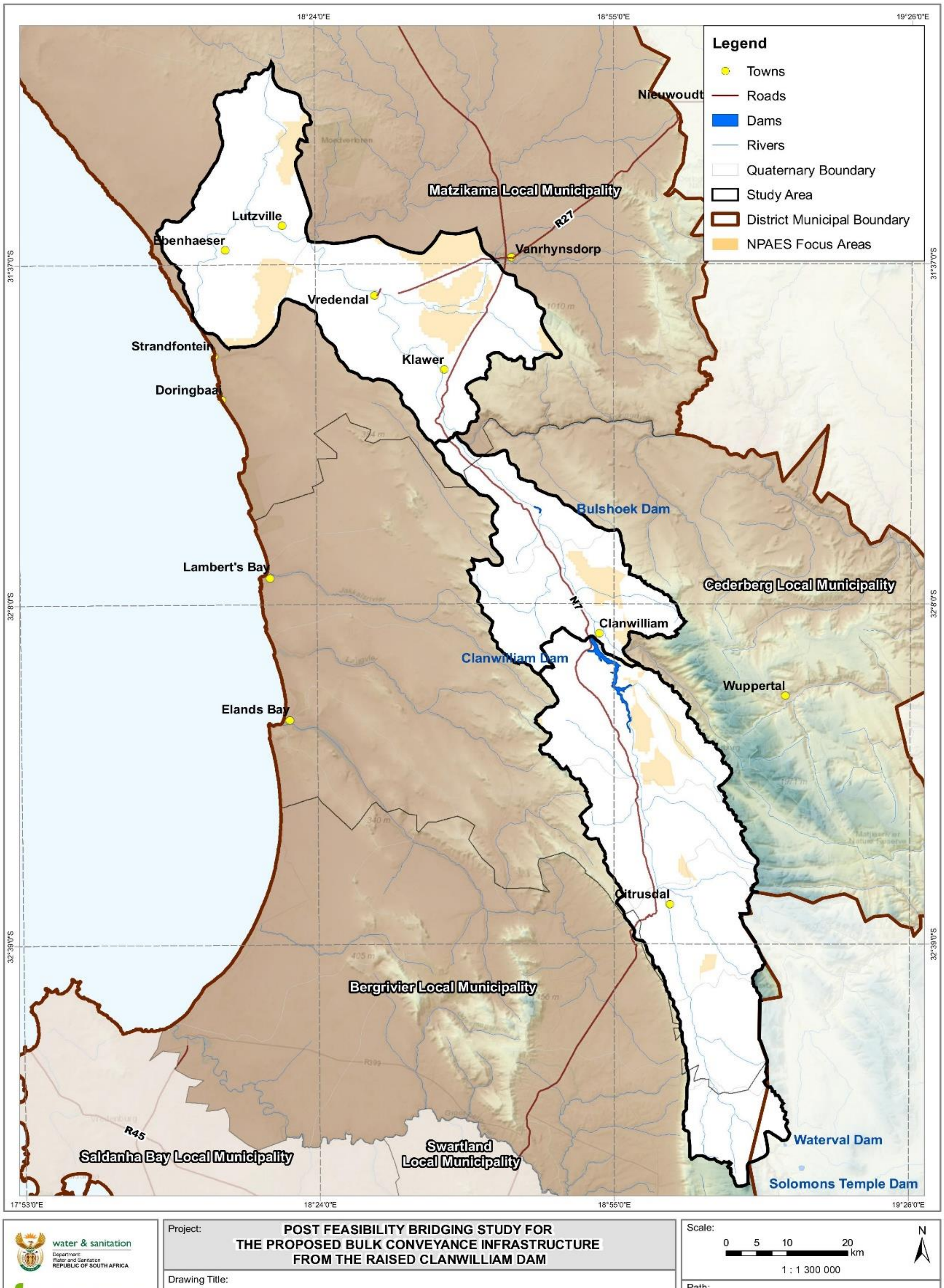
6.1.4 Natural Protected Area Expansion Strategy

National Protected Area Expansion Strategy (NPAES) aims to achieve cost-effective protected area expansion for ecological sustainability and increased resilience to climate change. This is very important considering South Africa's protected area network falls short of sustaining biodiversity and ecological processes.

Two focus areas identified as part of the NPAES are located within the study area and surrounds. They are the Knersvlakte Hantam focus area and the Tankwa Cederberg Roggeveld focus area. The Knersvlakte Hantam focus area straddles the Western Cape and Northern Cape and is a Succulent Karoo priority area. It contains numerous irreplaceable quartz patches and provides opportunities to protect whole intact river reaches.

The Tankwa Cederberg Roggeveld focus area also straddles the Western Cape and the Northern Cape and is important from a freshwater biodiversity perspective. It includes a large portion of the Doring River, which plays a central economic role in sustaining the high levels of utilisation of the Olifants River and meeting the water requirements of the Olifants estuary. The Tankwa Cederberg Roggeveld focus area also presents opportunities for protecting several threatened river types and important fish sanctuary areas that harbour endemic and threatened freshwater fish.

Figure 6.3 shows the NPAES focus areas within the study area.



water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

aurecon

Project: POST FEASIBILITY BRIDGING STUDY FOR THE PROPOSED BULK CONVEYANCE INFRASTRUCTURE FROM THE RAISED CLANWILLIAM DAM

Drawing Title: *NPAES Focus Areas*

Scale: 0 5 10 20 km
1 : 1 300 000

Path:
Document Path:
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Figure 6.3 │ Protected Areas Expansion Strategy map

6.2 Wetlands and National Freshwater Ecosystem Priority Areas

The study area comprises numerous wetlands, drainage lines and rivers that are classified as National Freshwater Ecosystem Priority Areas (NFEPAs), as shown in **Figure 6.4**. These areas play an important role in water supply and aquatic ecosystem functioning and should be maintained in a natural state as far as possible. Some of these contain endemic floral and faunal species, which are highly sensitive to change in the environment. The National Water Act (NWA), Act 36 of 1998 also defines the regulated area of a watercourse as 100 m from the edge of a river / stream and 500 m from the edge of a wetland, or within the 1:100-year floodline of a watercourse, whichever is the greatest. Any work undertaken within these aquatic regulated areas should be authorised in terms of Section 21 and 22 of the NWA. The predominant watercourses and aquatic features in the study area are:

1. The estuarine wetland associated with the Verlorevlei River (Class C: Moderately Modified) and dam near Elands Bay.
2. The Olifants River (Class D: Largely Modified) and associated natural NFEPA wetland.
3. The Jan Dissels River (Class D: Largely Modified) and associated natural NFEPA wetland.
4. The estuarine wetland associated with the Jakkals River (Class C: Moderately Modified) near Lamberts Bay.
5. The estuarine wetland associated with the Olifants River near Ebenhaeser.

6.3 Threatened Ecosystems

Ecosystem threat status is indicative of the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition – on which their ability to provide ecosystem services depends. Ecosystems are categorized as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), based on the proportion of the ecosystem that remains in good ecological condition. This is illustrated in **Figure 6.5**.

Threatened ecosystems are an important factor to consider when identifying land for the various distribution options, as they are listed in terms of the National Environmental Management: Biodiversity Act (NEM:BA), Act 10 of 2004. It is advised that any Critically Endangered and/or Endangered ecosystems are avoided as far as possible.

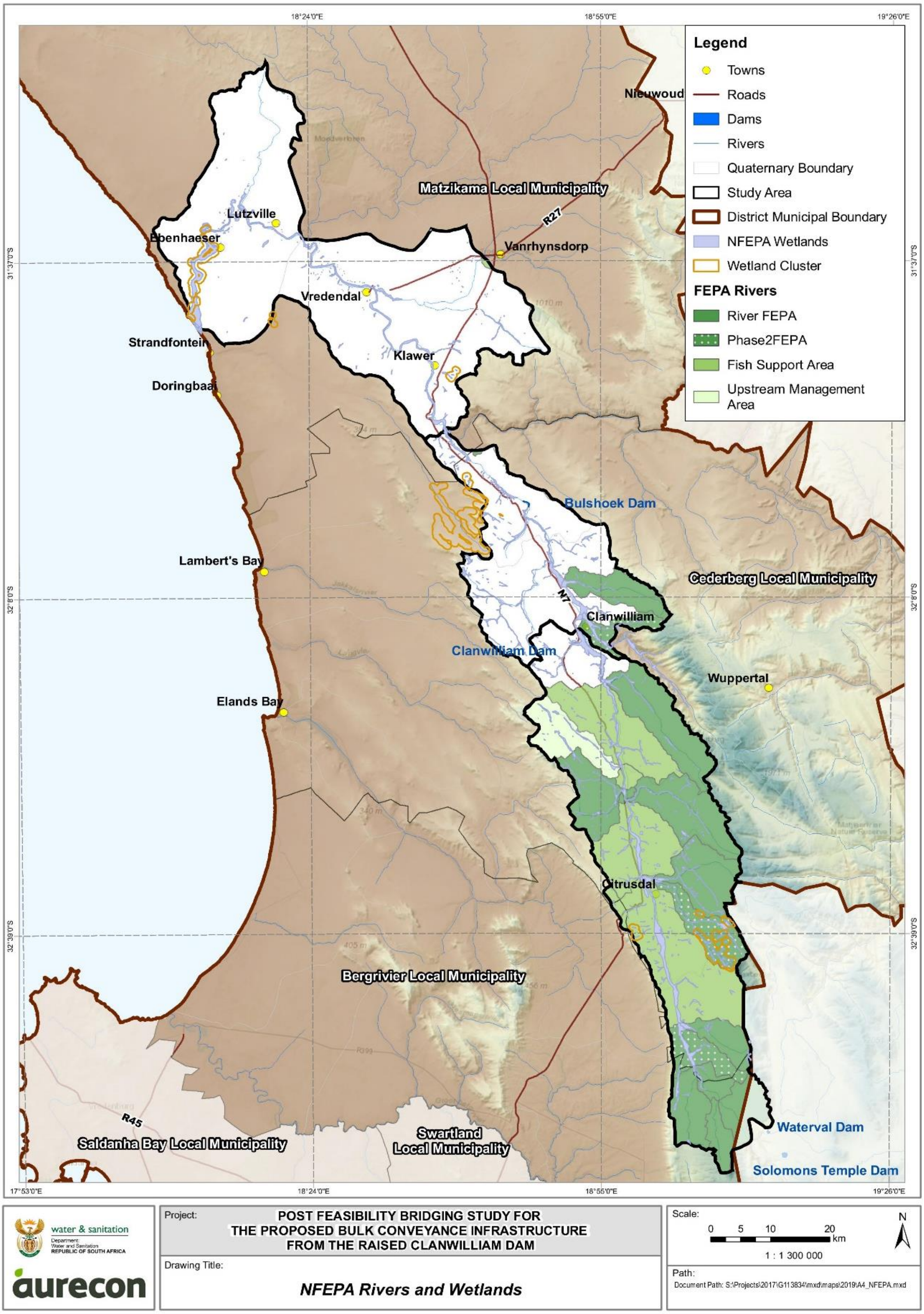

Figure 6.4 │ NFEPA wetlands and watercourses

The study area contains the following threatened ecosystems:

1. Arid Estuarine Salt Marshes (LT)
2. Bokkeveld Sandstone Fynbos (VU) - threatened plant species associations
3. Cape Inland Salt Pans (LT)
4. Cape Lowland Freshwater Wetlands (LT)
5. Cederberg Sandstone Fynbos (VU) - threatened plant species associations
6. Citrusdal Shale Renosterveld (EN) - irreversible loss of natural habitat
7. Citrusdal Vygieveld (LT)
8. Doringrivier Quartzite Karoo (LT)
9. Fynbos Riparian Vegetation (LT)
10. Graafwater Sandstone Fynbos (LT)
11. Klawer Sandy Shrubland (VU) - irreversible loss of natural habitat
12. Knersvlakte Dolomite Vygieveld (LT)
13. Knersvlakte Quartz Vygieveld (LT)
14. Knersvlakte Shale Vygieveld (LT)
15. Kobee Succulent Shrubland (LT)
16. Lambert's Bay Strandveld (VU) - irreversible loss of natural habitat
17. Langebaan Dune Strandveld (LT)
18. Leipoldtville Sand Fynbos (EN) - irreversible loss of natural habitat
19. Namaqualand Riviere (LT)
20. Namaqualand Sand Fynbos (LT)
21. Namaqualand Spinescent Grassland (LT)
22. Namaqualand Strandveld (LT)
23. Nardouw Sandstone Fynbos (VU) - irreversible loss of natural habitat
24. North Hex Sandstone Fynbos (LT)
25. Northern Inland Shale Band Vegetation (LT)
26. Olifants Sandstone Fynbos (LT)
27. Vanrhynsdorp Gannabosveld (LT)
28. Vanrhynsdorp Shale Renosterveld (LT)

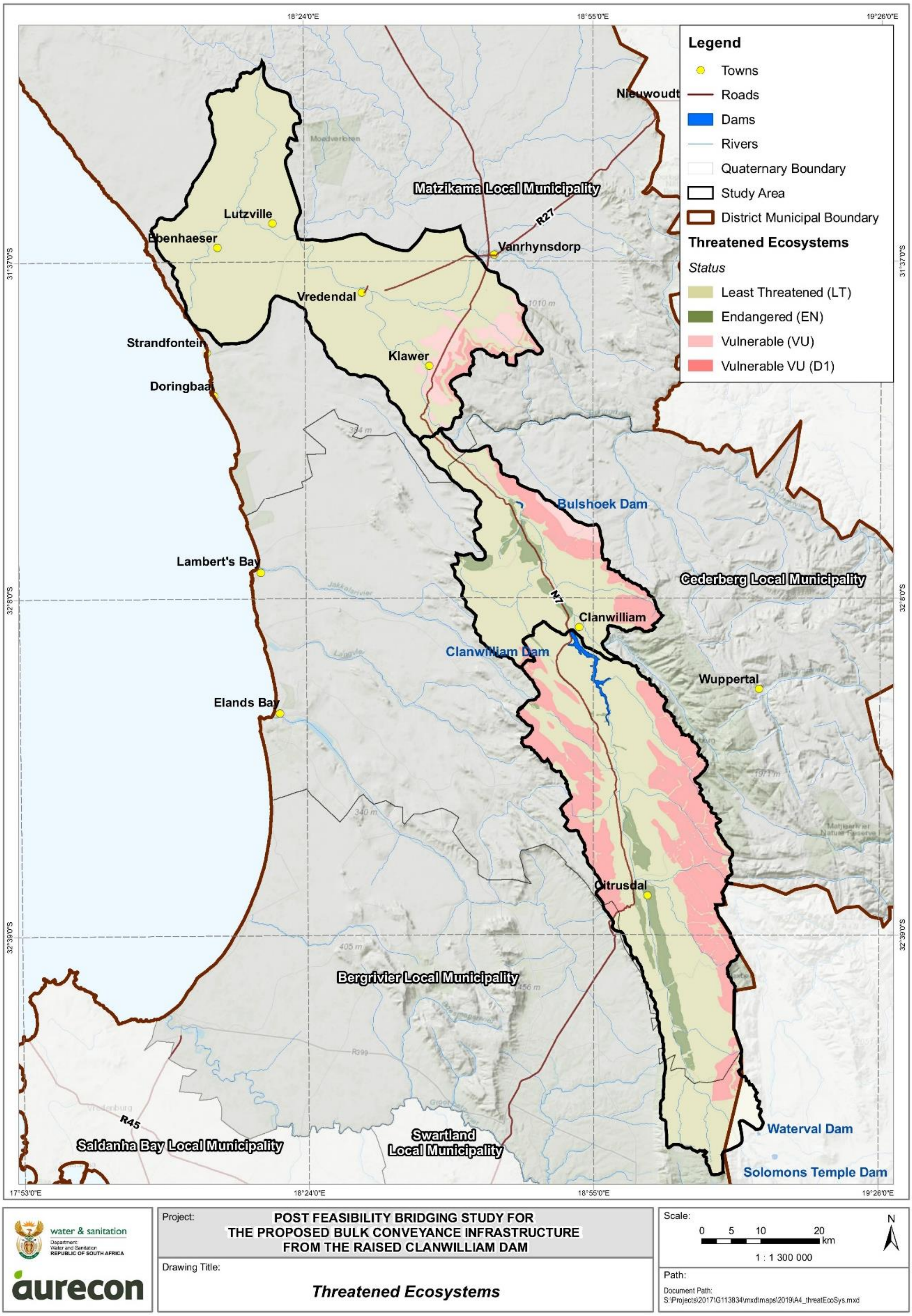

Figure 6.5 | Threatened Ecosystem status

6.4 Stewardship Sites

During 2003 CapeNature initiated the Biodiversity Stewardship programme to facilitate conservation on privately owned land by means of agreements between the parties involved. Part of the Jan Dissels Scheme has been identified as the Augsberg stewardship site (CapeNature, 2017). This stewardship site has a signed Biodiversity Agreement in place and is identified as approximately 1138.77 ha in size. The purpose of the Biodiversity Agreement is to conserve private conservation-worthy land.

Stewardship sites are shown in **Figure 6.2**.

7 Water Quality Considerations and Constraints

7.1 Introduction

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is suitable for all uses. There is some evidence of elevated phosphate concentrations, which may be the result of agricultural activities and wastewater return flows in the Citrusdal area. The good quality water is stored in Clanwilliam Dam and Bulshoek Weir, from where it is distributed via a system of canals to irrigation farmers in the middle and lower Olifants River valley.

In the Olifants River downstream of Clanwilliam Dam and upstream of the Doring River confluence, the water quality remains suitable for agriculture and domestic water supplies although minor impacts of irrigation return flows and treated effluent discharges (elevated phosphate concentrations) are already evident. The Olifants River downstream of the Doring River confluence is progressively impacted by irrigation return flows resulting in a steady increase in salinity in a downstream direction. The result is that water in the lower Olifants River, upstream of the tidal effect zone, is poor and salinity exceeds the requirement for irrigation use.

This chapter provides an overview of water quality monitoring in the study area, and the water quality requirements of irrigation farmers. Water quality monitoring points are shown in **Figure** 7.1.

7.2 Water quality monitoring in the lower Olifants River

7.2.1 Department of Water and Sanitation

As part of the National Chemical Monitoring Programme (NCMP), the Department of Water and Sanitation has an extensive monitoring network in the Olifants River catchment that has been sampled at various frequencies for several years. The key monitoring points in the study area, for which data has been obtained, are presented in **Table 7.1**.

Table 7.1 | Key DWS water quality monitoring points used in this study

Point number	Description	n	First date	Last date	Flow Gauge	Latitude	Longitude
101895	E1H006 - Jan Dissels River at Clanwilliam Commonage Warmhoek - at Gauging Weir on Jan Dissels River	527	1/4/1978	11/4/2016	E1H006	-32.21156	18.93676
101903	E2H003 - Doring River at Melkboom on Doring River	724	5/13/1972	11/14/2017	E2H003	-31.86028	18.6875
101908	E3H001 - Troe-Troe River at Farm 256/Troe-Troe	13	7/21/1987	9/10/2013	E3H001	-31.62972	18.69472
186216	E3H004 - Olifants River at Lutzville (Formerly E2H016)	140	12/11/2002	5/23/2017	E3H004	-31.5653	18.3306
101900	E1R001Q01 - Bulshoek Weir on Olifants River: near Dam Wall	608	6/29/1972	3/16/2017	E1R001	-31.996	18.78645
101901	E1R002Q01 - Clanwilliam Dam on Olifants River: near Dam Wall	557	4/3/1968	8/3/2010	E1R002	-32.18472	18.875
101896	E1H007 - Bulshoek Weir on Left Bank Canal from Bulshoek Weir	349	3/10/1972	2/27/2018	E1H007	-31.99523	18.7866

Notes – Point number = Registered number on WMS, n = number of samples collected, First Date and Last Date = date the first sample was collected and date of the last sample date in the database when it was accessed.

Water samples are typically analysed for a number of constituents, which include Calcium, Chloride, Dissolved Mineral Salts, Electrical conductivity, Fluoride, Potassium, Magnesium, Sodium, Ammonia, Nitrate-nitrogen, Ortho-phosphate, pH, Silicon, and Total Hardness. A number of indices are also calculated, which include the sodium adsopbtion ratoi (SAR), aSAR, Corrosivity index, Langelier index, Aggressiveness index, and Rayznar index.

7.2.2 Western Cape Department of Agriculture

The Western Cape Department of Agriculture conducted intensive weekly monitoring of the lower Olifants River below Bulshoek Weir for a period of three years (hydrological years, September 2010 to October 2011, Sept 2011 to Oct 2012, and Sept 2012 to Oct 2013). Samples were collected at seven monitoring points (**Table 7.2**) and analysed for a number of constituents.

Table 7.2 | Western Cape Department of Agriculture monitoring points

Sampling point name	Longitude	Latitude
1 Bulshoek Weir	18.787245	-31.99595
2 Doring River	18.686265	-31.862627
3 Verdeling	18.619466	-31.835101
4 Spruitdrift	18.532857	-31.722385
5 EB de Waal	18.460242	-31.647809
6 Lutzville	18.327511	-31.564697
7 Klawer	18.618328	-31.77775

The samples were analysed for pH, Conductivity, total dissolved salts (TDS), Calcium, Magnesium, Potassium, Sodium, Chloride, Sulphate, Bicarbonate, Copper, Iron, Alkalinity, and Hardness. Indices that were calculated include SAR, Corrosivity index, Langelier index, Aggressiveness index, and Rayznar index.

This data set provided a very good indication of the changes in quality along the length of the lower Olifants River, as well as the seasonal changes in quality. These changes are discussed below.

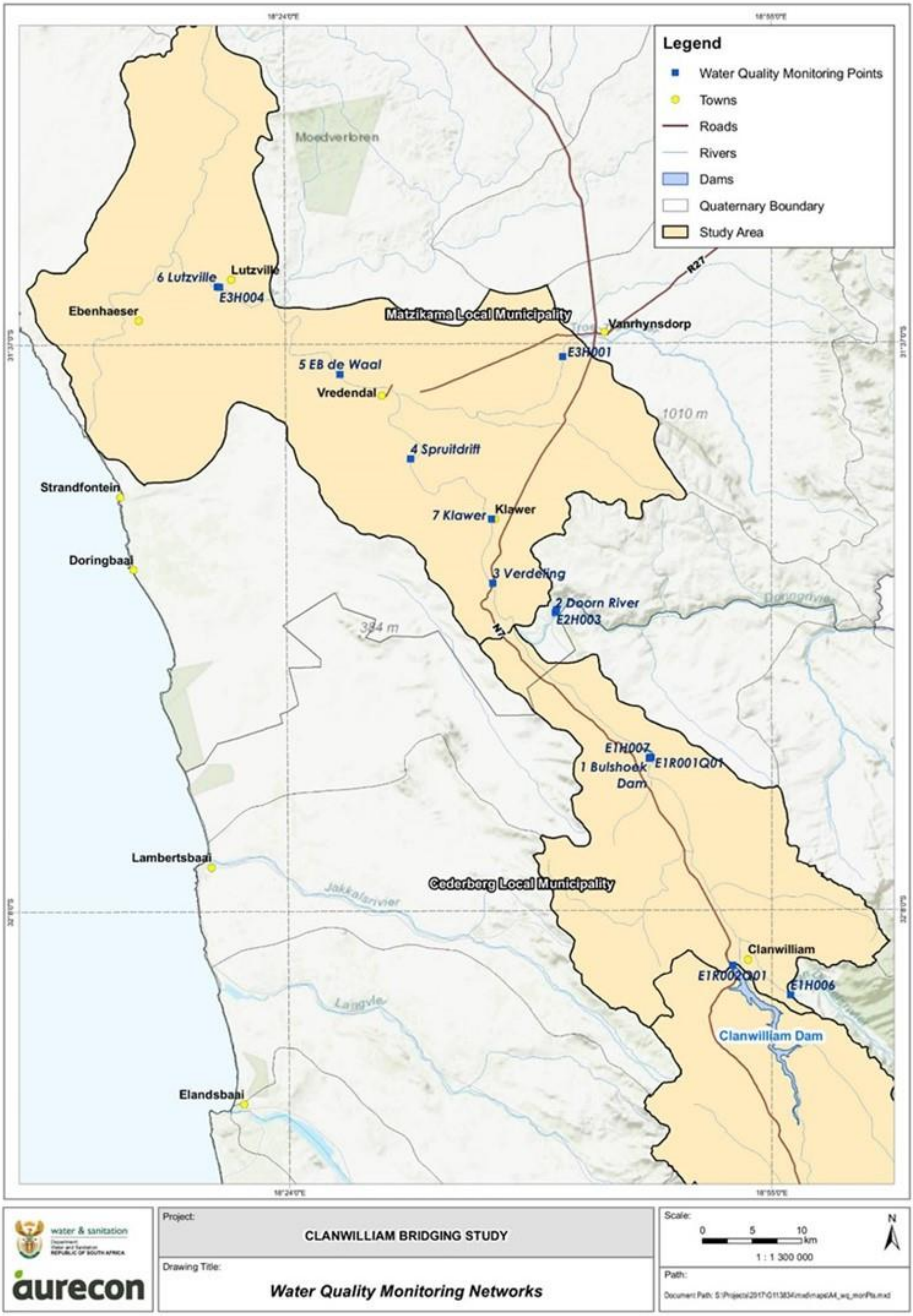

Figure 7.1 │ Map showing the location of water quality monitoring points

7.3 Water quality requirements

Irrigation water supply is the key water use in the lower Olifants River followed by domestic water use. The generic water quality requirements of these two user sectors and their fitness for use categories (DWS, 2006) are summarised in **Table 7.3** and **Table 7.4.**

Table 7.3 | Generic water quality guidelines for Agricultural Use: Irrigation

VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Total Suspended Solids	mg/l	50	75	100	>100
CHEMICAL REQUIREMENTS					
Chloride	mg/l	100	137.5	175	>175
Electrical Conductivity	mS/m	40	90	270	>270
Fluoride	mg/l	2.0	8.5	15.0	>15.0
pH (upper)		8.4	8.4	8.4	>8.4
pH (lower)		6.5	6.5	6.5	<6.5
Sodium Absorption Ratio	mmol/l	2.0	8.5	15.0	>15.0
Sodium	mg/l	70.0	92.5	115.0	>115.0
Aluminium	mg/l	5.0	12.5	20.0	>20.0
Arsenic	mg/l	0.1	1.05	2.0	>2.0
Beryllium	mg/l	0.1	0.3	0.5	>0.5
Boron	mg/l	0.5	0.75	1.0	>1.0
Cadmium	mg/l	0.01	0.03	0.05	>0.05
Chromium VI	mg/l	0.1	0.56	1.0	>1.0
Cobalt	mg/l	0.05	2.75	5.0	>5.0
Copper	mg/l	0.2	2.6	5.0	>5.0
Iron	mg/l	5.0	12.5	20.0	>20.0
Lead	mg/l	0.2	1.1	2.0	>2.0
Lithium	mg/l	2.5	2.5	2.5	>2.5
Manganese	mg/l	0.02	5.1	10.0	>10.0
Molybdenum	mg/l	0.01	0.03	0.05	>0.05
Nickel	mg/l	0.2	1.1	2.0	>2.0
Selenium	mg/l	0.02	0.04	0.05	>0.05
Uranium	mg/l	0.01	0.06	0.1	>0.1
Vanadium	mg/l	0.1	0.56	1.0	>1.0
Zinc	mg/l	1.0	3.0	5.0	>5.0
BIOLOGICAL					
Faecal coliforms	per 100ml	1	500	1000	>1000

Reference: South African Water Quality Guidelines, Volume 4, Agricultural Water Use - Irrigation (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not consider site-specific conditions.

Table 7.4 | Generic water quality guidelines for Domestic Use

VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg $CaCO_3$	200	300	600	>600
Turbidity	NTU	0.1	1	20	>20
CHEMICAL REQUIREMENTS					
Calcium	mg/l	80	150	300	>300
Chloride	mg/l	100	200	600	>600
Chlorine (upper)	mg/l	0.6	0.8	1.0	>1.0
Chlorine (lower)	mg/l	0.3	0.2	0.1	<0.1
Electrical Conductivity	mS/m	70	150	370	>370
Fluoride	mg/l	0.7	1.0	1.5	>1.5
Magnesium	mg/l	70	100	200	>200
Nitrate + Nitrite	mg N/l	6.0	10.0	20.0	>20.0
PH (upper)		9.5	10.0	10.5	>10.5
PH (lower)		5.0	4.5	4.0	<4.0
Potassium	mg/l	25	50	100	>100
Sodium	mg/l	100	200	400	>400
Sulphate	mg/l	200	400	600	>600
Total Dissolved Solids (TDS)	mg/l	450	1000	2400	>2400
Arsenic	mg/l	0.01	0.05	0.2	>0.2
Cadmium	mg/l	0	0.01	0.02	>0.02
Copper	mg/l	1.0	1.3	2.0	>2.0
Iron	mg/l	0.5	1.0	5.0	>5.0
Manganese	mg/l	0.1	0.4	4	>4
Zinc	mg/l	20	20	20	>20
BIOLOGICAL					
Total coliforms	per 100ml	0	10	100	>100
Faecal coliforms	per 100ml	0	1	10	>10

Reference: Quality of Domestic Water Supplies, Volume 1: Assessment Guide. (Water Research Commission, 1998).

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not consider site-specific conditions.

7.3.1 Salinity

Salinity of water is measured by two common water quality criteria. The first, total dissolved solids (TDS), expressed in milligrams per litre (mg/l), is the total number of milligrams of salt that remains after a litre of water is evaporated. The higher the TDS, the higher is the salinity. The second measurement of salinity is electrical conductivity (EC). The dissolved salts conduct electricity and therefore salt concentration is directly related to the EC reading.

In the WODRIS report the Provincial Department of Agriculture developed a site-specific classification for salinity (**Table 7.5**) that is more stringent than the SA Water Quality Guidelines for Irrigation Agriculture, to specify the water quality requirements for the Olifants irrigation area and to assess the fitness for use of the water.

Table 7.5 │ Salinity ratings for irrigation in the Olifants River

(Provincial Government Western Cape, 2004). The values in brackets represent the generic SAWQG values for irrigation)

Salinity hazard	EC (mS/m)	TDS (mg/l)	Applicability
Low (Ideal*)	10 – 25 *(<40)*	64 – 160 *(<260)*	Can be used on most soils with little likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soil of extremely low permeability.
Medium (Acceptable*)	25 – 75 *(40-90)*	160 – 480 *(260-585)*	Can be used for irrigation if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.
High (Tolerable*)	75 – 225 *(90-270)*	480 – 1 440 *(585-1755)*	Not to be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
Very high (Unacceptable*)	≥ 225 *(>270)*	≥ 1 440 *(>1755)*	Not suitable for irrigation water under most conditions.

** The equivalent water use categories (Ideal, Acceptable, Tolerable, and Unacceptable) were added to the original table.*

7.3.2 Sodicity

Sodicity of water refers to the quantity of sodium in relation to calcium and magnesium in the water. Sodicity is measured as the function of the ratio of sodium to calcium and magnesium, and is called the sodium adsorption ratio (SAR). Generally, sodic conditions are accompanied by high concentrations of salts. The SAR limits for irrigation water are listed in **Table 7.6** (PGWC, 2004).

Table 7.6 │ Sodicity ratings for irrigation water

Sodicity hazard	SAR	Explanation
S1	0 – 10	**Low sodium water** can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.
S2	10 – 18	**Medium sodium water** will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity, especially under low leaching conditions unless gypsum is applied.
S3	18 – 26	**High sodium water** may produce harmful levels of exchangeable sodium in most soils and will require special soil management – good drainage, high leaching and organic matter additions.
S4	> 26	**Very high sodium water** is unsatisfactory for irrigation purposes.

The Provincial Government Western Cape (2004) salinity and sodicity guidelines were therefore used to assess the fitness for use of the water in the study area for irrigation use.

7.4 Spatial and seasonal water quality trends

The focus of this assessment is on irrigation water supply because one of the many bulk conveyance options is to potentially use the Olifants River downstream of Bulshoek Weir as a conduit. Water can then be abstracted at points along the length of the river, where the quality is still fit for irrigation use. Total Dissolved Salts or its equivalent, Dissolved Mineral Salts, was used to assess the fitness for use for irrigation agriculture.

Water quality in Clanwilliam Dam (E1R002Q01) (**Figure 7.4**) and in Bulshoek Weir (E1R001) (**Figure 7.5**) is ideally suited for irrigation use. There is also very little change in salinity between Clanwilliam Dam and Bulshoek Weir. The salinity in the Doring River (E2H003) is also low, although higher than in Bulshoek Weir during the summer months. However, there is a large increase in salinity between Bulshoek Weir and the low water bridge at Lutzville (E3H004). The salinity increases to such a degree that the water in the lower reaches is unsuitable for irrigation at certain times of the year (**Figure 7.2**).

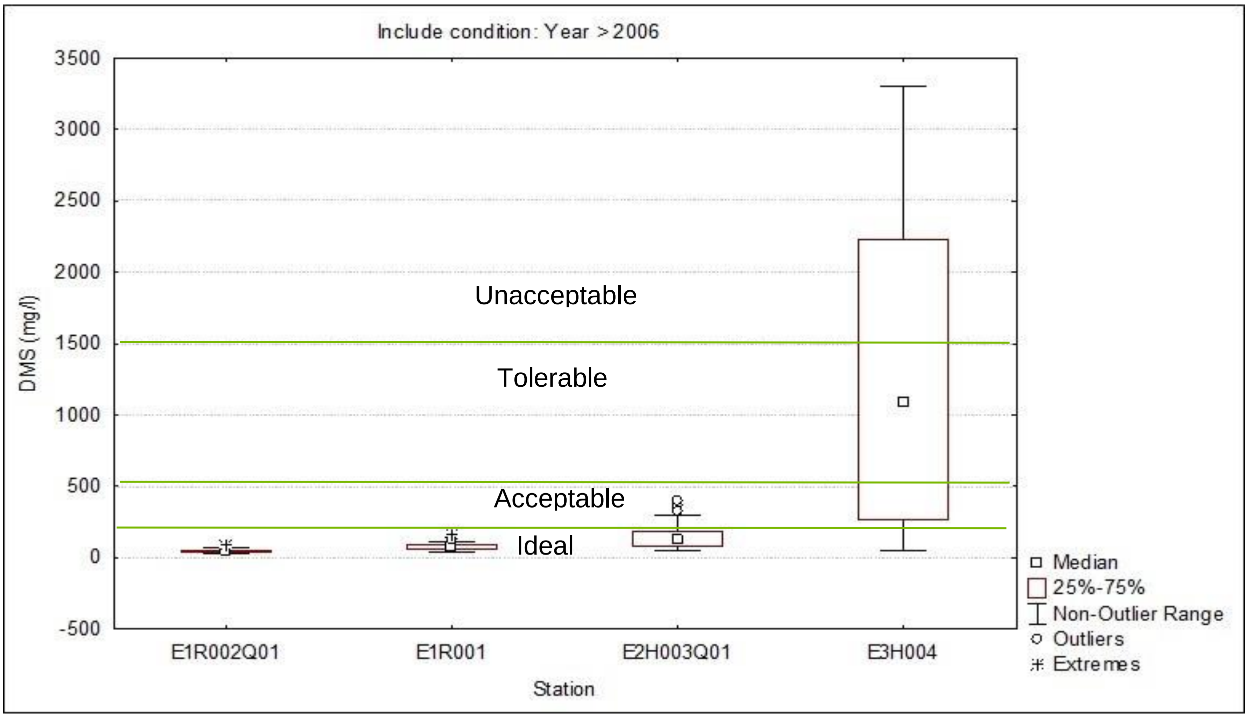

Figure 7.2 | TDS in the Lower Olifants River from 2006 to 2017/18

To assess the changes in salinity between Bulshoek Weir and Lutzville, the monitoring data that were collected by the Western Cape Department of Agriculture at seven monitoring points has been reviewed (**Figure 7.3**). Observations made relating to specific monitoring data sets have been indicated as observations A to E, and the data sets being referred to have been indicated in **Figure 7.3**.

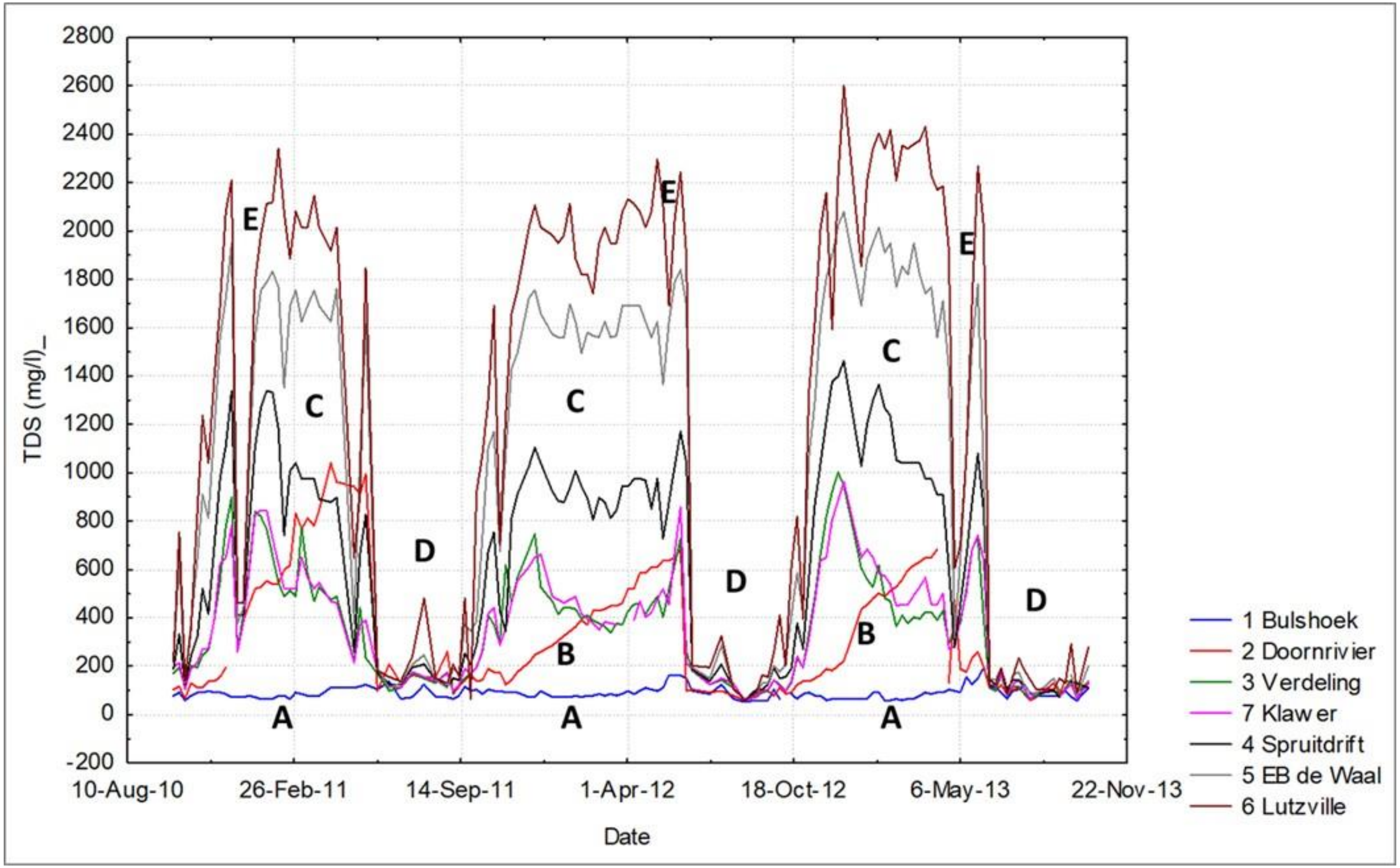

Figure 7.3 │ Change in salinity along the Lower Olifants River - Bulshoek Weir to Lutzville

Several observations can be made from the data (**Figure 7.3**):

A. The salinity in Bulshoek Weir (blue line) was consistently low over the three hydrological years that were sampled.

B. Salinity in the Doring River (red line) was similar to the quality in Bulshoek Weir at the end of the wet winter season. It then increased steadily through the dry summer season, until the onset of the wet winter season that reset the salinity back to low concentrations. This increase was probably due to evaporation losses in summer, moderate irrigation return flows, and shallow groundwater inflows. The increase in salinity towards the end of summer did not seem to have a major impact on salinities at Verdeling and Klawer, probably due to very low flow in the Doring River.

C. During the dry summer season, when farmers are irrigating their crops, irrigation return flows increased the salinity in the Olifants River, and the increase was cumulative in a downstream direction. Between Bulshoek Weir and Verdeling there was, on average, about a 400% increase in salinity. There was almost no difference between the salinities at Verdeling and Klawer. Between Klawer and Spruitdrift there was a 72% increase in salinity, a 67% increase between Spruitdrift and EB de Waal, and about a 22% increase in salinity between EB de Waal and Lutzville. The biggest percentile increase was therefore between Bulshoek Weir and Verdeling, downstream of the confluence with the Doring River.

D. With the onset of the wet winter season, salinities fell rapidly and remained moderate to low, up to the onset of the next dry season. The wet season flows reset salinity to background concentrations. With the onset of the dry season, salinities increased rapidly.

E. A decrease in salinity during a late season rainfall event is temporary and salinity levels return to high concentrations as soon as the pulse of good quality water leaves the system.

In an ideal situation, gauged flow records would be available for the lower Olifants River, and these could be used to calculate salt loads at the sampling points, as well as the areal salt loads based on the irrigation area between the sampling points that would contribute to the return flow salt loads. However, flow gauging in the lower Olifants River at Bulshoek Weir, Lutzville and the Doring River is almost non-existent to support load calculations.

7.5 Temporal trends

The long-term DWS data were used to examine the temporal trends at the sampling points. Over the past 10 years there appears to be an increasing trend in salinity in both Clanwilliam Dam (E1R002Q01) (**Figure 7.4**) and Bulshoek Weir (E1R001) (**Figure 7.5**). However, the dissolved major salts (DMS) concentrations are still within the ideal range.

A concern is that the sampling frequency at Clanwilliam Dam and at Bulshoek Weir was severely curtailed after 2008, which may tend to skew the trend lines. The sampling for Clanwilliam Dam stopped in 2010. It is recommended that sampling in the lower Olifants River be restored and normalised.

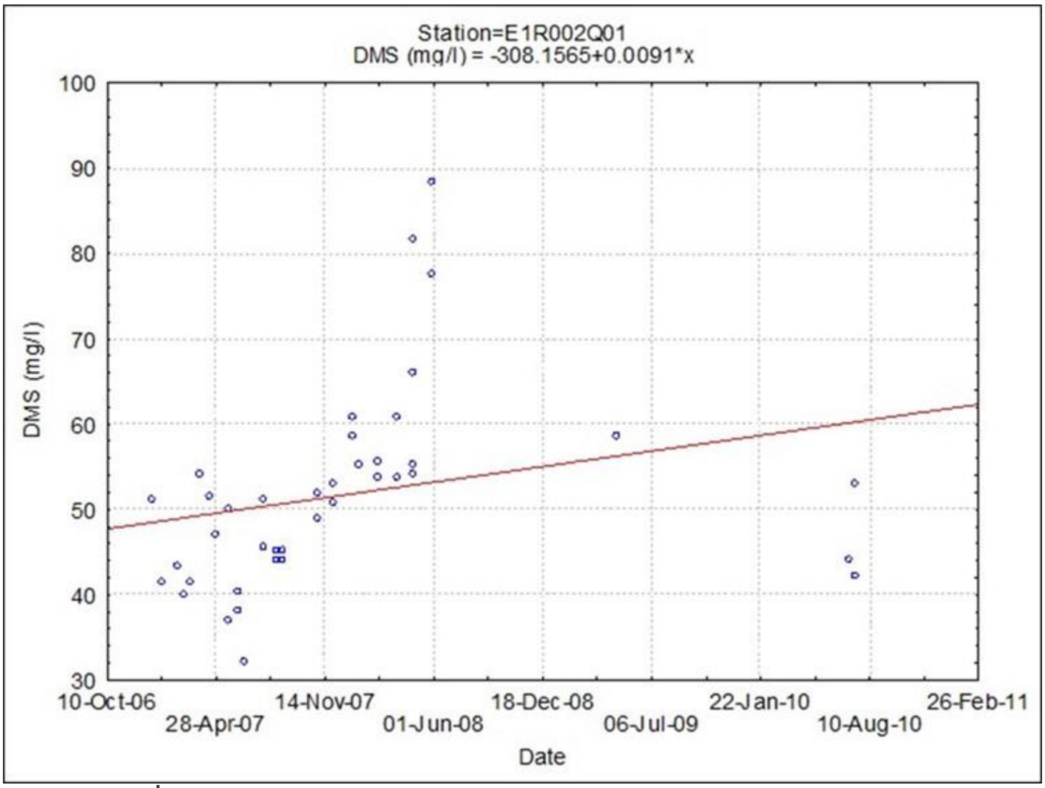

Figure 7.4 │ TDS concentrations in Clanwilliam Dam from 2007 to 2010

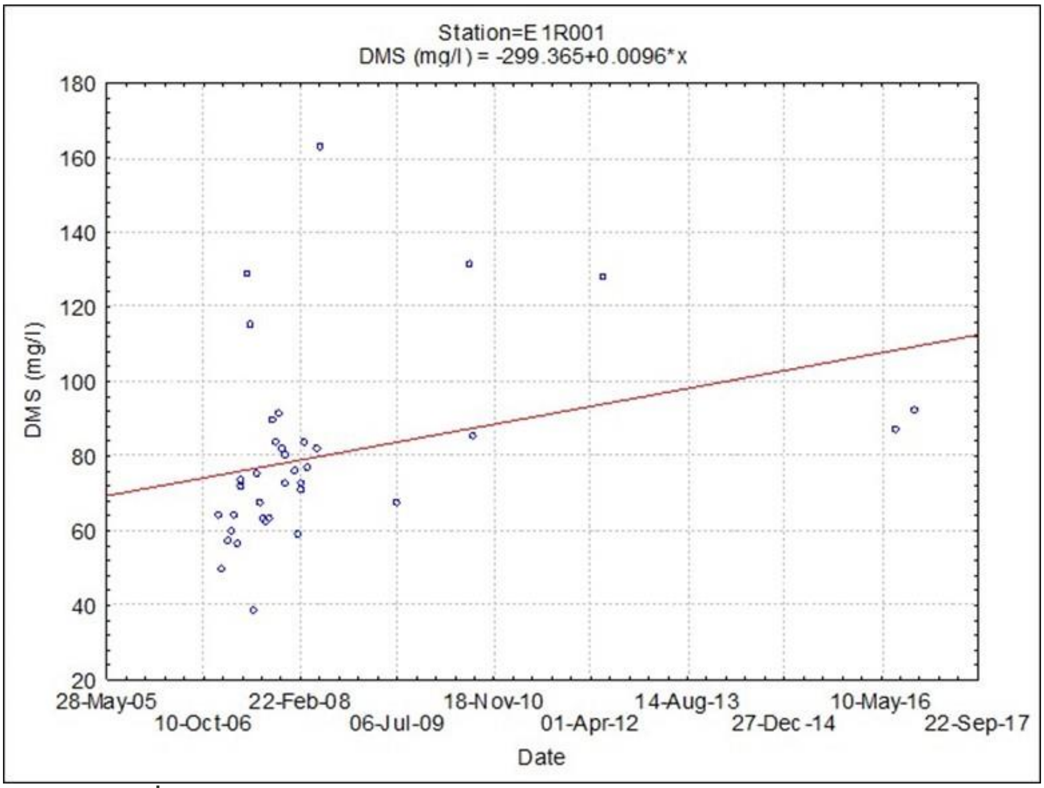

Figure 7.5 │ TDS concentrations in Bulshoek Weir from 2007 to 2017

In the Doring River the long-term trend appears to be stable (**Figure 7.6**).

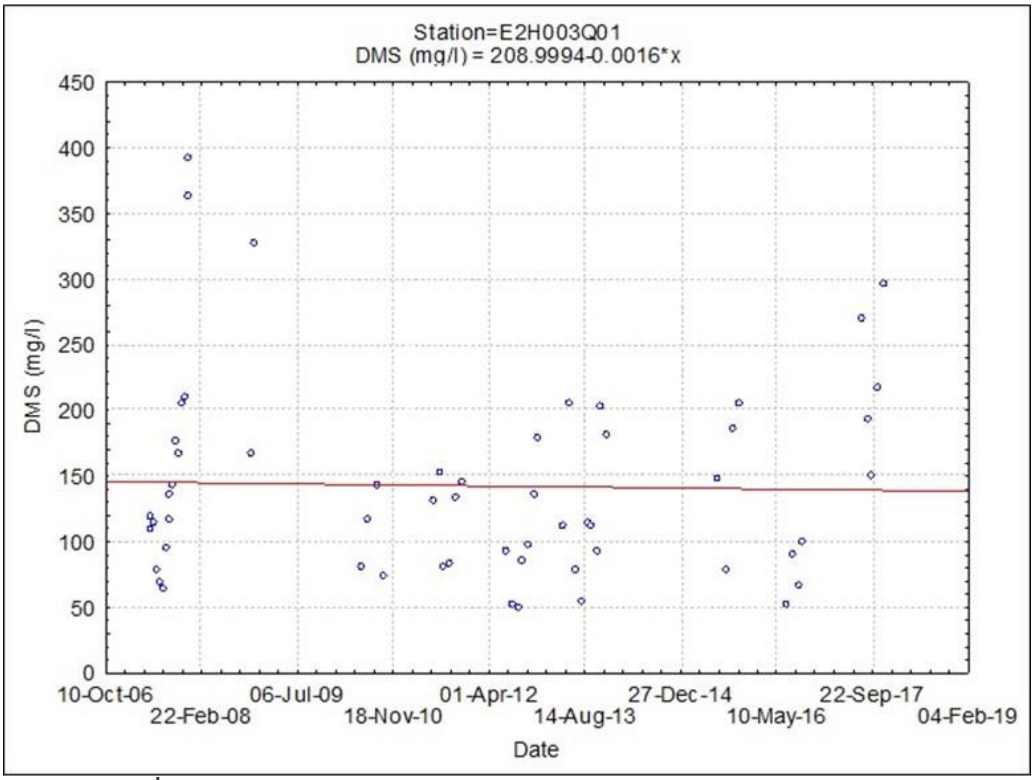

Figure 7.6 │ TDS concentrations in the Doring River (before the confluence) from 2007 to 2017

The long-term trend in the Olifants River at Lutzville (E3H004) indicates an increasing trend **(Figure 7.7**). The upper limit for DMS for irrigation use (1440 mg/l from **Table 7.5**) is exceeded at least every year.

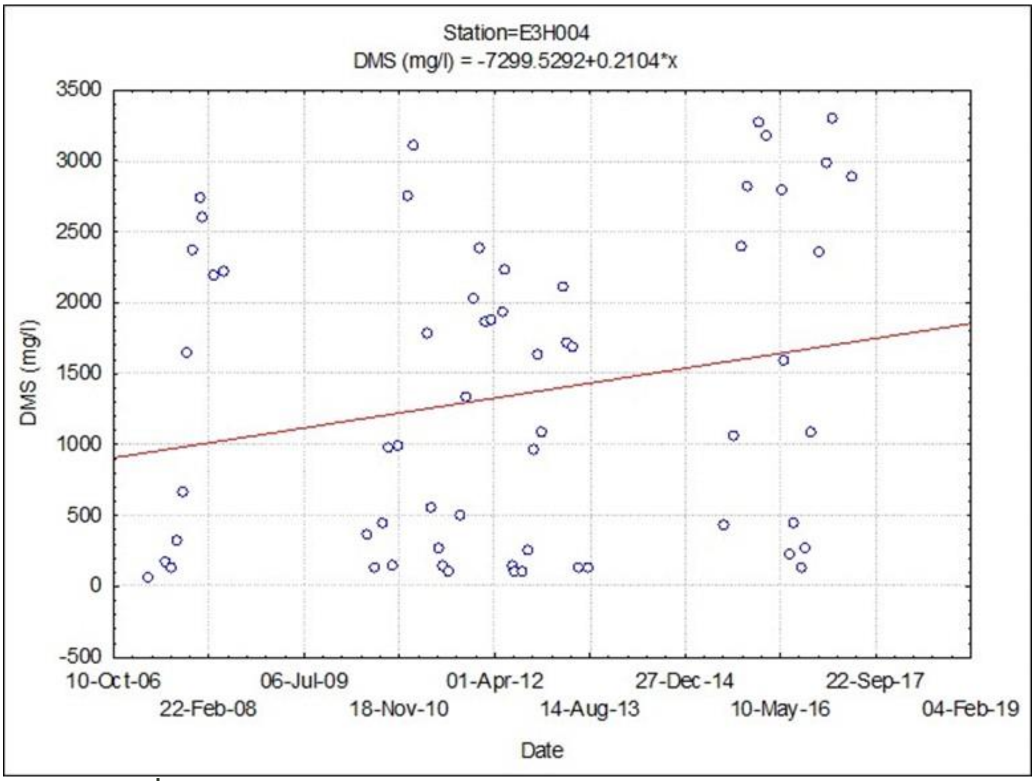

Figure 7.7 │ TDS concentrations in the Olifants River at Lutzville from 2007 to 2017

7.6 Estimating salt export loads from irrigated areas

To estimate the impact of establishing new irrigation areas on the potential salt loads and concentrations in the Olifants River, the weekly water quality data collected by the Department of Agriculture over the 2010 – 2013 hydrological years were analysed. The calculations were focused on the dry summer seasons only as this was the period during which excessive salt concentrations were observed in the Olifants River below Bulshoek Weir. This is also the period during which the Olifants River could be considered as a conduit for irrigation water from Bulshoek Dam to users further downstream.

The salt loads and areal salt load contribution were calculated as follows:

1. At the time of sampling (2010 – 2013), river releases at Bulshoek Dam and gauged flows in the Doring River were estimated for the day a water sample was collected. No gauged flows were available for the gauging structure at Lutzville for the 2010 – 2013 sampling period.
2. For calculating salt loads an assumption was therefore made that the flow in the Olifants River downstream of the confluence of the Olifants River and the Doring River was the sum of the two flows. This flow was used to calculate the salt loads at the sampling sites from Verdeling to Lutzville. The salt load in kg/day was calculated by multiplying the salt concentration by the total flow for the day.
3. The mass of salt (kg/day) that entered the river between consecutive sampling points was calculated by subtracting the salt load at the upstream sampling point from the load at a particular sampling point.
4. The irrigation areas that would contribute return flows (with salts) to a particular sampling point were then estimated by adding together the irrigated areas within the river reaches. The contributing irrigated areas in the various sections are given in **Table 7.7**.

Table 7.7 | Contributing irrigated areas

River reach	Irrigated area (ha)
Bulshoek to Doring River confluence	1 170.15
Doring River confluence to Verdeling	1 083.07
Verdeling to Klawer	2 13.56
Klawer to Spruitdrift	2 207.21
Spruitdrift to EB de Waal	3 819.78
EB de Waal to Lutzville	3 916.32

5. The areal salt load (kg/ha/day) was then calculated by dividing the salt load by the irrigated area.
6. The median salt load (**Table 7.8**) per reach (kg/ha/day) was then calculated, as well as the range (interquartile range – 25th and 75th percentile values).

Table 7.8 | Salt load per reach

River reach	Areal salt load (kg/ha/day) (dry season)		
	Median	25th percentile	75th percentile
Bulshoek to Verdeling	11.54	8.94	18.75
Verdeling to Spruitdrift	14.30	9.73	19.22
Spruitdrift to EB de Waal	11.66	8.51	15.58
EB de Waal to Lutzville	6.37	3.20	8.50

7. The areal salt load can then be used to estimate, on average, the additional salt loads that could be added to the river in a particular river reach, from the added irrigation area. The change in salt concentration can then be estimated by assuming some flow in the river. These estimates would only be valid for the dry season, which is the critical period in terms of return flows to the lower Olifants River.

7.7 Water quality constraints and opportunities

If the Olifants River is being considered as a conduit for transporting irrigation water for abstraction further downstream, the following constraints would apply:

- During the summer months, high salinity irrigation return flows would probably increase the salinity to unacceptable levels for irrigation use. Fourie (1976) measured TDS in irrigation returns to the lower Olifants River and found that the concentrations typically varied between 3000 – 4000 mg/l. No recent measurements of TDS concentrations in the drainage water could be found. The biggest increase was between Bulshoek Dam and Verdeling, which is located downstream of the confluence with the Doring River. At Verdeling the water was, on average, still within an acceptable range, but further downstream, the salinity increased to a Tolerable range, and eventually an Unacceptable range for irrigation use.
- If new irrigation is established on soils with elevated salts, then additional water would be required to leach the salts from the soils. This would probably create additional salt loads to the lower Olifants River during the establishment of the fields (PGWC, 2004).

There may also be opportunities with respect to water quality:

- During the high flow winter months, salinity in the lower Olifants River is reset to concentrations similar to that in Clanwilliam Dam and Bulshoek Dam, or slightly higher, but still within the Ideal to Acceptable range for irrigation use. If off-channel storage can be created further downstream, low salinity water can be released during the winter season and abstracted further downstream with little impact on salinity in the river.
  It is recommended that only water of an Acceptable quality (**Figure 7.8**) be abstracted from the river. This is to ensure that the quality in the off-channel storage dams is acceptable for

irrigation with occasional incursions into a tolerable quality because of evaporation and local runoff.

A historical duration diagram of TDS concentrations at sampling points during the months of June to September (wet season) was compiled (**Figure 7.8**). Note that in **Figure 7.8** the TDS (Y axis) is a log scale. Water of an Acceptable quality can be abstracted at all the monitoring points for about 86% of the time, and quality of an Ideal quality for at least 50% of the time. Some pumping can be conducted at the end of the dry season (May) or the start of the dry season, in October (**Figure 7.9**). However, water quality of an Acceptable quality can only be abstracted at Spruitdrift for about 55% of the time, for 40% of the time at EB de Waal, and about 30% of the time Lutzville. The quality in the lower Olifants River in the two months bordering the wet season is at most of a marginal quality.

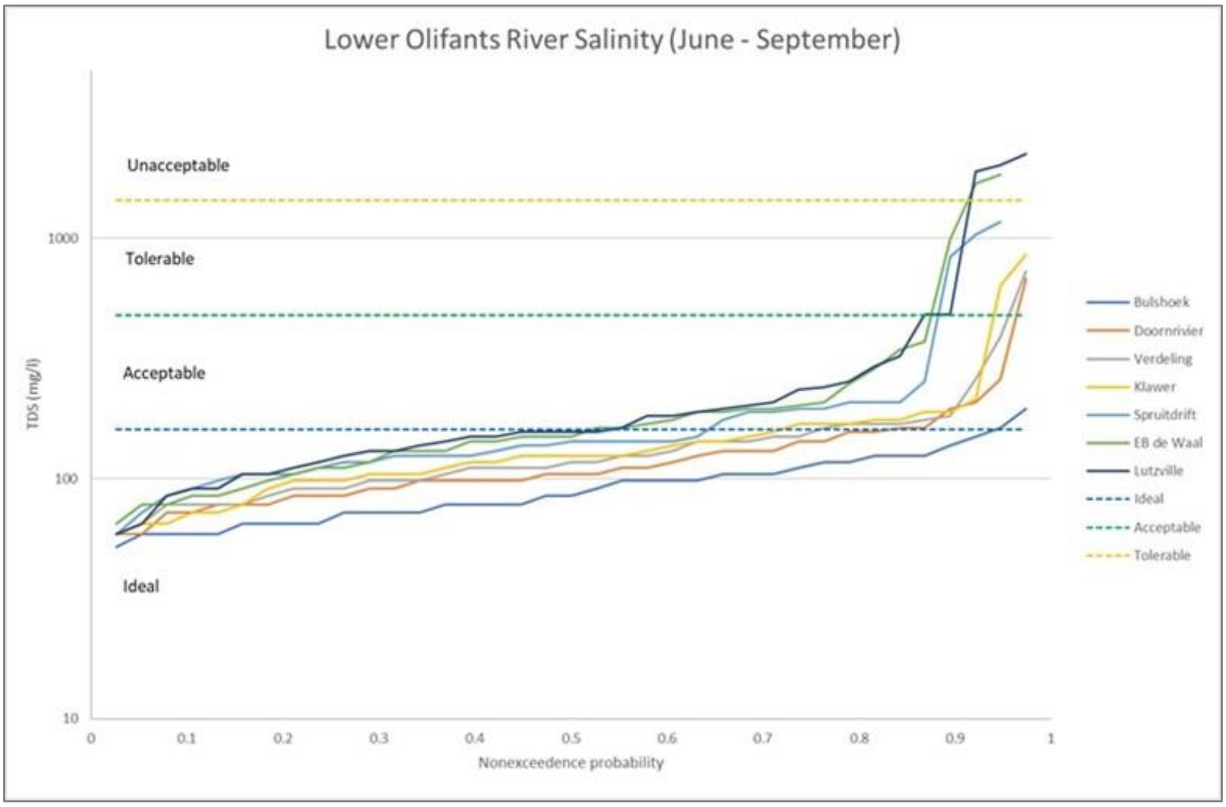

Figure 7.8 │ TDS concentrations along the Lower Olifants River from June to September

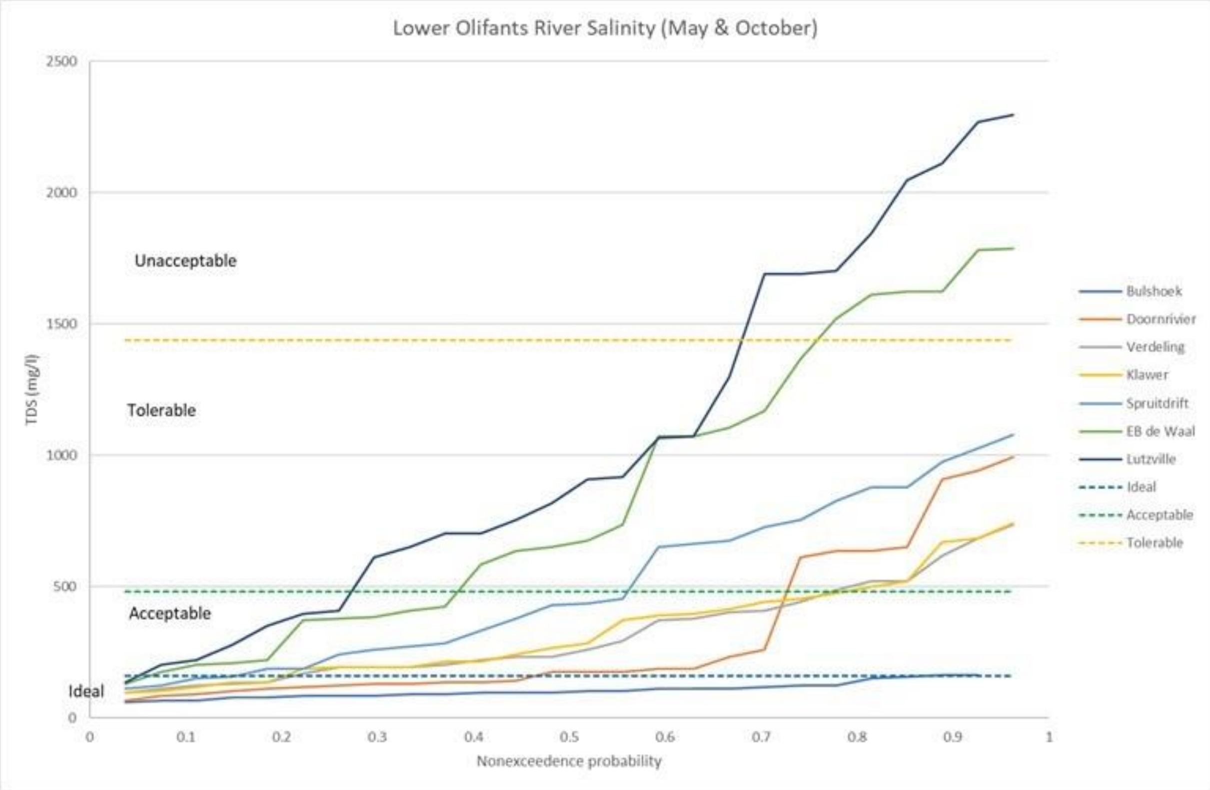

Figure 7.9 | TDS concentrations along the lower Olifants River in May and October

This proposed storage of better quality water would require farmers to monitor salinity in the lower Olifants River and to only transfer water when the salinity is in an Acceptable category (TDS < 480 mg/l or Electrical conductivity < 75 mS/m or <750 µS/cm[1]). During pumping the salinity levels in the off-channel storage dams should also be monitored to maintain the salt concentrations in an Acceptable category.

Consideration should be given to limiting the discharge of high salinity irrigation drainage water into the lower Olifants River. Options such as creating "salt dams" have been identified during the WODRIS study (PGWC, 2004). Other options for controlling saline runoff from irrigated areas in South Africa have been documented in for example van Rensburg et al. (2011) and Moolman et al. (1999).

[1] Most handheld electrical conductivity meters record EC in µS/cm.

8 Options Analysis Process and Screening

8.1 Introduction

This section describes the process followed for the selection, evaluation and screening of new irrigation development options.

The process followed includes the following steps in chronological order:

a) Identification of all potential options, compilation of a Long List of potential options, and first-level screening of the Long List of options,
b) Compilation of a Preliminary Short List of options, and qualitative screening of the Preliminary Short List of options,
c) Compilation of a Short List of options to be evaluated further,
d) Evaluation and documentation of short-listed options,
e) Discussion of options with key stakeholders at the December 2018 Options Workshop,
f) Refining of the options presented at the Options Workshop, considering the workshop recommendations,
g) Preparation of the *Evaluation of Development Options Sub-Report* that documents the background, process and (refined) options presented at the options workshop,
h) Re-evaluation of the existing options and defining and evaluating new options not previously identified, following comments and recommendations made at the Options Workshop,
i) Revisiting the comparison and screening of options, considering workshop recommendations,
j) Preparation of the *Suitable Areas for Agricultural Development Report* (this report) inclusive of updated and new options and with recommendations for feasibility-level evaluation,
k) Following the acceptance of recommendations, the Feasibility Design phase of this study will proceed.

8.2 Compilation of the Long List of Options

A significant number of potential irrigation development options were identified from previous and on-going studies, liaison with officials and stakeholders, evaluation of soil-suitability maps and existing land use, as well as formulating new potential options. The list of these initial potential options has been termed the "*Long List*" of options. The Long List describes potential options that could be considered for the study area, and has been included in **Appendix A**.

The options have been categorised according to the sub-area where they are located or will abstract water from.

8.3 Screening of Potential Options

Potential options in the Long List of options were interrogated by the Study Team to ascertain which of these could be seriously considered for further evaluation. The results of this initial evaluation, with reasons, are documented in a draft Distribution Options Discussion Paper. An Options Brainstorming Workshop was held with key stakeholders on 6 August 2018, to discuss the initial identified potential options, where after the Long List of options was refined, and the Options Discussion Paper updated.

The Options Discussion Paper was then circulated for contributions and reviews by the Project Steering Committee (PSC) members and discussed with stakeholders at the PSC meeting held on 22 August 2018. The potential options were also discussed during meetings held with the Lower Olifants River Water User Association (LORWUA) and the Clanwilliam Water User Association (WUA) on 20 September 2018.

The outcome of this preliminary screening process was the identification of the options that should be evaluated further (to produce a Preliminary Short List of Options).

The characteristics of these preliminary-identified options were unpacked and a qualitative assessment of the options characteristics, access to the additional water supply following the raising of Clanwilliam Dam, the order of magnitude of the additional bulk water distribution costs and potential impacts were then done. This initial, more qualitative evaluation, reduced the options on *technical* grounds to develop a Short List of Options.

This was followed by quantitative evaluation of the Short List of Options, requiring some iteration as information became available, to identify the "better" development options from a technical, socio-economic and political perspective. The Preliminary Short List of Options evaluated for the December 2018 Options Workshop have been included in Section 8.6. The Final Short List of Options has been included in Section 8.13.

8.4 Options screened out before the Options Workshop

The following identified options have been screened out during the initial evaluation process, at the Options Work Session held in August 2018:

- Zone 1: Olifants River catchment upstream of Clanwilliam Dam
- Zones 4 and 5: Reducing losses in the LORGWS canal / refurbishment of the canal system
- Zones 2, 4 and 5: Changes in crops

8.4.1 Zone 1: Olifants River catchment upstream of Clanwilliam Dam

It has been decided that prospective irrigators may continue to apply for water use authorisations for the use of water for irrigation in the Olifants River valley upstream of the Clanwilliam Dam. Since there is very little scope for additional irrigation development upstream of Clanwilliam Dam without creating more on-farm balancing storage, water for new irrigation in this sub-area would likely need be abstracted from the Olifants River in winter and stored in new/enlarged off-channel farm dams. This is expected to be an expensive option. Several dam sites were identified in the Olifants/Doring River Basin Study (DWAF, 1998), and were considered as possible storage dams to supply existing users and allow for possible future development. This option will not be further evaluated in this study, but farmers will not be excluded from applying for water use authorisations according to the standard application process.

8.4.2 Zones 4 and 5: Reducing losses in the LORGWS canal / refurbishment of the canal system

Undertaking of short-term and medium-term canal repairs is essential, as not doing so would negatively impact the functionality of the scheme. This option has the benefit of limiting losses from the canal. Improved water use efficiency, i.e. reducing losses, covering the canal, and other efficiency measures would limit losses and thus increase the supply from the canal. The overall condition of the canal is however so poor that a significant maintenance programme will take many years and will not improve the condition of the canal sufficiently in a short enough period of time, to be able to allow further development of irrigation from the canal, based on efficiency savings.

8.4.3 Zones 2, 4 and 5: Changes in crops

The LORWUA has suggested future crop changes as an option, e.g. instead of wine grapes shifting to table grapes, increasing the use of tunnels or shading, or grow nuts and vegetables. This is however a process driven by markets and is not regarded as a distribution option. An increase in the reliability of water supply to existing irrigators, once Clanwilliam Dam has been raised, may also influence the type of crops being grown, with especially citrus, that needs water year-round, being considered more frequently.

8.5 Options Screened Out During Qualitative Evaluation

The following identified options have been screened out during the qualitative evaluation of preliminary short-listed options, at the Options Work Session held in August 2018:

- Zone 2: Using the full capacity of the Clanwilliam Canal
- Zone 2: Increase the capacity of the Clanwilliam Canal
- Zone 2: Replace Clanwilliam Canal with a pipeline
- Zone 4: New main canal section from Bulshoek on Right Bank of Olifants River
- Zones 4-5: Increase Abstraction from Existing Canals
- Zones 4-5: High volume low head lifting pump stations
- Zones 4-5: Replace all or sections of LORGWS Canal with increased capacity canal
- Zones 4-5: Additional farm dams along the canal
- Zone 5: Klawer 2 Scheme
- Zone 5: Klawer 3 Scheme
- Zone 5: Coastal 1 Scheme
- Zone 5: Coastal 2 Scheme
- Zone 5: Lutzville 1 Scheme
- Zones 4-5: Provision of additional balancing dam/s along the canal
- Zones 4-5: Increase Winter Use from Existing Canals

8.5.1 Zone 2: Using the full capacity of the Clanwilliam Canal

According to the Clanwilliam WUA the canal is already fully used during 'normal' years and it is not feasible to increase flow for further development. In addition, there are no identified irrigable areas that could be irrigated from the canal.

8.5.2 Zone 2: Increase the capacity of the Clanwilliam Canal

As no additional irrigable area has been identified that can be irrigated from the canal, this option falls away.

8.5.3 Zone 2: Replace Clanwilliam Canal with a pipeline

While this option would reduce losses from 30% to about 3% and free up water, this will be a very costly option. In addition, no additional irrigable area has been identified that can be irrigated from the canal. This is an issue for existing irrigators only.

8.5.4 Zone 4: New main canal section from Bulshoek on Right Bank of Olifants River

This has been considered and has been incorporated in the 'Right Bank Canal' option. Removed because of duplication.

8.5.5 Zones 4-5: Increase Abstraction from Existing Canals

This has been incorporated into a similar option termed 'Increase capacity of LORGWS canal and other betterments'.

8.5.6 Zones 4-5: High volume low head lifting pump stations

Benefit will be achieved for a limited distance only. This will be a very costly option that will also present an operational challenge.

8.5.7 Zones 4-5: Replace all or sections of LORGWS Canal with increased capacity canal

This has been incorporated into a similar option termed 'Increase capacity of LORGWS canal and other betterments'.

8.5.8 Zones 4-5: Additional farm dams along the canal

Although this option could increase the yield from the system, especially for larger farm dams, it is not considered to have much potential, mainly because of limited land availability for farm dams, due to the small farm sizes.

8.5.9 Zone 5: Klawer 2

This option requires a balancing dam to store water to be pumped in winter, and then blended with abstracted summer releases of poorer water quality in order to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter. The entire site except for a small portion near the northern boundary is located within a CBA1, which also rules out the option.

8.5.10 Zone 5: Klawer 3

The Klawer 3 scheme is an identified irrigable area located along a tributary of the Troe-Troe River near Vredendal. Following environmental screening, only very small and dispersed irrigable areas remained, which were too small to practically consider further, and were located far away from the Olifants River. This option requires a balancing dam to store water to be pumped in winter, and then blended with abstracted summer releases of poorer water quality in order to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

8.5.11 Zone 5: Coastal 1

The Coastal 1 irrigable area is an area located close to Vredendal, along the left bank of the river. The re-evaluation of the balancing dam storage required for this option, of water to be pumped in winter, to blend with abstracted summer releases of poorer water quality to ensure an acceptable minimum irrigation water quality for the crops (notably grapes) showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

8.5.12 Zone 5: Coastal 2

The Coastal 2 irrigable area is an area located about halfway between Vredendal and Lutzville, along the left bank of the river. Following environmental screening, only two very small irrigable areas remained, which were too small to practically consider further. This option requires a balancing dam to store water to be pumped in winter, and then blended with abstracted summer releases of poorer water quality in order to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

8.5.13 Zone 5: Lutzville 1

This option requires a balancing dam to store water to be pumped in winter, and then blended with abstracted summer releases of poorer water quality in order to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

8.5.14 Zones 4-5: Provision of additional balancing dam/s along the canal

A significant benefit of an additional balancing dam along the canal may be realised during a drought, while it could also augment the yield or irrigate new areas. A careful evaluation of potential balancing dam sites that would be located near the existing LORWUA canal, led to the identification of two potential balancing dam sites. The first site is located on the left bank of the Olifants River, in the hills near the confluence of the Olifants and Doring rivers and Trawal. While it seems like a good dam site, and the Trawal and Zypherfontein schemes could easily be irrigated from it, the dam is located too high. While different dam sizes could be considered, pumping from the canal or river to the dam would need to be at least 130m high or more, which would be extremely expensive, and not viable. The dam would inundate the road leading south from Trawal to Skurfkop Station. A second dam site has also been identified in the hills near Klawer on the right bank, but the pumping requirement would be even higher, which also rules out this dam site.

8.5.15 Zones 4-5: Increase Winter Use from Existing Canals

There is very little scope to release more water through the canals during the peak summer months. A distribution option that can be considered is to put more water through the canals from March to October, i.e. during the winter period. This would require the introduction of alternative crop types that have a different water requirement, with peak demands at different times to those crops currently grown. This option has a high risk involved in terms of the need for a reliable market to be available for the alternative crops at the right time. This is an option to expand existing summer irrigation, but as an option for new irrigation on its own this option will not be viable.

8.6 Preliminary Short List of Options Evaluated for Workshop

The following short-listed options have been selected for further evaluation, as documented in the *Evaluation of Development Options Sub-Report*. As some of the options were evaluated but discarded, the numbering is not chronological.

Zone 2 - Clanwilliam Dam and Jan Dissels River:

- Option 1: Abstraction from Clanwilliam Dam
- Option 5: Transfer of lower Jan Dissels River scheduled allocations to the Olifants River

Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir:

- Option 6: Pumping from Olifants River
- Option 7: Pumping from Olifants River
- Option 8: Pumping from Olifants River
- Option 9: Pumping from Olifants River
- Option 10: Abstraction from Bulshoek Weir .

Zone 3 - Options Located Outside the Olifants River Valley:

- Option 11: Jakkals River Irrigation Scheme (JRIS) and Graafwater
- Option 12: Provision of water to coastal towns
- Option 13: Provision of water to JRIS, Graafwater, Lamberts Bay and Elands Bay.

Zone 4 - Olifants River below Bulshoek Weir to Trawal

- Option 14: Release at Bulshoek Weir and pump from river: Zypherfontein 1
- Option 15: Release at Bulshoek Weir and pump from river: Combined areas 15-33, Trawal
- Option 16: Release at Bulshoek Weir and pump from river: Zypherfontein 2
- Option 17: Release at Bulshoek Weir and pump from river: Melkboom.
- Option 18: Release at Bulshoek Weir and pump from river: Combined areas 14-16-17
- Option 19: Release at Bulshoek Weir and pump from river: Combined areas 14-15-17

Zone 5 - Olifants River from Klawer to the Coast

- Option 22: Klawer
- Option 23: Aties-Karoo
- Option 24, Coastal 1
- Option 25: Ebenhaeser New
- Option 27: Lutzville 2
- Option 29: Use of spare capacity in the Karoovlakte canal section
- Option 30: Use of spare capacity in the Naauwkoes canal section
- Option 31: Use of spare capacity in the Vredendal canal section

Zones 4 and 5: LORGWS (Bulshoek) Canal

- Option 32: Replace all or sections of LORGWS Canal with a pipeline with increased capacity
- Option 33: Increase capacity of LORGWS canal and other betterments

8.7 Options Workshop and Sub-Report

At the Options Workshop held on 11 and 12 December 2018, the background to and findings of the evaluation of options was presented to a group of key stakeholders. The stakeholders provided comment and made suggestions regarding improvements and variations of the potential options or clarified specific facts.

Several recommended changes to the options presented are incorporated in the descriptions and costing of the short-listed options, as described in the *Evaluation of Development Options Sub-Report*. These include:

- Principles for the sizing of farm dams when pumping from a river or canal were reviewed - 24 hrs of storage when irrigating from the Olifants River and 4 days of storage when irrigating from a canal.
- Increased river losses (from 25% to 50%) in the Jakkals River for the Scheme 11, Jakkals River Irrigation Scheme (JRIS) and Graafwater option, where water is released down the Jakkals River.

- River losses were recorded as a fixed value, in addition to being recorded as a percentage.
- Cadastral boundaries from Cape Farm Mapper were used to check land ownership for all scheme options. This was to determine areas that are privately owned.
- Recommendations on aspects and acceptability of the options were incorporated and their features and costs were updated.
- Social considerations were included in the option descriptions.

8.8 Options Screened Out Following the Options Workshop

The following identified options have been screened out following the Options Workshop:

- Zone 2: Schemes 6, 7 and 8
- Zone 2: Schemes 9 and 10
- Zone 5: Schemes 29 Use of spare capacity in the Karoovlakte canal section

8.8.1 Zone 2: Pumping from the Olifants River (Schemes 6, 7 and 8)

Following the workshop, the potential irrigable areas were revised, taking the Marginally Recommended soil types and currently irrigated areas of non-perennial crops in the identified areas for potential irrigation into consideration. In addition, environmental impacts were revisited to a more detailed level, changing potential irrigable areas. This completely changed these schemes. One combined scheme was identified, replacing these 3 schemes.

8.8.2 Zone 2: Pumping from the Olifants River (Schemes 9 and 10)

Following the workshop, the potential irrigable areas were revised, taking the Marginally Recommended soil types and currently irrigated areas of non-perennial crops in the identified areas for potential irrigation into consideration. In addition, environmental impacts were revisited to a more detailed level, changing potential irrigable areas. This completely changed these schemes. One combined scheme was identified, replacing these 2 schemes.

8.8.3 Zone 5: Use of Spare Capacity in the Karoovlakte canal section

By revisiting the positioning of the abstraction points, and as pointed out at the Options Workshop, it became evident that there was no benefit to be gained from this option, when compared to Scheme 22, the Klawer Scheme that pumped water from the Olifants River, since the abstraction point from the river and canal respectively was so close together.

8.9 Re-evaluation of Options

Several of the changes that were requested by workshop attendees significantly influenced the analysis of options. The re-evaluation of options was done following the tabling of the *Evaluation of Development Options Sub-Report*.

The re-evaluation includes the following:

- The most significant change requested by workshop attendees was that areas which have been identified from the soil survey as Marginally Recommended should also be considered for irrigable areas, as farmers in the area are currently successfully farming on these soils.
- Inclusion of areas that are currently irrigated for non-perennial crops, and identifying the existing water use authorisations of such land.
- Environmental impacts have had a significant impact on the size of irrigable areas. After consultation with environmental specialists, it was stressed that not only CBAs would affect the size of the areas, other environmental aspects also needed to be considered. To avoid further complications, more detailed environmental aspects were considered when identifying the new irrigable areas with contributions from environmental scientists. All the factors considered resulted in multiple changes of features and costs for the options identified.
- A new option of replacing the Trawal main canal with a ‘right bank’ canal (with an increased capacity) that includes flows for new irrigation between Bulshoek Weir and the Doring River confluence, in the Trawal area.
- The need for balancing storage for the options for pumping from the Olifants River into canal sections with spare capacity. A small balancing dam with 12 hours of storage as well as a reject was added at the abstraction point from existing canals.
- Allowing for and including the costs for canal re-lining, using the existing canal as formwork, for all the options that include the existing Lower Olifants canal or sections thereof.
- Evaluating the potential implications of blending water pumped from the Olifants River with canal water on water quality in existing canal sections, for options that include the pumping of water from the lower Olifants River (released flows from Bulshoek Weir) into sections of the Lower Olifants canal.
- The irrigable areas of the Klawer scheme will potentially be reduced because of a national protected area (NPAE) identified following environmental screening. The irrigable area has therefore been reduced for the evaluation.

- New irrigable areas were identified following the inclusion of previously omitted marginally irrigable soils, above Bulshoek Weir. Options 1, 2, 3, 5 and 6, as presented at the workshop needed to be updated to accommodate non-irrigated areas plus currently irrigated areas, and the associated increased irrigation water requirement. This is expected to very significantly change these options.
- Water requirements for most options changed and were recalculated. Leaching factors for several options changed and were recalculated, following liaison with the soil survey team for clarification. This led to the re-design of most pipelines, pump stations, canals and other bulk infrastructure for most options. The costs and URVs were also updated.
- Splitting of the costs of options between betterment costs and the cost for new irrigation, for options where this is relevant, such as in the instance of a new canal with increased capacity. This will provide all costs for purposes of motivation for allocation and sourcing of funding.

8.10 Revised Options following Re-evaluation

The inclusion of Marginally Recommended soil types, and currently irrigated areas of non-perennial crops in the identified areas for potential irrigation, had a very significant influence on the identified options. Many of the options had to be delineated and evaluated do novo, most notably for the options in Zone 2, where all the development options changed, as indicated in **Table 8.1**.

Table 8.1 | Options revised following Options Workshop

Preliminary pre-workshop option	Revised option
Jan Dissels: 3 options, previously screened out due to environmental impacts	Jan Dissels, consisting of currently irrigated land and new land
Abstraction from Clanwilliam Dam	Redefined, with 3 sub-options, including currently irrigated areas and enlarged new irrigation areas
Options 6, 7 and 8. Pumping from the Olifants River	These 3 options were combined into one option, inclusive of several currently irrigated areas and additional irrigable areas
Options 9 and 10. Pumping from the Olifants River	These 2 options were combined into one option, inclusive of currently irrigated areas and additional irrigable areas

Preliminary pre-workshop option	Revised option
Zypherfontein 1	The irrigable area of the Zypherfontein 1 Scheme has increased, inclusive of currently irrigated areas and additional irrigable areas. This then also changes the irrigable areas of both the combined options in the Trawal area
Klawer	Significantly reduced area because of the NPAE
Use of spare capacity in the Naauwkoes canal section, for irrigation of the Klawer 2 irrigation area	Replaced by an option that uses spare capacity in the Naauwkoes canal section, for irrigation of a scaled-down Klawer irrigation area

8.11 New Options Identified Following Re-evaluation

The following new options were identified and evaluated following the tabling of the *Evaluation of Development Options Sub-Report*.:

- Replacing the Trawal main canal with a 'right bank' canal that also allows for additional irrigable areas between Bulshoek Weir and the Doring River confluence.
- Zone 2: New option consisting of currently irrigated and new irrigation areas, near the new N7 road bridge, pumping from Clanwilliam Dam.
- Zone 2: Right bank near the tailwater of Bulshoek Weir, consisting mostly of already irrigated areas.
- Zone 5: Use of spare capacity in the Naauwkoes and Vredendal canal sections, irrigating the lower-lying portions of the reduced Klawer irrigation areas and the Coastal 1 irrigation area, abstracting at the beginning of the Naauwkoes canal section at 'Verdeling'.
- Zone 5: Use of Spare Capacity in the Naauwkoes/Vredendal canal sections to provide water to the Ebenhaeser restitution farms and augmenting the existing Ebenhaeser scheme.

8.12 Further Option Screened Out

The following identified option has been screened out following the Project Steering Committee meeting 3 held on 14 March 2019:

- Zone 2: Pumping from Clanwilliam Dam, near the new road bridge (Clanwilliam 2)

8.12.1 Zone 2: Pumping from Clanwilliam Dam, near the new road bridge (Clanwilliam 2)

It became evident that the farmers owning the land had already started with the development of this potential irrigation area, for a new scheme consisting of a combination of currently irrigated and new irrigation areas, near the new N7 road bridge, pumping from Clanwilliam Dam, and that the option cannot be consideration further.

8.13 Options Evaluated (Final Short List)

The following short-listed options have been selected for further evaluation, as documented in the *Cost of Water Supply to Farm Boundaries Sub-Report*.

Zone 2 - Clanwilliam Dam and Jan Dissels River:

- Option 1: Jan Dissels
- Option 2: Abstraction from Clanwilliam Dam

Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir:

- Option 3: Transfer of lower Jan Dissels River scheduled allocations to the Olifants River
- Option 4: Pumping from Olifants River - Zandrug
- Option 5: Abstraction from Bulshoek Weir

Zone 3 - Options Located Outside the Olifants River Valley:

- Option 6: Jakkals River Irrigation Scheme (JRIS) and Graafwater (2 options)
  - 6a: Pipeline transfer to Jakkals River (original proposed scheme)
  - 6b: Pipeline via secondary road
- Option 7: Provision of water to coastal towns
- Option 8: Provision of water to JRIS, Graafwater, Lamberts Bay and Elands Bay

Zone 4 - Olifants River below Bulshoek Weir to Trawal

- Option 9: Release at Bulshoek and pump from river: Zypherfontein 1
- Option 10: Release at Bulshoek and pump from river: Trawal
- Option 11: Release at Bulshoek and pump from river: Zypherfontein 2
- Option 12: Release at Bulshoek and pump from river: Melkboom
- Option 13: Pipeline from Bulshoek and pump to farm dams: Combined Options 9-10-11
- Option 14: Raised (and lined) canal from Bulshoek and pumped to canal on right bank: Combined Options 9-11-12 (2 options):
  - 14a: 8 km of raised Trawal canal section
  - 14b: 8 km of raised and lined Trawal canal section

- Option 15: Syphon and Right-bank canal to replace Trawal canal section and supply Options 9, 10, 11 and 12

Zone 5 - Olifants River from Klawer to the Coast

- Option 16: Klawer
- Option 17: Aties-Karoo
- Option 18, Ebenhaeser New
- Option 19: Lutzville 2
- Option 20: Use of Spare Capacity in the Naauwkoes canal section – Klawer (2 options):
  - 20a: Full Klawer area with portion of Naauwkoes canal section lined
  - 20b: Scaled-down (818 ha) Klawer area with no canal lining
- Option 21: Use of Spare Capacity in the Naauwkoes/Vredendal canal sections – Coastal 1 (4 options):
  - 21a: Full Coastal 1 area with lined Naauwkoes/Vredendal canal sections
  - 21b: Scaled-down (818 ha) Coastal 1 area with no canal lining
  - 21c: Scaled-down (818 ha) Coastal 1 area – Post Right-bank Canal
  - 21d: Scaled-down 2 (450 ha) Coastal 1 area with no canal lining
- Option 22: Use of Spare Capacity in the Naauwkoes/Vredendal canal sections – Ebenhaeser restitution farms and augmentation:
  - 22a: Pre-Right Bank canal
  - 22b: Post Right-bank Canal

Zones 4 and 5: LORGWS (Bulshoek) Canal

- Option 23: Replace all or sections of LORGWS canal with a pipeline with increased capacity
- Option 24: Increase capacity of LORGWS canal and other betterments

The option locations are shown in **Figure 8.1**, **Figure 8.2**, **Figure 8.3**, and **Figure 8.4**.

Figure 8.1 | Jan Dissels and Clanwilliam Dam options

Figure 8.2 | Supply to JRIS, Graafwater, Lamberts Bay and Elands Bay

Figure 8.3 | Zypherfontein 1 and 2, Trawal and Melkboom areas

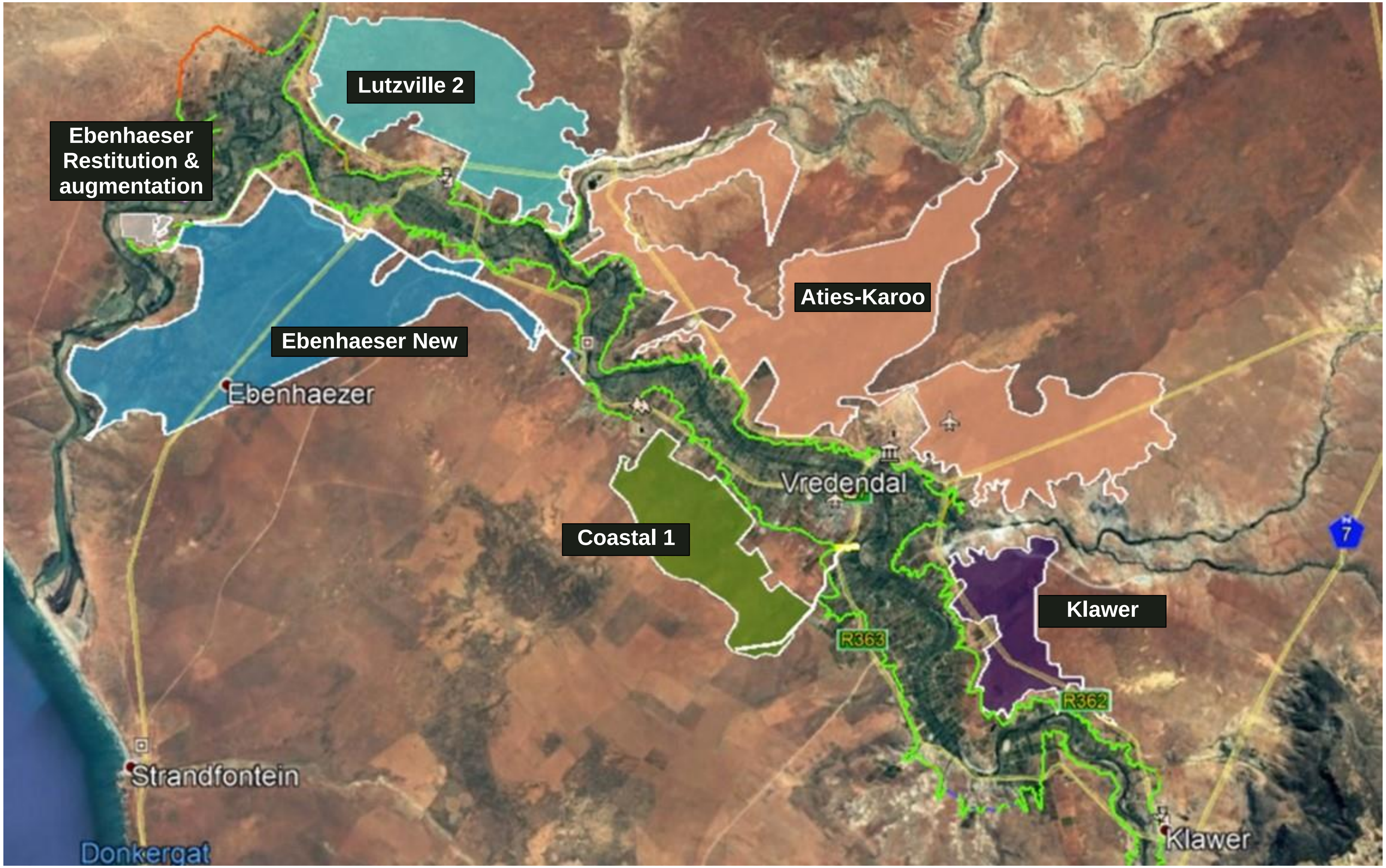

Figure 8.4 │ Lower Olifants irrigable areas

9 Evaluation Process

9.1 Technical Evaluation

9.1.1 Irrigation water requirements

The factors considered for the calculation of irrigation water requirements were the following:

- Average updated zone crop water requirements,
- Water use authorisations for currently-irrigated crop fields, where this has been considered,
- Crop rotation (only where applicable such as the JRIS schemes),
- Leaching requirements,
- River conveyance losses,
- Infrastructure conveyance losses, and
- Monthly peaking irrigation factors (January), for infrastructure design.

9.1.2 Conveyance losses

River conveyance losses in the Olifants and Jakkals rivers were estimated by river reach, as indicated in **Table 9.1**.

Table 9.1 | Cumulative Conveyance Losses in the Olifants River

River section	% River Losses at abstraction point
Zone 2: Olifants River, Clanwilliam Dam to Bulshoek Weir	5%
Zone 3: Jakkals River	50%
Zone 4: Olifants River, Bulshoek Weir to Verdeling	29%
Zone 5: Olifants River, Verdeling to Klawer	33%
Zone 5: Olifants River, Klawer to Spruitdrift	42%
Zone 5: Olifants River, Spruitdrift to EB de Waal	45%
Zone 5: Olifants River, EB de Waal to Lutzville	51%

Conveyance infrastructure losses were estimated as follows:

- Short pipelines: 0%,
- Longer pipelines: 3%,
- Lined concrete canal: 15%,
- Existing Lower Olifants canal: 22% over the full length,
- Existing Clanwilliam canal: 30% over the full length.

9.1.3 Privately-owned land

Purchasing of privately-owned land was estimated from recent land sales in the study area.

9.1.4 Reconnaissance-level design

The following criteria were used for technical evaluation of identified options:

Bulk pipelines and pump stations were sized to cater for peak monthly water requirements. They were designed to pump to farm dams which would be typically placed at the highest point on the irrigation development area, to allow for on-farm irrigation by gravity.

Dam sizes were based on topographical variation (either lined kraal (square or rectangular) dams or U-shaped dams) and three hours of pumping were allowed for storage when pumping from Clanwilliam Dam or Bulshoek Weir. Allowance for 12 hours of balancing storage (next to the canal) was allowed for pumping from the existing Lower Olifants canal. When pumping from the Olifants River, 24 hours of storage was allowed. When pumping from canals, 96 hours of storage was allowed.

Balancing reservoirs were provided between rising main and gravity main pipelines to allow for some operational flexibility.

For **new canals**, a bench/road wide enough to accommodate the canal has been allowed, with side slopes of 1V : 1.5H. Allowance was made for 100 mm thick mesh reinforced concrete lining. A large replacement canal, such as the main section of the Lower Olifants canal (Trawal section) would have a gradient of 1: 4 000.

For **canal raising and lining** of existing sections of the Lower Olifants canal, construction was envisaged as per the sketch below (**Figure 9.1**) to calculate the volume of new concrete required. End formwork would be required. For the canal lining, the existing canal would be used as formwork for the 100 mm thick mesh reinforced concrete lining, which may result in further incremental raising to compensate for the reduced cross-section. Due to the steepness of the existing canal walls formwork would be required on either side. The lining would probably be cast in 3 to 4 m long panels, and while they could follow the irregular plan alignment to some extent, they would probably span across in places resulting in a thicker lining with consequently marginally extra concrete. A by-pass system to provide access for relining of a reasonable length of canal was allowed for.

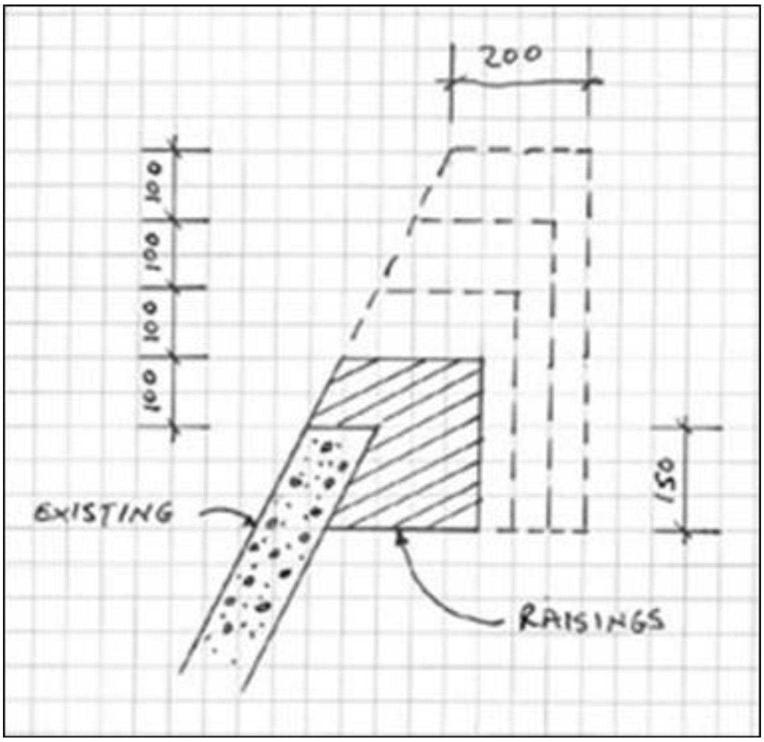

Figure 9.1 | Raising of existing canals

Syphons have been allowed for several options, mostly for crossing the Olifants or Doring rivers. The cost of syphons has been assumed to be twice the cost of the pipeline of similar size.

River abstraction works have not been costed. It is not expected that there will be a problem with sediment below Clanwilliam Dam, and abstraction works may be simplistic, although this would need to be confirmed.

In-house spreadsheets were developed and used for reconnaissance-level design and costing.

9.1.5 Costing

Typical infrastructure costs were developed. Certain capital costs were based on costs available from previous studies or costs of similar sized infrastructure. Costs were escalated to be representative of the base year costs (2018) if such costs were not too dated. In some cases, capital costs have been estimated from basic principles, as some options have not been evaluated before or the costs were too outdated.

Net present values (NPVs) were determined for both capital and operating costs, over scheme lifetimes.

The unit reference value URV is a means of comparing different options on an equal basis by calculating an economic cost per unit (here R/m^3) for each option. The URV calculation is based on the same assumptions in terms of evaluation period, equipment replacement periods, electricity costs etc. It provides a *comparative indication of the unit cost of water* supplied from the scheme over the scheme lifetime using an economic discount rate of 8% p.a. A URV refers to the economic cost per unit, i.e. per cubic metre of water to be used. Multiplication factors were added to allow for additional unforeseen costs. An evaluation period of 32 years (2018 to 2045) was selected for all water augmentation schemes, for determination of URV.

Where options had both betterment and development cost components, the water requirements, URVs and NPVs were determined based on the development costs and development water requirements (excluding losses) of such options.

For the sake of comparison of options, URVs were classed in three categories, at 2018 cost levels, as follows:

- Low: Below R 1.60/m^3
- Medium: Between R 1.60/m^3 and R 2.50/m^3
- High: Greater than R 2.50/m^3.

Implementation programmes for options were estimated, to ascertain practical duration (number of years) until first water can be delivered from irrigation schemes.

As some of the options include betterment components, it was necessary to split capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators). This applies to options that include the lining of canal sections, and to the new right-bank canal. The split between new irrigation development and betterment costs should be revisited during the feasibility design, where relevant. If the betterment works are to be implemented earlier than they would have been, without the link to the new works, then an increased portion may have to be attributed to the new works initiative to make it attractive. On the other hand, linking betterment works with the new works may represent a once-off opportunity to have the work undertaken in an economic way.

It should be noted that some of the irrigable areas evaluated as options are quite large areas, with the extent of pumping differing by close to 100 m in height between the lowest and highest elevations of the irrigable areas. Most of the irrigable areas assessed for the various options could be divided into the higher and lower lying areas as sub-options, which would have differing URVs if assessed as separate options. The evaluation in this report produces average URVs for the options. This could be addressed further in the feasibility design, as a form of phasing.

9.2 Ecological Considerations

A desktop-level assessment of the environmental and socio-economic impacts of each option was carried out. Municipal, provincial and national maps showing threatened ecosystems, critical biodiversity areas, ecological support areas, other natural areas, heritage sites, protected areas, NPAES areas and NFEPA wetlands / rivers were used to identify sensitive areas within the study area and the proposed development areas. Depending on the sensitivity of any of the proposed intervention areas, recommendations were provided which are aligned with the NEMA mitigation hierarchy (**Figure 9.2**). Potential impacts related to the various development options are listed in each option's description, as well as their predicted severity and mitigation measures. Specific impacts include inter-basin transfer of raw water, which has environmental implications (water quality, transfer of biota between catchments etc.), impacts on environmentally sensitive areas and social infrastructure, as well as impacts of construction on the environment.

Figure 9.2 | NEMA Mitigation Hierarchy

9.3 Socio-economic considerations

Specific impacts include impacts on social infrastructure, as well as impacts of construction on communities in the area. Positive impacts are e.g. increased water supply to rural communities and small towns lacking treated water supply, and socio-economic benefits arising from high-value irrigation development.

Options that are located close to towns, that provide an opportunity for small plots to be developed (possibly 7.5 ha), for residents of such towns, have been identified. This would primarily make provision for Subsistence Household Producers, which are producers that produce for household consumption and markets surplus production or Smallholder Producers, that produce for household consumption and markets. Farming is therefore consciously undertaken in order to meet the needs of the household and derive a source of income. These are usually the new entrants aspiring to produce for markets at a profit with a maximum turnover of up to R5 million per annum.

Water supply to farms to be transferred to beneficiaries of the Ebenhaeser restitution process has been considered, as well as augmentation of supply to the existing Ebenhaeser community scheme.

9.4 Water Quality Considerations

The irrigation water requirements are affected by the quality of the irrigation water. Two aspects were considered: the leaching requirement, and the storage of good quality water needed to blend with poor quality water abstracted from the lower Olifants River during the dry summer months.

9.4.1 Leaching requirements

The leaching requirement refers to the volume of additional water that needs to be applied to crops to prevent the build-up of salts in the soil. This volume is a function of the salt concentration of the irrigation water, and the salinity of the soils being irrigated. Salinity in Clanwilliam Dam and Bulshoek Weir is low, and the water is in an Ideal category for irrigation.

If the source of irrigation water being used originates from Clanwilliam Dam or its canal, the Olifants River between Clanwilliam Dam and Bulshoek Weir, or the canal from Bulshoek Weir, then an additional 3% needs to be added to the water requirement to prevent salinization of the irrigated soils.

If the source of irrigation water is water abstracted directly from the Olifants River downstream of Bulshoek Weir, then the Electrical Conductivity for irrigation water (ECiw) at the abstraction point needs to be estimated, and the leaching requirement needs to be calculated. The higher the salt concentration in the irrigation water, the higher estimated water requirement to leach salts from the irrigated soils.

The soils in some of the new areas identified for future irrigation development are naturally saline and additional leaching water needs to be applied for the first 3-5 years to leach the salts from the soils. Thereafter, the normal leaching requirement needs to be applied as described above. However, the infrastructure should be designed to accommodate the additional water during the initial 3-5 years. Therefore, for new greenfield irrigation areas, the soil sub-groups in the new area was determined from the 2018 soils surveys, and the recommended leaching requirement for the dominant soil form was looked up (**Table 9.2**).

Table 9.2 │ Recommended chemical amelioration measures and leaching requirements for soil sub-groups in the lower Olifants River area

Soil sub-group	Chemical amelioration required	Leaching requirement (%)	Soil sub-group	Chemical amelioration required	Leaching requirement (%)
A1	None	0	H1	Recommended	10
A2	None	0	H1 + G2	None	0
A3	None	0	H2	Recommended	10
A4	None	0	I1	None	0
A5	Essential	20	I1 + B1	None	0
A6	Recommended	10	I1 + B3	None	0
A7	None	0	I1 + I2	Recommended	10
A8	None	0	I1 + L5	None	0
B1	None	0	I2	Recommended	10
B2	None	0	I3	Essential	20
B3	None	0	I3 + E2	Essential	20
B3 + I1	None	0	I3 + I4	None	0
B4	None	0	I3 + L3	None	0
C1	None	0	I4	Essential	20
C1 + G1	None	0	I5	Essential	20
C1 + J1	None	0	J1	None	0
C2	None	0	J2	None	0
C3	None	0	J2 + J1	None	0
D1	None	0	J3	None	0
D2	Recommended	10	J4	Essential	20
D3	Essential	20	K1	None	0
D4	Essential	20	K1 + F1	Essential	20
D5	Essential	20	K2	None	0
D6	Essential	20	K3	None	0
E1	Essential	20	L1	None	0
E2	Essential	20	L2	None	0
E2 + F1	Essential	20	L3	None	0
E3	Recommended	10	L4	None	0
F1	Essential	20	L5	None	0
G1	None	0	L6	None	0
G2	None	0			

9.4.2 Storage requirement for good quality water for blending

The canal from Bulshoek Weir is running at almost full capacity. Because of this, good quality irrigation water may need to be released down the lower Olifants River during the irrigation season to meet the requirements of new schemes. However, currently irrigation return flows during the summer months results in a gradual increase in salinity downstream of Bulshoek Weir to the extent that the quality of water at Lutzville is in an Unacceptable category (> 1440 mg/l TDS) for most of the dry summer season. One strategy to compensate for the increase in salinity along the length of the lower Olifants River is to abstract good quality water from the river during the high flow winter months, store it, and then blend it with the poor-quality water abstracted from the lower Olifants River to meet a specified quality of irrigation water.

A mass balance approach was used to calculate the volume of good quality water that needs to be stored to dilute the poor-quality water abstracted from the river. The return flow salt loads (kg/ha/day) were calculated from existing irrigation areas using historical salt concentrations recorded along the river, and the size of the irrigation area contributing to the loads. The total dissolved solids (TDS) concentration at a specific location was then estimated using a mass balance approach which considered the average salt load released from Bulshoek Weir (volume and TDS concentration), the average summer salt load from the Doring River, and the salt loads from existing irrigation areas between Bulshoek Weir and the abstraction point. The volume of good quality water that should be stored to blend with the abstracted water to a minimum average TDS concentration of 800 mg/l (Tolerable category) was then calculated.

10 Zone 2, Clanwilliam Dam and Jan Dissels River

This Chapter describes an option relating to abstraction directly from the Clanwilliam Dam, as well as an option in the Jan Dissels River catchment.

10.1 Option 1: Jan Dissels

10.1.1 Layout of Option 1: Jan Dissels

The option layout is shown in **Figure 10.1**.

10.1.2 Description of Option 1: Jan Dissels

The potential irrigable area, located south-east of Clanwilliam town in the Jan Dissels River valley has been reduced to 148 ha, following environmental screening. This option consists of a smaller greenfield area as well as an area of existing irrigation. Existing crop fields are in the identified area, with an existing scheduled water allocation.

Irrigators can pump water directly from the lake of the raised Clanwilliam Dam, although the abstraction point will be affected by the rise/fall of the water level.

The option involves the construction of a ±0.6 km long, 315 mm diameter uPVC rising main from the pump station located at Clanwilliam Dam to a small balancing reservoir. The pumping head from the dam to the reservoir is 94 m. From the small reservoir, water will be supplied by gravity via a 3,8 km long, 250 mm diameter uPVC pipeline to the farm dam located on the land at the other side of the Jan Dissels River (right bank). A very short pipeline will branch to a small farm dam on the land located closest to the dam. The combined farm dam capacity is 467 m^3. The cost of the abstraction works is expected to be minimal and has not been allowed for in the comparative cost.

There is potential for smallholder plots of 7.5 ha, considering the proximity of the area to Clanwilliam town and existing markets. The identified land is government-owned.

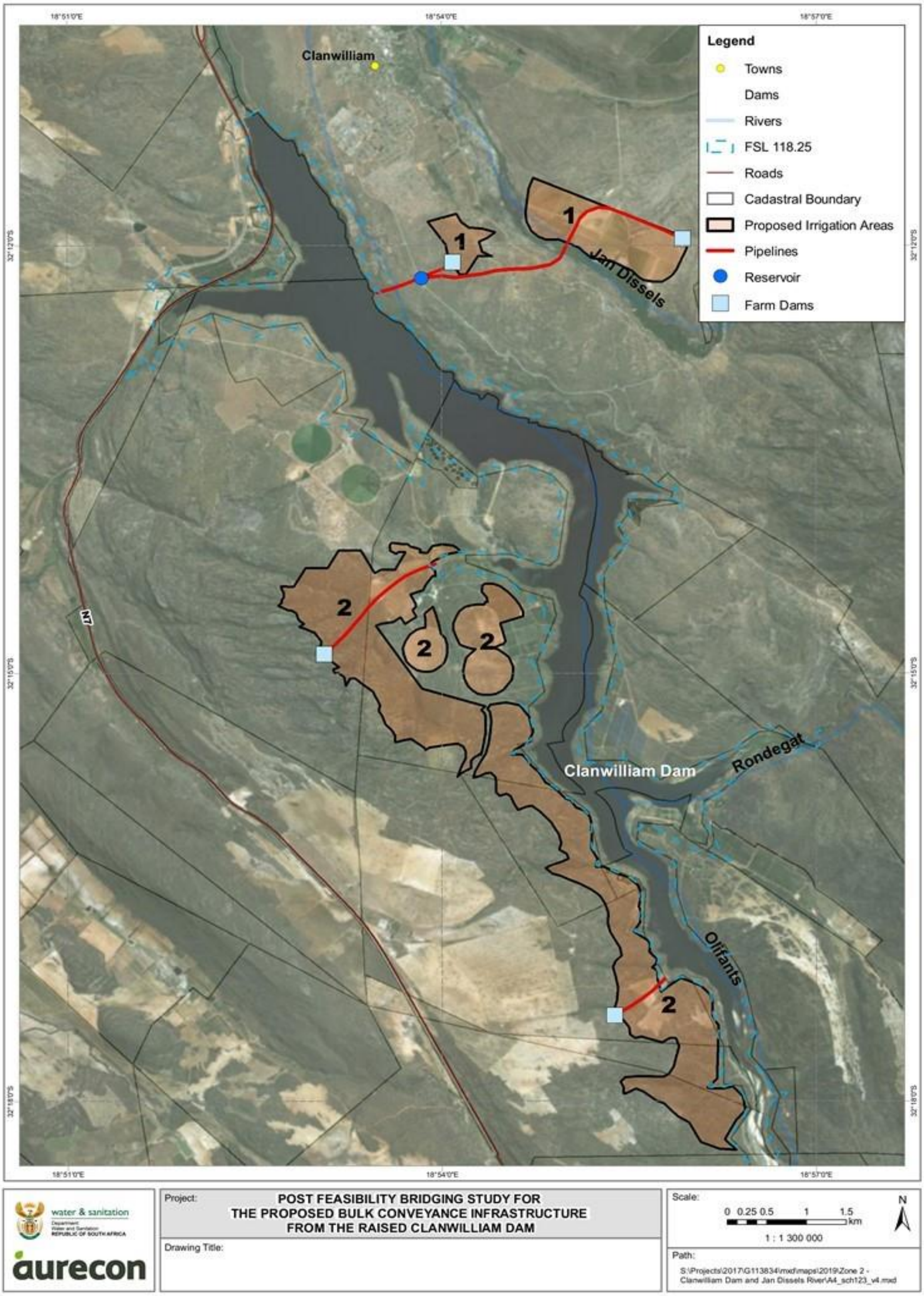

Figure 10.1 | Layout of Options in Zone 2: Clanwilliam Dam and Jan Dissels River

10.1.3 Net Water Requirements and Losses

The water requirement for the 148 ha is 1.36 million m^3/a. Conveyance losses will be minimal (short pipeline).

The current water allocation is 0.49 million m^3/a, and the incremental water requirement is 0.87 million m^3/a.

10.1.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

10.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 10.1**. The URV for this option is given in **Table 10.2**.

Table 10.1 | Option 1: Jan Dissels Comparative Capital Costs in million Rand

Pipeline	Pump station	Balancing Reservoir	Farm dam	Purchase of land	Prof. design & support	Total Cost
7.14	4.85	0.06	0.03	No Cost	1.81	13.89

Table 10.2 | Option 1: Jan Dissels URV in R/m³

Item	Discount Rate 8%
Total comparative capital cost (R million)	13.89
Annual operating cost (R million/annum)	0.59
NPV Cost (R million)	23.14
Unit Reference Value (R/m³)	1.47

10.1.6 Ecological Impact

Sensitivity: **Medium:** Small ESA 1 and ESA 2 corridors occur within the natural areas around the pivot irrigation fields of JD 3. The JD1 area is mapped as an ESA 1. The objective of this ESA 1 area is to maintain the area in a functional, near-natural state. Some habitat loss is acceptable, provided the underlying biodiversity objectives and ecological functioning are not compromised. Reasons for environmental sensitivity include ecological processes, vegetation types, threatened vertebrates, water resource and wetland protection and upland-lowland interface.

Recommendation: The Jan Dissels River flows to the south of the irrigation fields and it would be advisable to limit development to above the 1:100-year floodline of the river. The proposed site would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity. Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist). The site may require biodiversity offsets if residual impacts are significant. It should be highlighted that sections of the site, close to watercourses, should not be replanted in future where cultivation may pose a threat to the water resource and its function (as indicated by the NWA, CARA and NEMA).

10.1.7 Summary of Option 1: Jan Dissels

The potential irrigation area has been significantly reduced by environmental concerns, which changed from high to medium sensitivity when the CBA and NPAES areas were avoided. The scheme has a good location and a low URV. There is no water quality concern and water losses are insignificant (short pipeline). There is potential for 7.5 ha plots, as it is located close to Clanwilliam town. A potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

10.2 Option 2: Abstraction from Clanwilliam Dam

10.2.1 Layout of Option 2: Clanwilliam

The option layout is shown in **Figure 10.1**.

10.2.2 Description of Option 2: Clanwilliam

The areas identified are located very close to the Clanwilliam Dam on the western side. Irrigators can pump water directly from the lake of the Clanwilliam Dam, although abstraction points will be affected by the rise/fall of the water level. The farmable area is 549 ha.

There are some existing crop fields located in the identified area, with an existing scheduled water allocation.

This option involves the construction of the following infrasytructure at two abstraction points:

- A ±1.9 km long, 400 mm diameter steel rising main from the pump station located at the Olifants River to a small farm dam, with a pumping head of 118 m, and
- A ±0.7 km long, 400 mm diameter steel rising main from the pump station located at the Olifants River to a small farm dam, with a pumping head of 72 m.

The cost of abstraction works is expected to be minimal and has not been allowed for in the comparative cost. The total farm dam storage capacity is 1 733 m^3.

10.2.3 Net Water Requirements and Losses

The water requirement for the 549 ha development is 5.06 million m^3/a. Minimal conveyance losses are expected (short pipeline).

The existing water use authorisation is 0.29 million m^3/a.

The incremental water requirement is 4.77 million m^3/a.

10.2.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

10.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 10.3**. The URV for this option is given in **Table 10.4**.

Table 10.3 | Option 2: Clanwilliam Comparative Capital Cost in million Rands

Pipeline	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
4.54	18.57	0.13	11.58	3.47	38.28

Table 10.4 | Option 2: Clanwilliam URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	38.28
Annual operating cost (R million/annum)	2.20
NPV Cost (R million)	73.67
Unit Reference Value (R/m^3)	1.26

10.2.6 Ecological Impact

Sensitivity: **Medium:** The site consists of mostly undeveloped land with some agricultural development in the northern and southern sections. The rest of the site is mapped as ESA 1 with small ESA 2 corridors near watercourses in the south and north of the site. A small wetland area exists to the north outside of the site boundaries and should be buffered by a specialist. The most northern part of the site falls within a climate change adaptation corridor and should be avoided for new developments. The north western section also falls within an upland-lowland interface, which supports important ecological functions.

Recommendations: Avoid the upland-lowland interface and climate change adaptation corridor areas in the north and north west of the site as far as possible. The proposed site would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity. Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist). The site may require biodiversity offsets if residual impacts are significant.

10.2.7 Summary of Option 2: Clanwilliam

Option 2 has a good location and a low URV. There are no water quality concerns and insignificant water losses (short pipelines). There is potential for 7.5 ha plots, as it is located close to Clanwilliam town. Potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

11 Zone 2, Clanwilliam Dam to Bulshoek Weir

This Chapter describes the options for abstraction from the Olifants River between Clanwilliam Dam and Bulshoek Weir.

Users in the area between Clanwilliam Dam and Bulshoek Weir have the advantage of not being reliant on bulk water distribution infrastructure and only require limited, if any, balancing capacity. This portion of the river is already used to convey releases from Clanwilliam Dam to Bulshoek Weir and the downstream canals. Water can be pumped directly from the Olifants River for irrigation.

11.1 Option 3: Transfer of Lower Jan Dissels River Scheduled Allocations to the Olifants River

11.1.1 Layout of Option 3: Transfer of Allocations

The option layout is shown in **Figure 11.1**.

11.1.2 Description of Option 3: Transfer Allocations

The Jan Dissels River Compulsory Licensing Study recommended moving some or all the existing allocations of irrigators in the lower Jan Dissels River to either the Olifants River or to the Clanwilliam Canal. This proposal was made to improve the ecological condition of the lower section of the Jan Dissels River. This recommendation is also contained in Section 4.2 of the ‘Task 5’ *Existing Infrastructure and Current Agricultural Development Report* of this study. It is an opportunity for three water users in the lowest stretch of the Jan Dissels River to shift their abstractions to the Olifants River (Clanwilliam Canal fully used), thereby increasing low flows to improve the currently very poor ecological status of this stretch of the Jan Dissels River.

While this option is not focussed on ‘new’ irrigation development, it has previously been strongly recommended.

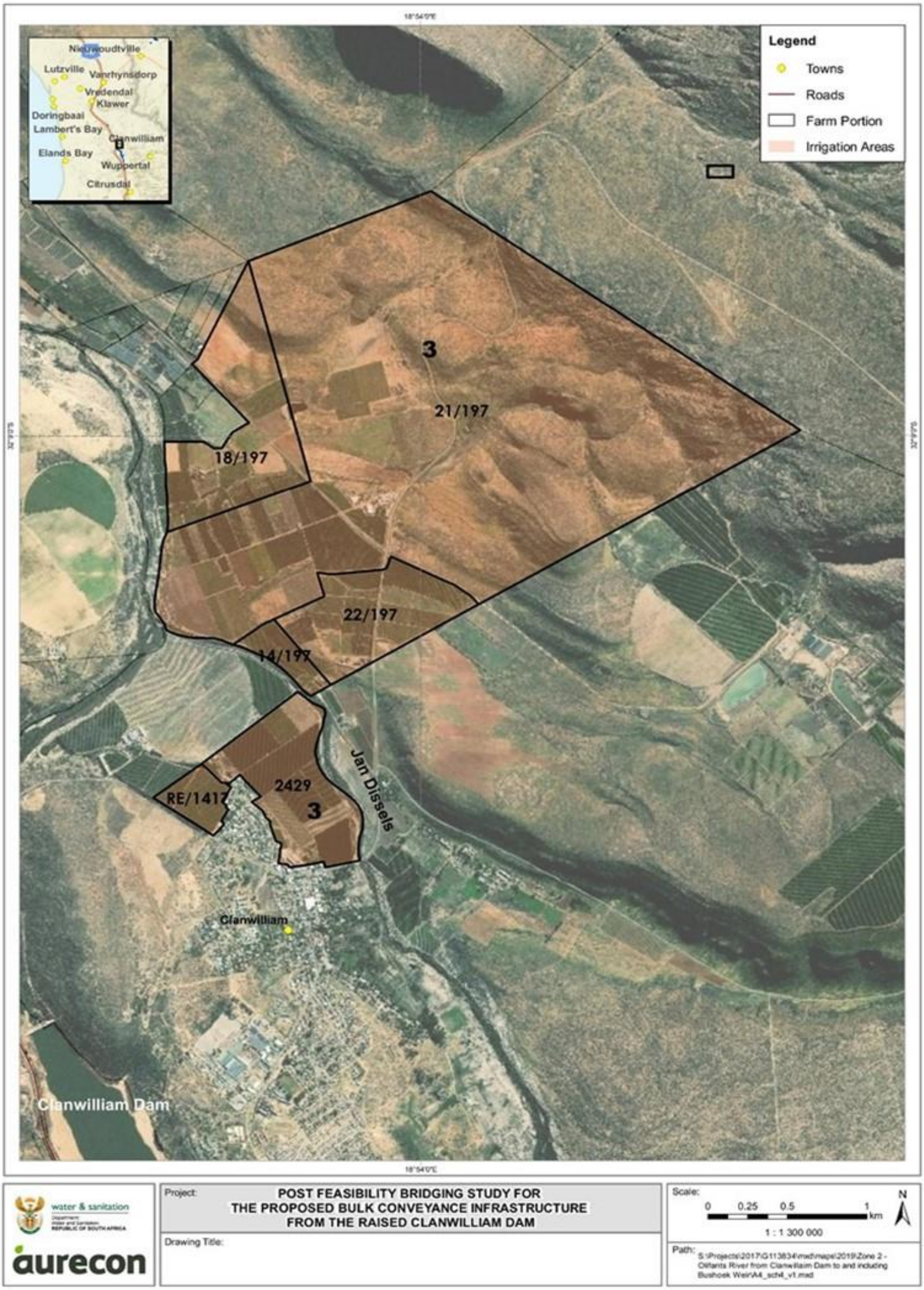

Figure 11.1 | Layout of Option 3: Transfer of Jan Dissels River Allocations

11.1.3 Net Water Requirements and Losses

The existing total water allocations of the three (3) farmers are 1.0 million m^3/a.

There are no water losses associated with this option.

11.1.4 Water Quality

This option has no water quality implication.

11.1.5 Cost and Unit Reference Value

This option has no cost implication.

11.1.6 Ecological Impact

This option is expected to have a positive ecological impact. It will relieve pressure on the lower Jan Dissels River in summer and thereby contribute to the improvement of the ecological condition of the lower Jan Dissels River.

11.1.7 Summary of Option 3: Transfer Allocations

This option is expected to relieve pressure on the lower Jan Dissels River in summer and to contribute to the improvement of the ecological condition of the lower Jan Dissels River.

This allocation will need to be made from the 25% portion of the additional yield from the raised Clanwilliam Dam for improving the assurance of supply of existing users.

The transfer of water allocations to the Olifants River will increase the low summer flows and thereby improve the ecological status of the bottom stretch of the Jan Dissels River, which is currently very poor. This option has no cost or water quality implications.

11.2 Option 4: Pumping from Olifants River - Zandrug

11.2.1 Layout of Option 4: Zandrug

The option layout is shown in **Figure 11.2**.

11.2.2 Description of Option 4: Zandrug

The southern portion of this area is located about 3 km from Clanwilliam town. There is potential for smallholder plots of 7.5 ha, considering the proximity of the area to Clanwilliam town and existing markets. Water would be pumped from the Olifants River to farm dams, with irrigation under gravity. The irrigable area is 1 219 ha. The land is privately-owned.

There are some existing crop fields located in the identified area, with an existing scheduled allocation for water.

This option involves the construction of the following bulk water infrastructure at three abstraction points:

- A ±1.7 km long, 500 mm diameter steel rising main from a pump station located at the Olifants River. The pumping head from the river to the farm dam is 74 m,
- A ±1.5 km long, 500 mm diameter steel rising main from a pump station located at the Olifants River. The pumping head from the river to the farm dam is 105 m, and
- A ±2.4 km long, 500 mm diameter steel rising main from a pump station located at the Olifants River. The pumping head from the river to the farm dam is 113 m.

11.2.3 Net Water Requirements and Losses

The water requirement for the 1 219 ha irrigable area is 11.24 million m^3/a.

Limited river losses of 0.56 million m^3/a (5%) are expected as the scheme is located close to Clanwilliam Dam. Infrastructure conveyance losses will be negligible (short pipelines).

The existing water allocation is 2.55 million m^3/a.

The incremental water requirement is 8.69 million m^3/a.

11.2.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

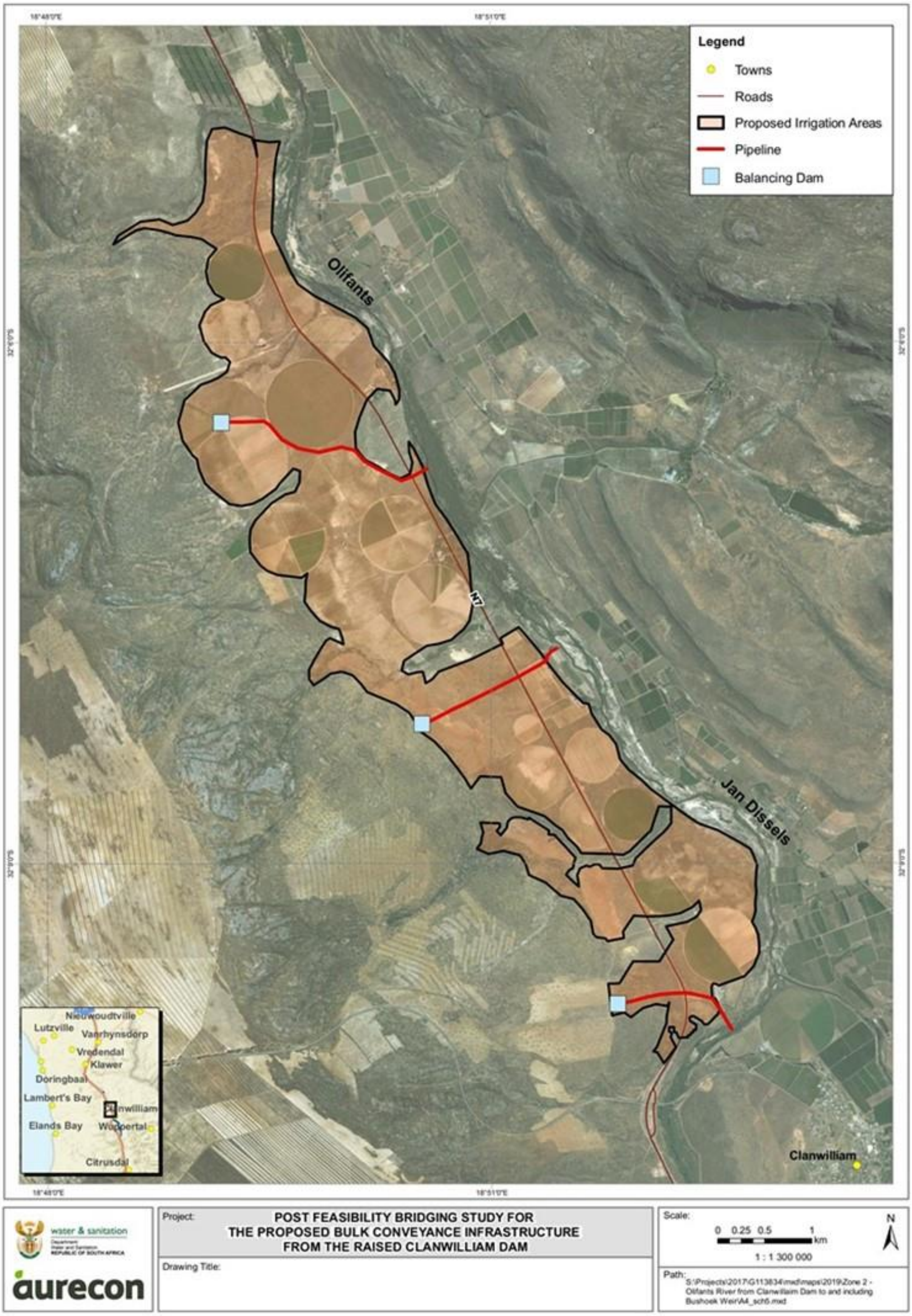

Figure 11.2 | Layout of Option 4: Zandrug

11.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 11.1**. The URV for this option is given in **Table 12.2 11.2**.

Table 11.1 | Option 4: Zandrug Comparative Capital Cost in million Rands

Pipelines	Pump stations	Farm dams	Purchase of land	Prof. design & support	Total Cost
10.99	37.21	2.26	28.94	5.22	84.62

Table 11.2 | Option 4: Zandrug URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	84.62
Annual operating cost (R million/annum)	3.51
NPV Cost (R million)	144.08
Unit Reference Value (R/m^3)	1.11

11.2.6 Ecological Impact

Sensitivity: High: All remaining natural areas within the proposed site are mapped as ESA 1 and CBA 1, with all watercourse corridors mapped as ESA 2. Reasons for environmental sensitivity include threatened vertebrates, water resource and wetland protection and upland-lowland interface (southern half of the study area). The remaining natural vegetation across the bottom third of the site is mapped as Leipoldtville Sand Fynbos, which is classified as an Endangered ecosystem.

Recommendation: All CBA 1 and natural vegetation areas should be avoided, and the ESA 1 and ESA 2 areas would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity. Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist). The site may require biodiversity offsets if residual impacts are significant. All development should also be located outside of the 1:100-year floodlines of the Olifants and Jan Dissels rivers and other tributaries in the area.

11.2.7 Summary of Option 4: Zandrug

The scheme has a good location and a low URV. Environmental concerns are Moderate. There are no water quality concerns and water losses are very low. There is potential for 7.5 ha plots, as a portion of the area is located close to Clanwilliam town.

11.3 Option 5: Abstraction from Bulshoek Weir

11.3.1 Layout of Option 5: Bulshoek

The option layout is shown in **Figure 11.3**.

11.3.2 Description of Option 5: Bulshoek

For this option, irrigators could pump water directly from the lake of the Bulshoek Weir, although, abstraction points will be affected by the rise/fall of the water level. The current operating rule of Bulshoek Weir is that the water level is kept at about 60% of capacity, to limit the leaks from the weir. The irrigable area for this option is 354 ha.

There are existing crop fields located in the identified area, with an existing allocation.

This option will involve the construction of infrastructure for three abstraction points as follows:

- A ±1.7 km long, 300 mm diameter steel/uPVC rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 144 m,
- A ±1.2 km long, 300 mm diameter steel/uPVC rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 122 m,
- A ±1.0 km long, 200 mm diameter uPVC rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 70 m.

11.3.3 Net Water Requirements and Losses

The water requirement for the 354 ha irrigable area is 3.26 million m^3/a.

Limited river losses of 0.16 million m^3/a (5%) are expected. Infrastructure conveyance losses will be negligible (short pipelines).

The existing water allocation is 0.33 million m^3/a.

The incremental water requirement is 2.93 million m^3/a.

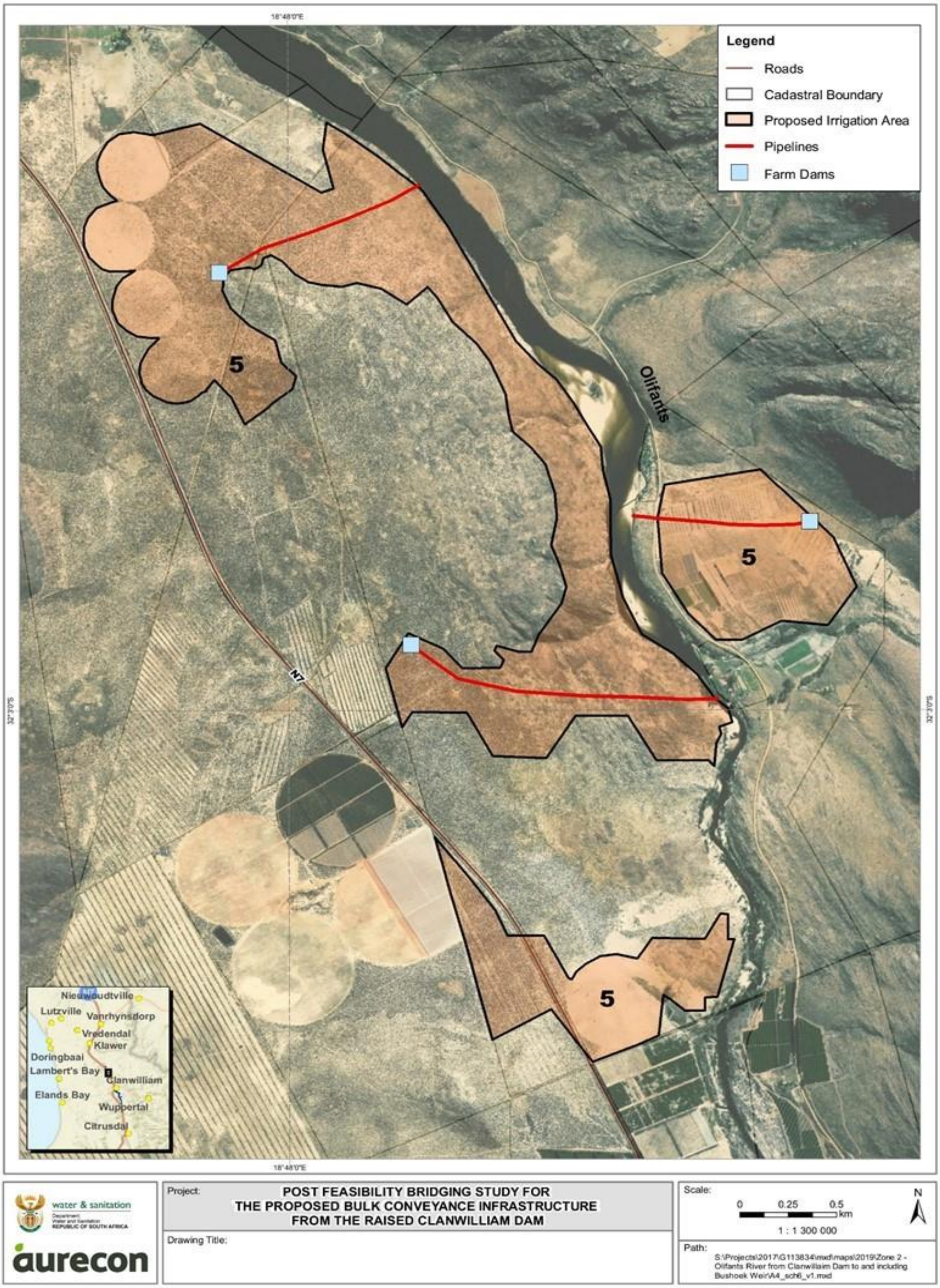

Figure 11.3 │ Layout of Option 5: Bulshoek

11.3.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

11.3.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 11.3**. The URV for this option is given in **Table 11.4**.

Table 11.3 | Option 5: Bulshoek Comparative Capital Costs in million Rand

Pipeline	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
4.96	13.77	0.08	11.93	2.53	33.27

Table 11.4 | Option 5: Bulshoek Option URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	33.27
Annual operating cost (R million/annum)	1.49
NPV Cost (R million)	57.58
Unit Reference Value (R/m^3)	1.52

11.3.6 Ecological Impact

Sensitivity: **Medium:** All watercourse corridors within the proposed site are mapped as ESA 1 for watercourse protection as well as a very small section in the most western section across an existing pivot irrigation field. There are no CBAs in this area, but the area is mapped as an upland-lowland interface across the western half of the entire site. There is also a wetland to the south, outside of the boundaries of the study area and a buffer should be provided for this by a specialist. The remaining natural vegetation across the western boundaries, as well as the most southern portion of the site, is mapped as Leipoldtville Sand Fynbos, which is classified as an 'Endangered' ecosystem.

Recommendation: The proposed site would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity, and to confirm the areas to be excluded as an upland-lowland interface and those containing endangered vegetation or species of concern. Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist). The remaining sections may require biodiversity offsets if residual impacts are significant. The development should also be limited to outside the 1:100-year floodline of the river.

11.3.7 Summary of Option 5: Bulshoek

This option has a good location and a low URV, with low environmental concerns. There are no water quality concerns and water losses are low.

12 Zone 3, Options Located Outside the Olifants River Valley

Chapter 12 describes the options that are not located in the Olifants River valley. Pumping water to these schemes with electricity from a new, enlarged hydropower plant at the raised Clanwilliam Dam is a possible opportunity for the usage of power to be generated by the new hydropower plant.

12.1 Option 6a/b: Jakkals River Irrigation Scheme (JRIS) and Graafwater

12.1.1 Layout of Option 6a/6b: JRIS

The layout for option 6a and option 6b is shown in **Figure 12.1**.

The two options that have been assessed supply water via alternative routes. The Jakkals Vlei irrigation option was identified by an interest group. A secondary identified objective is to supply Graafwater with water for domestic use. This option is based on the Jakkals River Irrigation Scheme Project (JRIS), which was identified by the Sandveld Investment & Development Co. Ltd (SANID) Water. SANID Water identified four farms as possible irrigation areas. The four farms have an irrigable area of 3 187 ha.

12.1.2 Description of Option 6a: JRIS Pumping to the Jakkals River

SANID identified a scheme to pump water from the raised Clanwilliam Dam, with a pipeline along the N7 highway, branching off close to the raised dam, crossing mountains towards the Jakkals River, and running along the Jakkals River to the identified irrigation area. This was identified as a very expensive scheme (due to the pipeline), and a reduced-cost version of this proposed scheme was instead evaluated.

The option evaluated involves pumping water from the raised Clanwilliam Dam, releasing it in the Jakkals River outside of the Olifants River catchment, and abstracting it downstream from the Jakkals River, close to the identified irrigation area.

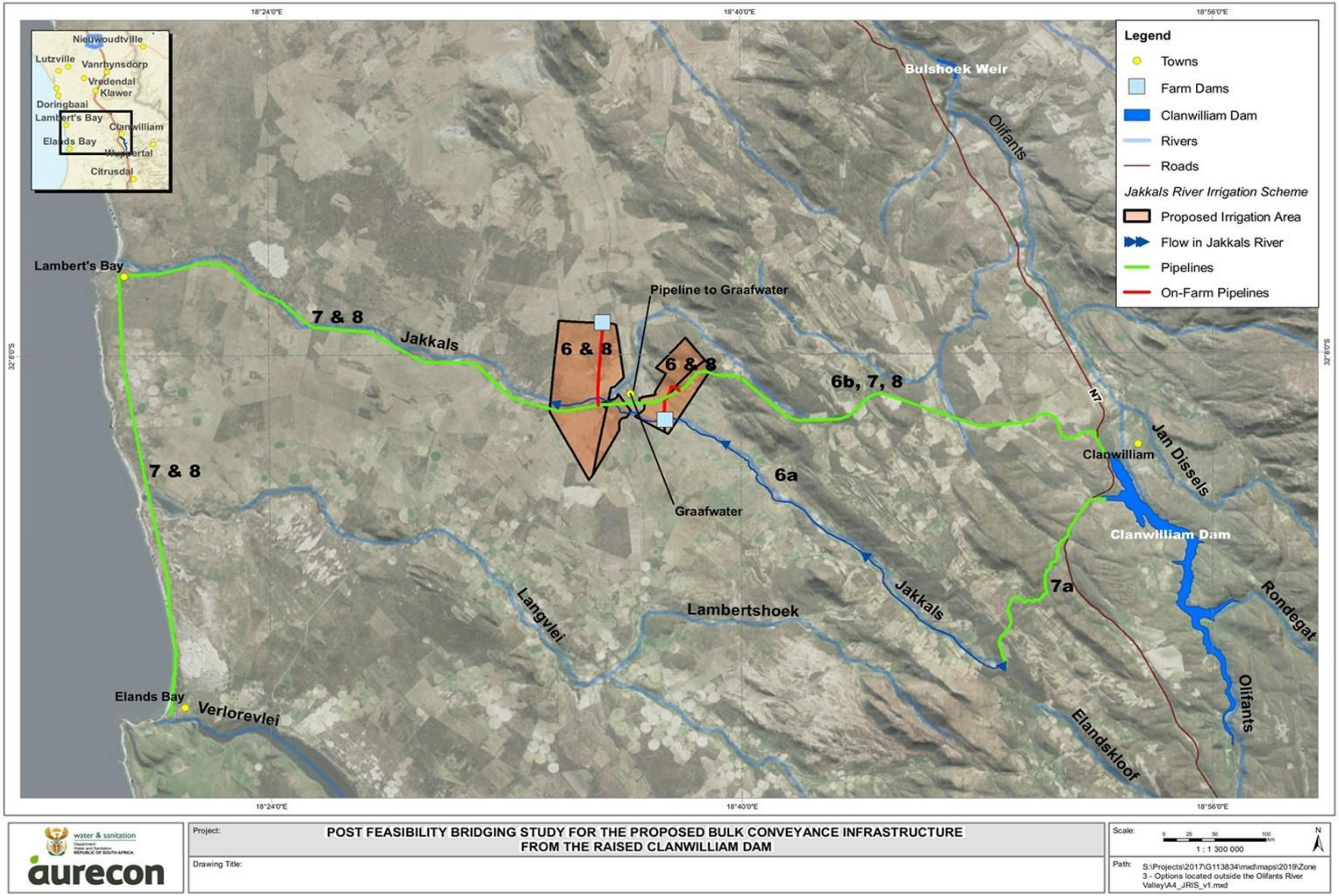

Figure 12.1 │ Layout of Zone 3 Options

Option 6a involves the construction of a ±12 km long, 600 mm diameter steel rising main from the Clanwilliam Dam to a small reservoir. The pipeline passes over a mountain range. The pumping head from the Clanwilliam Dam to the balancing reservoir is 532 m. A ±1.7 km long, 500 mm diameter steel gravity pipeline will deliver the transferred water to the Jakkals River. The water is then abstracted down-river from the Jakkals River for irrigation (water is pumped to farm dams) and for urban use by Graafwater.

12.1.3 Description of Option 6b: JRIS Direct pipeline

It is proposed for Option 6b that water will also be pumped from the raised Clanwilliam Dam, but the rising main will follow the R364 road to Graafwater. The rising main delivers water to a small reservoir, from where a gravity pipeline will supply a farm dam. A booster pump station may be needed to limit pressure in the pipeline.

This option involves the construction of a ±19.87 km long, 500 mm diameter steel rising main from the Clanwilliam Dam to a balancing reservoir. The pipeline passes over a mountain range. The pumping head from the Clanwilliam Dam to the balancing reservoir is 367 m. A gravity pipeline of 8.3 km long and 500 mm diameter then delivers the water to the JRIS and Graafwater.

12.1.4 Net Water Requirements and Losses

The water requirements for this scheme were calculated using a crop distribution of 100% potatoes, with a 40% rotation factor. Potatoes were considered as they are the dominant crop farmed in the area. Citrus was also considered for this scheme as there is evidence of citrus farming in the area. Citrus was however regarded as an unlikely option as citrus is not currently widely planted in the Jakkals Vlei/Graafwater area.

The water requirement for the Jakkals Vlei scheme was calculated as 10.27 million m^3/a for the 3 187 ha, for Options 6a and 6b.

Total water losses are 5.44 million m^3/a (53%) for Option 6a and 0.31 million m^3/a (3%) for Option 6b.

12.1.5 Water Quality

The quality of water abstracted from Clanwilliam Dam is in an Ideal category for irrigation. A leaching requirement of 3% has been added to the estimated irrigation water requirement to leach salts from the soil.

After discharge into the Jakkals River, the salinity of the water transferred from Clanwilliam Dam will probably increase moderately in a downstream direction. Only one water quality sample has been collected in the Jakkals River and that was in September 2002 at the farm Kleinfontein. This sample indicated that, at the start of the dry season, salinity (50 mS/m) was in an Acceptable category (25-75 mS/m). Land use in the Jakkals River catchment up to Graafwater is dominated by dry-land agriculture, which has less of an impact on dry-season salinity than return flows from irrigated agriculture. It is therefore estimated that salinity of the transferred water may increase moderately between the discharge point and Graafwater, but probably remain within an Acceptable category.

12.1.6 Cost and Unit Reference Value

The comparative capital costs for Option 6a (2018 prices, excluding VAT) are shown in **Table** 12.1. The URV for this option is given in **Table 12.2**.

Table 12.1 | Option 6a: JRIS Comparative Capital Costs in million Rand

Pipelines	Pump stations	Balancing Reservoir	Farm dams	Purchase of land	Prof. design & support	Total Cost
101.91	267.57	44.01	2.07	67.28	61.54	544.38

Table 12.2 | Option 6a: JRIS URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	544.38
Annual operating cost (R million/annum)	44.12
NPV Cost (R million)	1 196.07
Unit Reference Value (R/m^3)	10.05

The comparative capital costs for Option 6b (2018 prices, excluding VAT) are shown in **Table** 12.3. The URV for this option is given in **Table 12.4**.

Table 12.3 | Option 6b: JRIS Comparative Capital Costs in million Rand

Pipelines	Pump stations	Balancing Reservoir	Farm dam	Purchase of land	Prof. design & support	Total Cost
164.85	162.31	36.99	2.07	67.28	54.62	488.12

Table 12.4 | Option 6b: JRIS URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	488.12
Annual operating cost (R million/annum)	21.50
NPV Cost (R million)	807.83
Unit Reference Value (R/m^3)	6.79

12.1.7 Ecological Impact

Sensitivity: **High:** The pipeline follows the road for much of the route, but the eastern section includes areas of CBA 1. The pipeline also transects ESA 1 and ESA 2 areas, mostly in the west, and includes watercourses and wetland areas. Option 6a mostly transects an area mapped as CBA 1. This area is very sensitive and should be avoided as far as practicably possible.

Recommendation: Avoid CBA 1 areas as far as practicable and apply site specific mitigation if not possible. Botanical and freshwater specialist assessments should be undertaken for the route, as well as for the associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. It would also require site specific mitigation, after an assessment was undertaken by a freshwater ecologist. Site rehabilitation would be very important along the pipeline corridors post-construction and would also require alien invasive clearing and regular maintenance for at least 5 years post-construction.

12.1.8 Summary of Option 6: JRIS

This is a very costly option that will not be financially viable without significant long-term subsidisation. There are significant environmental concerns relating to the inter-basin transfer of water, which would need to be mitigated. Option 6a should not be considered at all, given the higher cost, negative inter-basin transfer impacts on the Jakkals River, and the high conveyance losses with the associated significant lost opportunity cost.

The pipeline option (Option 6b) has moderate environmental impacts and limited conveyance loss. The socio-economic impacts of acquiring the farms with existing irrigation, as identified by SANID will be high. The prospective scheme has been around for some time and has a level of political support, following the marketing done by SANID Water.

12.2 Option 7: Provision of Water to Coastal Towns

12.2.1 Layout of Option 7: Coastal Towns

The option layout is shown in **Figure 12.1**.

12.2.2 Description of Option 7: Coastal Towns

A secondary objective of the postulated Jakkals River Irrigation Scheme was to supply Lamberts Bay and Elands Bay (and potentially surrounding farmers) with domestic water from Clanwilliam Dam. The provision of water to these coastal towns of an estimated 1.0 Mℓ/d should be compared to the option of drilling boreholes and/or desalinating water in these towns.

Many coastal towns in the Cape Province feel the pressure with water demands exceeding supply, especially during peak holiday seasons. An example is Lamberts Bay, a town about 280 kilometers from Cape Town, along the Cape West Coast, in Cederberg LM. To resolve this dilemma, the DWS and the Cederberg Municipality first considered two possibilities, namely to provide additional boreholes, or to install an 81 kilometer long pipeline from the Clanwilliam Dam. Investigative studies revealed that test boreholes exposed overly excessive iron and manganese content in the water. The DWS and the town's municipality therefore decided to commission a new desalination plant adjacent to the town's existing water purification plant.

A 1 700 m³/d reverse-osmosis (RO) seawater desalination plant, upgradeable to 5 000 m³/d, has subsequently been built in Lamberts Bay. The plant should alleviate growing pressure on the region's water system and improve availability of high-quality water for the region's nearly 40 000 residents. This plant is however not yet operational.

The proposed option to supply water from Clanwilliam Dam involves the construction of a 19.9 km long, 200 mm diameter rising main from the pump station, located at the Clanwilliam Dam, to the balancing reservoir. The pumping head from the Clanwilliam Dam to the balancing reservoir is 367 m. From there, water is supplied by gravity pipeline to the towns of Lambert's Bay and Elands Bay by a 61 km long, 200 mm diameter gravity pipeline.

12.2.3 Net Water Requirements and Losses

The water requirement is 0.37 million m^3/a.

Total water losses are 0.1 million m^3/a.

12.2.4 Water Quality

The abstracted water quality from Clanwilliam Dam is good.

12.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 12.5**. The URV for this option is given in **Table 12.6**.

Table 12.5 | Option 7: Coastal Towns Comparative Capital Costs in million Rand

Pipeline	Pump station	Reservoir	Prof. design & support	Total Cost
60.15	3.10	9.00	14.44	86.71

Table 12.6 | Option 7: Coastal Towns URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	86.71
Annual operating cost (R million/annum)	0.99
NPV Cost (R million)	92.64
Unit Reference Value (R/m^3)	21.61

12.2.6 Ecological Impact

Sensitivity: **High:** The pipeline transects numerous CBA 1 areas along the proposed route and the route also transects CBA 2 areas in small areas east of Graafwater, as well as west towards the coast en route to Lamberts Bay. The route includes EN and VU vegetation types as well as NFEPA wetlands. ESA 1 and ESA 2 areas are transected, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line.

Mitigation: Avoid CBA 1 areas as far as practicable and apply site-specific mitigation if the areas cannot be avoided. Botanical and freshwater specialist assessments should be undertaken for the route and associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. It would also require site-specific mitigation after an assessment has been undertaken by a freshwater ecologist. Site rehabilitation would be very important along the pipeline corridors, post-construction and would also require alien invasive clearing and regular maintenance for at least 5 years post-construction. Consultation with the Steenboksfontein Private Nature Reserve is recommended.

12.2.7 Summary of Option 7: Coastal Towns

This is a very costly option, which will not be financially viable without significant subsidisation, even though this is an urban water supply option. The option has high environmental and socio-economic impacts and low conveyance losses. The coastal towns likely have better, more cost-effective options for water supply, such as completing the construction of the desalination plant and groundwater (which requires treatment).

12.3 Option 8: Provision of Water to JRIS, Graafwater, Lamberts Bay and Elands Bay

12.3.1 Layout of Option 8: Jakkals River Irrigation Scheme (JRIS) and Coastal Towns

The option layout is shown in **Figure 12.1**.

12.3.2 Description of Option 8: JRIS and Coastal Towns

In addition to supplying the JRIS, a secondary objective of the postulated Jakkals River Irrigation Scheme (which includes supply to Graafwater) was to supply Lamberts Bay and Elands Bay, and potentially surrounding farmers, from Clanwilliam Dam. The irrigable area of the proposed JRIS is 3 187 ha.

It is proposed that water will also be pumped from the raised Clanwilliam Dam, with the rising main following the R364 road to Graafwater. The rising main delivers water to a small reservoir, from where a gravity pipeline will supply a farm dam. A booster pump station may be needed to limit pressure in the pipeline.

This option involves the construction of a ±19.87 km long, 500 mm diameter steel rising main from the Clanwilliam Dam to a balancing reservoir. The pipeline passes over a mountain range. The pumping head from the Clanwilliam Dam to the balancing reservoir is 367 m. A gravity pipeline of 8.3 km long, 500 mm diameter then delivers the water to the JRIS and Graafwater. From there, water is delivered by a 28.2 km long, 200 mm diameter gravity pipeline to Lambert's Bay, and a further 24.4 km long, 200 mm diameter pipeline from Lamberts Bay to Elands Bay.

12.3.3 Net Water Requirements and Losses

The water requirement for irrigation and domestic water supply is 10.63 million m^3/a. The provision of water to the three towns is an estimated 1.5 Mℓ/d.

Total water losses are 0.32 million m^3/a. A leaching requirement of 3% has been added to the estimated irrigation water requirement to leach salts from the soil for the first 5 years after establishment.

12.3.4 Water Quality

The quality of water to be abstracted from Clanwilliam Dam is good.

12.3.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 12.7**. The URV for this option is given in **Table 12.8**.

Table 12.7 | Option 8: JRIS & Coastal Towns Comparative Capital Costs in million Rand

Pipelines	Pump stations	Reservoir	Farm dam	Purchase of land	Prof. design & support	Total Cost
223.63	171.45	38.12	2.07	67.28	63.36	565.92

Table 12.8 | Option 8: JRIS and Coastal Towns URV in R/m³

Item	Discount Rate 8%
Total comparative capital cost (R million)	565.92
Annual operating cost (R million/annum)	23.17
NPV Cost (R million)	904.67
Unit Reference Value (R/m³)	7.34

12.3.6 Ecological Impact

Sensitivity: **High:** The pipeline route transects numerous CBA 1 (Terrestrial) and CBA 2 areas east from Graafwater, as well as west towards the coast en route to Lamberts Bay. The route includes EN and VU vegetation types as well as NFEPA wetlands. ESA 1 and ESA 2 areas are also transected, which represent mostly watercourse corridors. In most places the road reserve is excluded from the CBA/ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line.

Mitigation: Avoid CBA 1 areas as far as practicable and apply site specific mitigation if not possible. Botanical and freshwater specialist assessments should be undertaken for the route and associated development footprints. Working within the regulated area of a watercourse or wetland would require authorisation from the DWS. It would also require site-specific mitigation after an assessment was undertaken by a freshwater ecologist. Site rehabilitation would be very important along the pipeline corridors post-construction and would also require alien invasive clearing and regular maintenance for at least 5 years post-construction. Consultation with Steenboksfontein Private Nature Reserve is recommended.

12.3.7 Summary of Option 8: JRIS and Coastal Towns

This is a very costly option, which will not be financially viable without significant subsidisation. The option has high environmental and socio-economic impacts and limited conveyance loss. The prospective scheme has been mooted for some time and has a level of political support, following the marketing done by SANID Water. The coastal towns likely have better, more cost-effective options for water supply in terms of groundwater.

13 Zone 4, Olifants River from Bulshoek Weir to Trawal

Chapter 13 describes the options for abstraction from the Olifants River below Bulshoek Weir up to Trawal.

These options are based on releasing additional water down the Olifants River at the Bulshoek Weir, i.e. use the river as a conduit, and farmers abstracting water directly from the river. The extent of how far down the catchment, below the confluence with the Doring River, irrigation development can be considered (without significant conveyance infrastructure), will be influenced by water quality considerations. Development further down the catchment will require either additional canal or pipe conveyance infrastructure, or low-pressure desalination of water, which will be very expensive.

Water can be released from the Bulshoek Weir down the Olifants River and be pumped either directly for irrigation, or to farm dams.

13.1 Option 9: Release at Bulshoek Weir and Pump from River: Zypherfontein 1

13.1.1 Layout of Option 9: Zypherfontein 1

The option layout is shown in **Figure 13.1**.

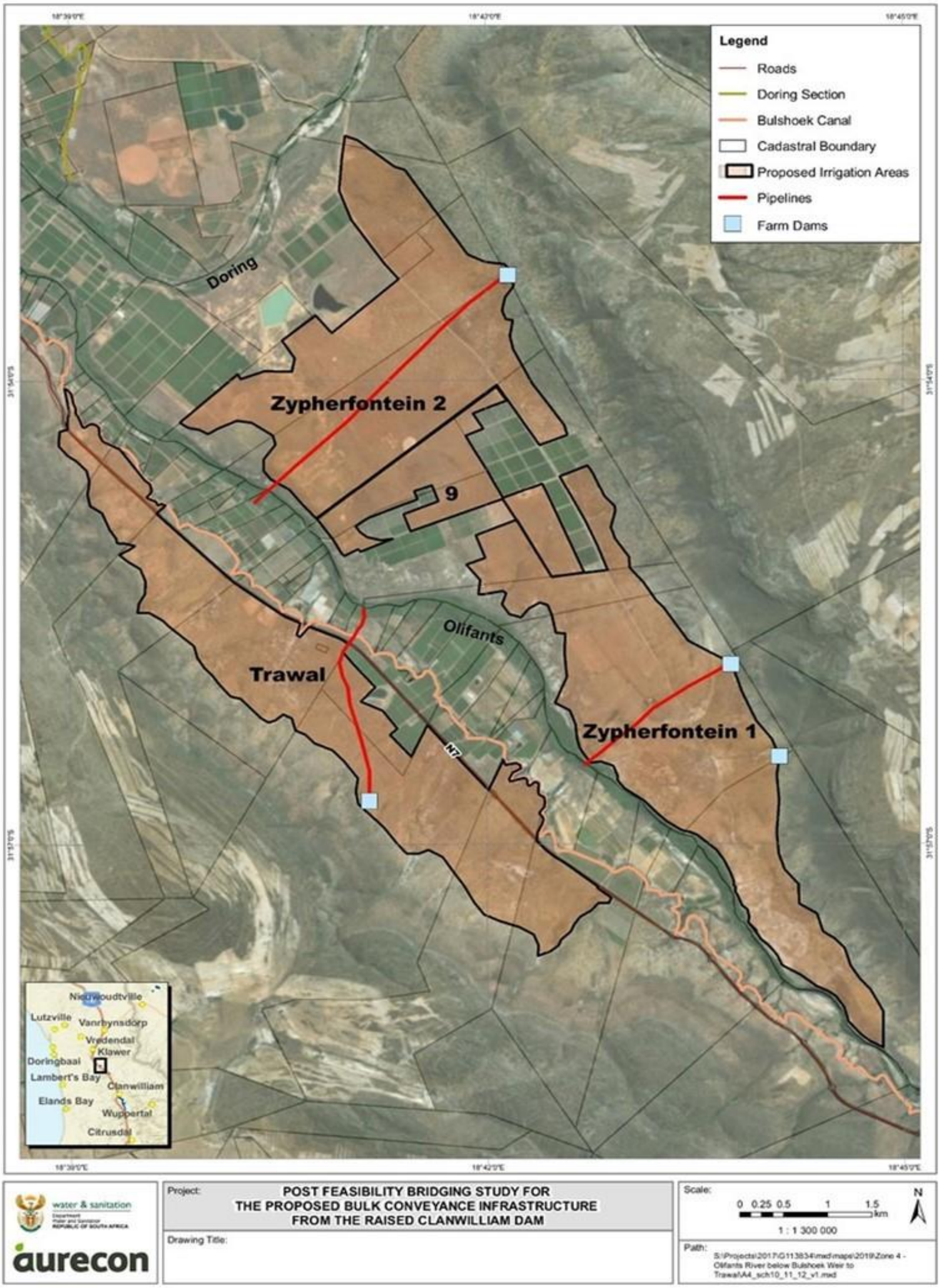

Figure 13.1 │ Layout of Options Zypherfontein 1, 2 and Trawal

13.1.2 Description of Option 9: Zypherfontein 1

The Zypherfontein 1 Scheme, and the other irrigation options located in close vicinity, provides opportunity for a large new development downstream of Bulshoek Weir, but above the confluence with the Doring River. These options therefore avoid the influence of poorer water quality below the confluence. While additional irrigation development may be phased in over time, the options together provide the opportunity for a much faster uptake of water. The Lower Olifants River Water User Association (LORWUA) has indicated that it would strongly support such a scheme. Because it is a large scheme, with much of the irrigation areas located further away from the river, costs are expected to be slightly higher than for small schemes located closer to the river. On the other hand, there are advantages of scale, due to the size of the project.

The proposed Zypherfontein Scheme is located on private land, with the whole area belonging to two farmers. The land will likely need to be acquired for the project to be undertaken. Conveyance options to be considered are the following:

- Pumping from the Olifants River
- New canal system from Bulshoek Weir (addressed in Scheme 13 and 14)

The irrigable area is 888 ha.

Option 9 involves the construction of a ±1.4 km long, 700 mm diameter rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 113 m.

13.1.3 Net Water Requirements and Losses

The water requirement is 7.94 million m^3/a.

Total conveyance losses are 2.30 million m^3/a.

13.1.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

13.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in

Table 13.1. The URV for this option is given in **Table 13.2**.

Table 13.1 | Option 9: Zypherfontein 1 Comparative Capital Costs in million Rand

Pipeline	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
7.00	31.94	1.60	18.74	5.84	**65.12**

Table 13.2 | Option 9: Zypherfontein 1 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	65.12
Annual operating cost (R million/annum)	3.91
NPV Cost (R million)	127.20
Unit Reference Value (R/m^3)	1.38

13.1.6 Ecological Impact

Sensitivity: **Medium:** A CBA 1 occurs adjacent to the south western border of the site along the Olifants River. All watercourse corridors across the site are mapped as ESA 1 and ESA 2 for watercourse protection. The north eastern section of the study area is also classified as an upland-lowland interface and should be regarded as requiring specialist input.

Recommendation: The site should be assessed from a botanical and freshwater perspective to buffer watercourses and wetland areas, as well as to provide input into the possible impact on the upland-lowland interface area. Development should also be limited to areas outside the 1:100-year floodline of the Olifants River.

13.1.7 Summary of Option 9: Zypherfontein 1

This option has a good location and a low URV, although there are moderate lost opportunity costs as a result of the moderately-high water losses (29%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

13.2 Option 10: Release at Bulshoek Weir and pump from river: Trawal

13.2.1 Layout of Option 10: Trawal

The option layout is shown in **Figure 13.1**.

13.2.2 Description of Option 10: Trawal

Water will be pumped from the Olifants River, below Bulshoek Weir and the Doring River confluence, to the scheme on the left bank. The land is privately-owned. The irrigable area is 695 ha.

This option involves the construction of a ±2.5 km long, 600 mm diameter steel rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 107 m.

13.2.3 Net Water Requirements and Losses

The water requirement is 7.18 million m^3/a.

Total conveyance losses are 2.08 million m^3/a.

13.2.4 Water Quality

Water quality is good. A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

13.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 13.3**. The URV for this option is given in **Table 13.4**.

Table 13.3 | Option 10: Trawal Comparative Capital Costs in million Rand

Pipeline	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
9.55	25.48	1.24	14.68	5.39	56.34

Table 13.4 | Option 10: Trawal URV in R/m³

Item	Discount Rate 8%
Total comparative capital cost (R million)	56.34
Annual operating cost (R million/annum)	3.15
NPV Cost (R million)	105.81
Unit Reference Value (R/m³)	1.38

13.2.6 Ecological Impact

Sensitivity: **Medium:** All watercourse corridors across the site are mapped as ESA 1 and ESA 2 for watercourse protection. There is also a small wetland section on the north western side of the site.

Recommendation: The site should be assessed from a botanical and freshwater perspective to buffer watercourses and wetland areas. Development should also be limited to areas outside the 1:100-year floodline of the Olifants River.

13.2.7 Summary of Option 10: Trawal

This option has a good location and a low URV, although there are moderate opportunity costs as a result of the moderately-high water losses (29%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

13.3 Option 11: Release at Bulshoek Weir and pump from river: Zypherfontein 2

13.3.1 Layout of Option 11: Zypherfontein 2

The option layout is shown in **Figure 13.1**.

13.3.2 Description of Option 11: Zypherfontein 2

Water will be pumped from the Olifants River, below Bulshoek Weir and the Doring River confluence, to the scheme on the right bank. The land is privately-owned.

The irrigable area is 658 ha.

This option involves the construction of a ±3.62 km long, 600 mm diameter steel rising main from the pump station located at the pumping point. The pumping head from the river to thefarm dam is 106 m.

13.3.3 Net Water Requirements and Losses

The water requirement is 6.80 million m^3/a.

Total conveyance losses are 1.97 million m^3/a.

13.3.4 Water Quality

Water quality is good. A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

13.3.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 13.5**. The URV for this option is given in **Table 13.6**.

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Table 13.5 | Option 11: Zypherfontein 2 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
13.85	23.79	1.18	13.89	5.65	58.37

Table 13.6 | Option 11: Zypherfontein 2 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	58.37
Annual operating cost (R million/annum)	2.99
NPV Cost (R million)	104.59
Unit Reference Value (R/m^3)	1.44

13.3.6 Ecological Impact

Sensitivity: **Medium:** A CBA 1 occurs adjacent to the south western border of the site along the Olifants River as well as to the north along the Doring River. All watercourse corridors across the site are mapped as ESA 1 and ESA 2 for watercourse protection. The north eastern section of the study area is also classified as an upland-lowland interface and should be regarded as requiring specialist input.

Recommendation: The site should be assessed from a botanical and freshwater perspective to buffer watercourses and wetland areas, as well as to provide input into the possible impact on the upland-lowland interface area. Development should also be limited to areas outside the 1:100-year floodlines of the Olifants and Doring rivers.

13.3.7 Summary of Option 11: Zypherfontein 2

This option has a good location and a low URV, although there are moderate opportunity costs as a result of the moderately-high water losses (29%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

13.4 Option 12: Release at Bulshoek Weir and pump from river: Melkboom

13.4.1 Layout of Option 12: Melkboom

The option layout is shown in **Figure 13.2**.

13.4.2 Description of Option 12: Melkboom

Similar to the Zypherfontein Scheme proposal, the Melkboom option provides for a large new development downstream of the Bulshoek Weir on the right bank of the Olifants River, on the downstream side of the Doring River confluence. The current owners are not farming.

The irrigable area is 333 ha.

This option involves the construction of a ±4.12 km long, 500 mm diameter steel rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 120 m.

13.4.3 Net Water Requirements and Losses

The water requirement is 3.45 million m^3/a.

Total water losses are 1.00 million m^3/a.

13.4.4 Water Quality

Even though the abstraction point is located just below the confluence of the Doring River and the Olifants River, the abstracted water quality will still be good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

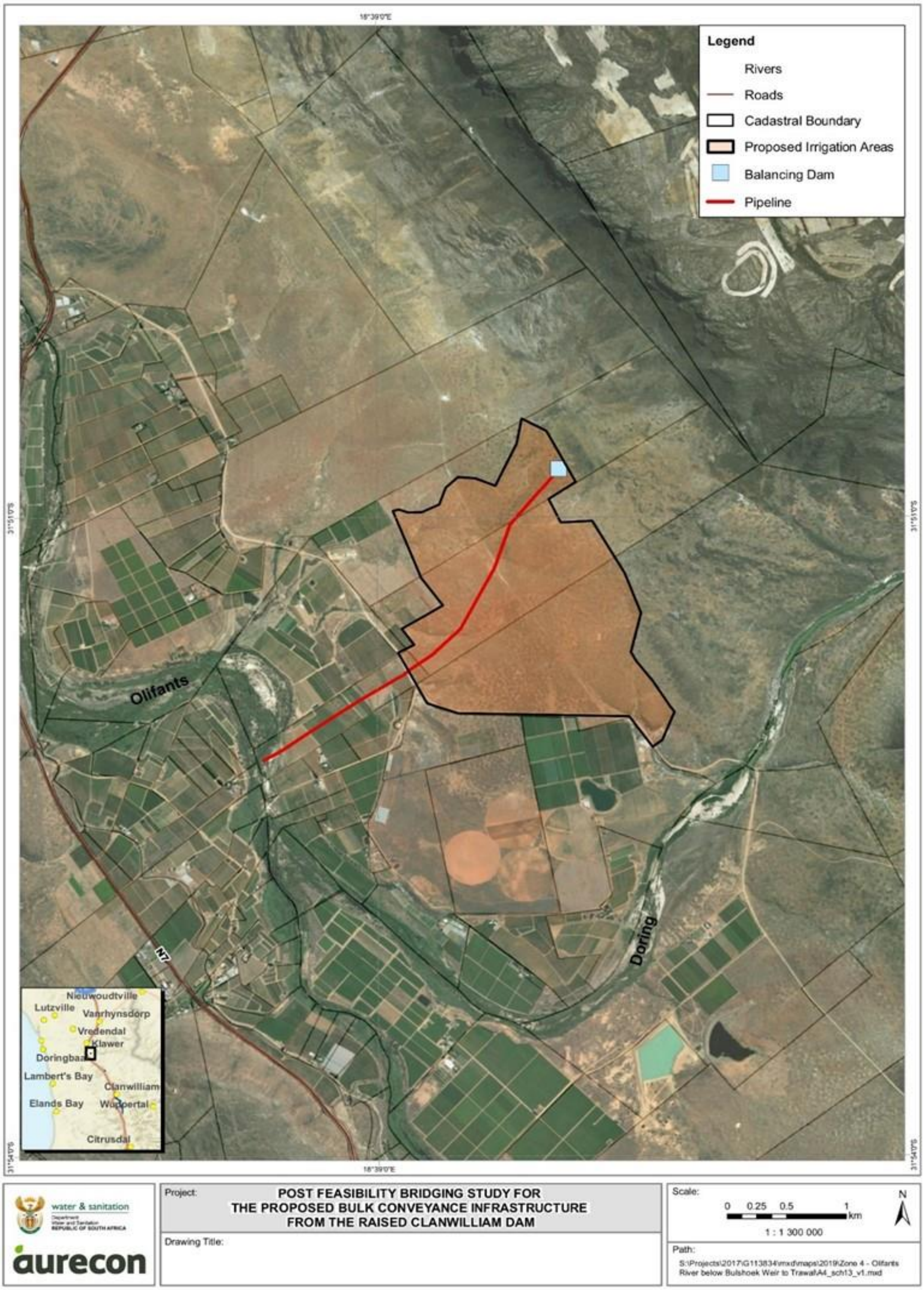

Figure 13.2 │ Layout of Option 12: Melkboom

13.4.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 13.7**. The URV for this option is given in **Table 13.8**.

Table 13.7 | Option 12: Melkboom Comparative Capital Costs in million Rand

Pipeline	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
10.95	15.27	0.69	7.02	4.03	37.96

Table 13.8 | Option 12: Melkboom URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	37.96
Annual operating cost (R million/annum)	1.91
NPV Cost (R million)	67.56
Unit Reference Value (R/m^3)	1.69

13.4.6 Ecological Impact

Sensitivity: **Medium:** A CBA 1 occurs adjacent to the north and north eastern border of the site. All watercourse corridors across the site are mapped as ESA 1 and ESA 2 for watercourse protection.

Recommendation: The site should be assessed from a botanical and freshwater perspective to buffer watercourses and determine mitigation measures for avoiding sensitive ecological corridors.

13.4.7 Summary of Option 12: Melkboom

This option has a good location and a medium URV, although there are high opportunity costs as a result of the moderately-high water losses (29%) and high leaching requirement (19%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

13.5 Option 13: Water supplied by pipeline from Bulshoek Weir, combined options 9-10-11

13.5.1 Layout of Option 13: Pipeline for Areas 9-10-11

The option layout is shown in **Figure 13.3**.

13.5.2 Description of Option 13: Pipeline for Areas 9-10-11

This option combines the irrigable areas of Zypherfontein 1 and 2, and Trawal . The combined irrigable area is 2 241 ha. The current owners are not farming these areas. Water will be supplied from Bulshoek Weir under gravity and then pumped from the gravity line to the separate farm dams.

This involves the construction of the following infrastructure:

- A ±14.9 km long, 1 400 mm diameter gravity main pipeline from Bulshoek Weir,
- A ±3.6 km long, 600 mm diameter rising main from the pump station located at the pumping point for the Zypherfontein 2 area. The pumping head from the river to thefarm dam is 106 m,
- A ±2.5 km long, 600 mm diameter rising main from the pump station located at the pumping point for the Zypherfontein 1 area. The pumping head from the river to the farm dam is 107 m,
- A ±1.4 km long, 700 mm diameter rising main from the pump station located at the pumping point for the Trawal area. The pumping head from the river to the farm dam is 113 m.

13.5.3 Net Water Requirements and Losses

The water requirement is 21.40 million m^3/a.

Total water loss, in comparison with Options 9, 10 and 11, is a relatively low 1.07 million m^3/a.

13.5.4 Water Quality

Water quality is good. A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

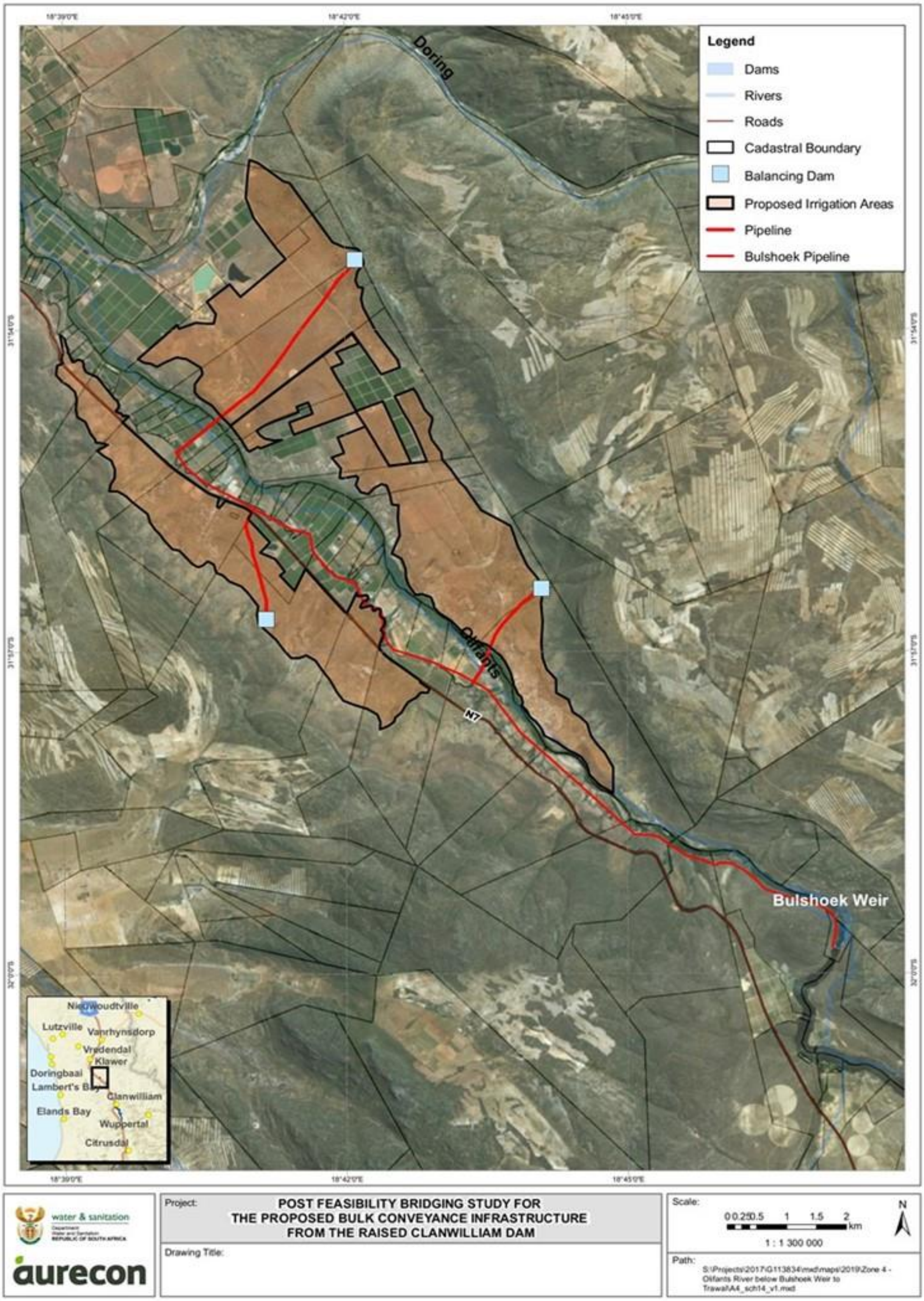

Figure 13.3 | Layout of Option 13: Pipeline for Areas 9-10-11

13.5.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 13.9**. The URV for this option is given in **Table 13.10**.

Table 13.9 | Option 13: Pipeline for Areas 9-10-11 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Prof. design & support	Total Cost
320.59	101.38	4.20	47.31	56.40	**529.89**

Table 13.10 | Option 13: Pipeline for Areas 9-10-11 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	529.89
Annual operating cost (R million/annum)	14.66
NPV Cost (R million)	726.43
Unit Reference Value (R/m^3)	**2.93**

13.5.6 Ecological Impact

Sensitivity: **Medium:** The ecological impact is as per the descriptions for Schemes 9, 10 and 11.

Recommendation: The recommendation is the same as for Schemes 9, 10 and 11.

13.5.7 Summary of Option 13: Pipeline for Areas 9-10-11

This option has a good location and a high URV. Environmental concerns are moderate and there are no water quality concerns. Opportunity costs are low as water losses are low. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

13.6 Option 14: Raised (and lined) canal from Bulshoek and small right-bank canal, combined options 9-11-12

13.6.1 Layout of Option 14: Small right-bank canal for Areas 9-11-12

The option layout is shown in **Figure 13.4**.

13.6.2 Description of Option 14: Small right-bank canal for Areas 9-11-12

This option includes the Zypherfontein 1 and 2, and Melkboom potential irrigation areas, which provides for a large new development downstream of the Bulshoek Weir on the right bank of the Olifants River, on the downstream side of the Doring River confluence.

The combined area for the three irrigable areas is 1 878 ha.

This option would involve the raising of the Trawal section of the canal by 0.16 m, for about 8.0 km. The total increase of design flow in the existing canal is 1.357 m^3/s, with a total flow of 8.826 m^3/s. An increase in the flow of the existing canal also increases the risk, given the poor state of the canal. Two sub-options have been assessed, Options 14a that does not include any lining of the existing canal, and Option 14b, that includes the lining of 8.0 km of the existing Trawal section of the canal.

The scheme further involves the construction of a ±1.5 km long, 1000 mm diameter rising main from the pump station located at the pumping point from the existing canal, to the start of a new, small canal on the right bank. The pumping head from the existing canal to the new canal is 100 m. Provision has been made for a 200 m long syphon through the Olifants River.

The small high-level canal then conveys the water to the development areas as follows:

- A 1st section of 960 m length and a flow of 1.257 m^3/s,
- A 2nd section of 7 190 m length and a flow of 0.737 m^3/s,
- A 3rd section of 4 160 m length and a flow of 0.261 m^3/s, which includes a 170 m syphon through the Doring River.

13.6.3 Net Water Requirements and Losses

The water requirement is 17.93 million m^3/a.

Total losses are 2.69 million m^3/a.

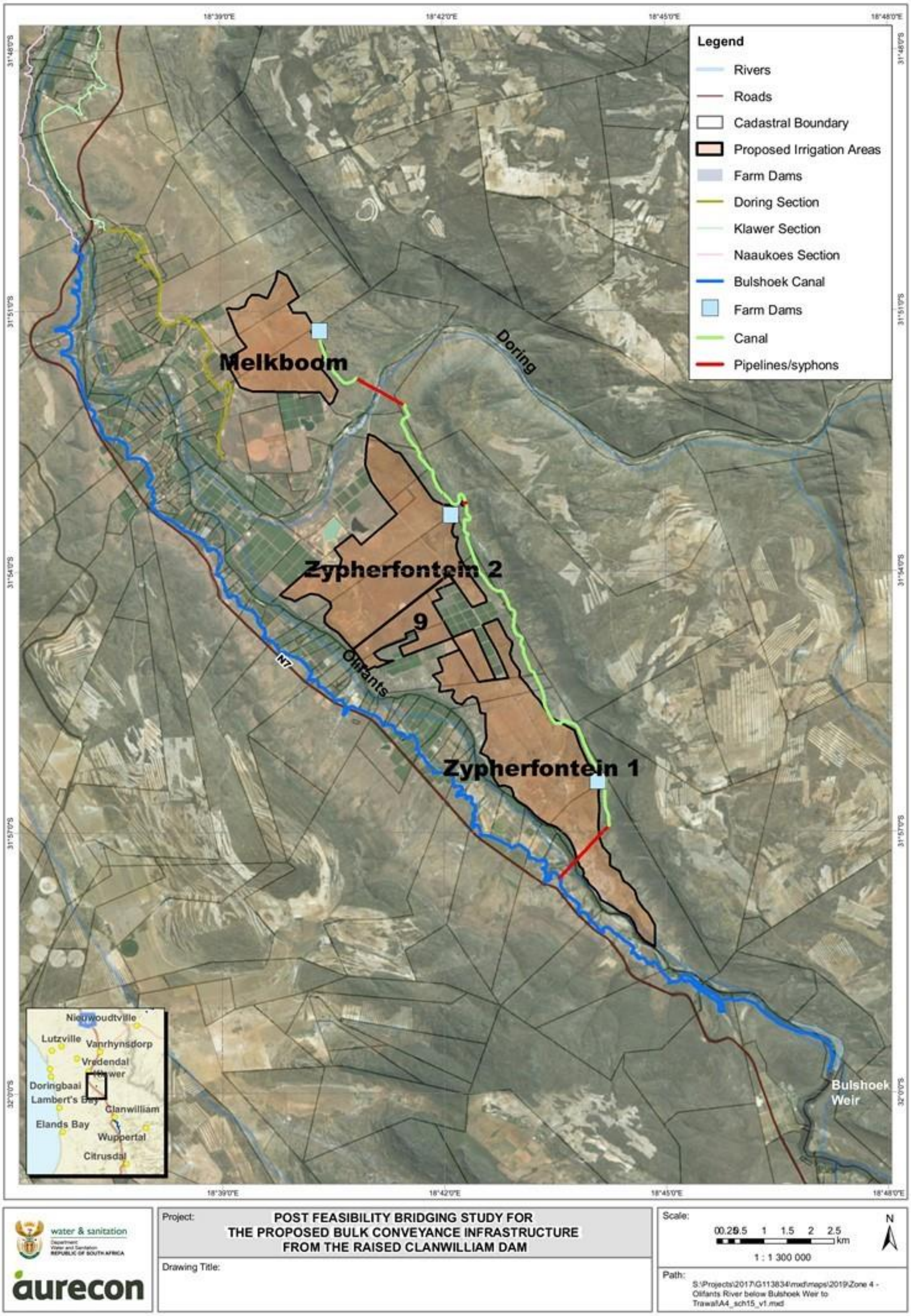

Figure 13.4 │ Layout of Option 14: Small right-bank canal for Areas 9-11-12

13.6.4 Water Quality

Water quality is good. A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

13.6.5 Cost and Unit Reference Value: Option 14a

The comparative capital costs (2018 prices, excluding VAT) for Option 14a is shown in **Table** 13.11 and in **Table 13.12** for Option 14b.

As shown in **Table 13.12**, the total comparative capital cost for Option 14b has been divided between development costs and betterment costs in terms of the comparative benefit to be derived (from comparative design flows, for the canal lining and associated professional design & support fees).

Table 13.11 │ Option 14a: Small right-bank canal Comparative Capital Costs in million Rand

Pipeline & syphon	Pump station	Farm dams	Raising of existing canal	High-level canal	Purchase of land	Prof. design & support	Total Cost no lining
20.56	71.00	15.89	17.2	77.5	47.31	25.36	**274.82**

Table 13.12 │ Option 14b: Small right-bank canal Comparative Capital Costs in million Rand

Cost distribution	Pipeline & syphon	Pump station	Farm dams	Raising & lining of existing canal	High-level canal	Purchase of land	Prof. design & support	Total Cost with lining
Development	20.56	71.00	15.89	43.54	77.5	47.31	29.31	**305.11**
Betterment	0	0	0	173.66	0	0	26.05	**199.71**
TOTAL	**20.56**	**71.00**	**15.89**	**217.20**	**77.5**	**47.31**	**55.36**	**504.82**

The URV for this option is given in **Table 13.13**.

Table 13.13 | Option 14: Small right-bank canal URV in R/m^3

Item	Discount Rate (without lining) HDI Farmers 8%	Discount Rate (with lining) HDI Farmers 8%
Total comparative capital cost (R million)	274.82	305.11
Annual operating cost (R million/annum)	9.51	9.64
NPV Cost (R million)	365.96	412.82
Unit Reference Value (R/m^3)	**1.76**	**1.99**

13.6.6 Ecological Impact

Sensitivity: **Medium:** The ecological impact is as per the descriptions for Schemes 9, 11 and 12.

Recommendation: The recommendation is the same as for Schemes 9, 11 and 12.

13.6.7 Summary of Option 14: Small right-bank canal

This option has a good location and a medium URV, although there are moderate opportunity costs as a result of the moderately-high water losses (15%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate. There is some concern of the effect of the additional head on the integrity of the old canal, even though the relevant section will be raised and lined.

13.7 Option 15: New Right Bank canal

13.7.1 Layout of Option 15: New Right Bank canal

The option layout is shown in **Figure 13.5**.

13.7.2 Description of Option 15: New Right Bank canal

This option involves the replacement of the main (Trawal) canal section with a new canal on the right bank of the Olifants River. The Trawal section of the canal poses the biggest risk to the downstream irrigators, and this option is aimed at mitigating that risk. The new canal would be sized to allow for all existing LORGWS irrigation, as well as the new irrigation areas in the Trawal area (Zypherfontein 1, Zypherfontein 2, Trawal and Melkboom irrigation areas). The combined irrigable area for the four new areas is 1 878 ha.

Since it will be a significant challenge to undertake construction on the existing canal/s while water needs to flow, this option offers a much more practical and cost-effective solution.

The flow required for existing irrigation in the Trawal section of the canal is 7.469 m^3/s. The additional flow required is 1.860 m^3/s, which is a total flow of 9.329 m^3/s.

13.7.3 Net Water Requirements and Losses

The water requirement for additional irrigation is 24.57 million m^3/a.

Total water losses are 3.69 million m^3/a.

13.7.4 Water Quality

Water quality is good. A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

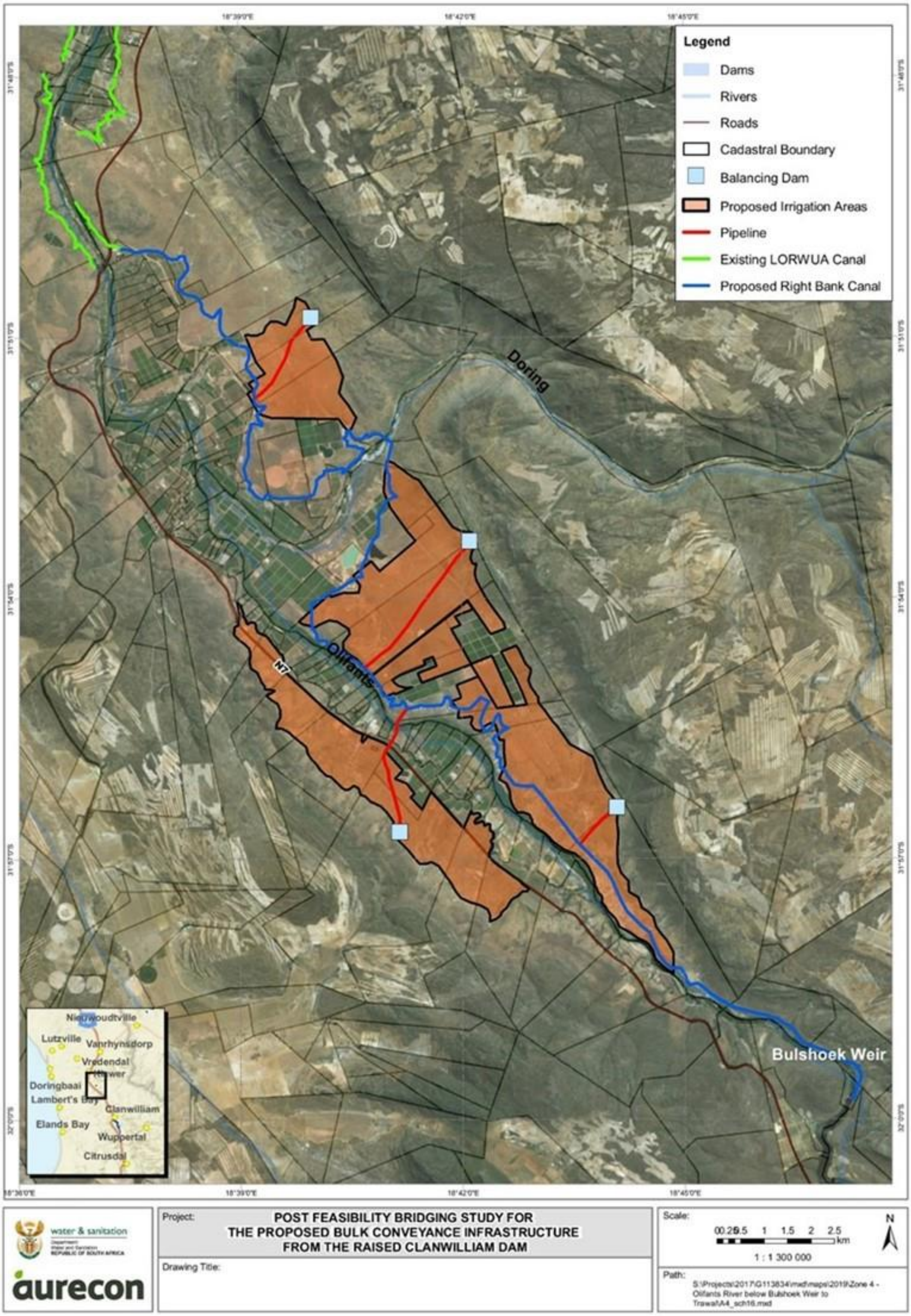

Figure 13.5 | Layout of Option 15: New Right Bank canal

13.7.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 13.14**. The development cost for this option has been assumed to be equal to the development costs of (Option 10 + Option14b), as shown in **Table 13.5**.

Table 13.14 │ Option 15: Right bank canal Comparative Capital Costs in million Rand

Cost distribution	Pipelines & syphon	Pump stations	Farm dams & balancing dams	Canal-related costs	Purchase of land	Prof. design & support	Total Cost
Development (Options 10+14b)	30.11	96.48	17.13	121.04	61.99	34.7	**361.45**
Betterment	25.19	10.34	6.89	399.85	0	71.74	**514.01**
TOTAL	**55.30**	**106.82**	**24.02**	**520.89**	**61.99**	**106.44**	**875.46**

Table 13.15 │ Option 15: Capital costs used for development costing

Development Costing	Pipeline & syphon	Pump station	Farm dams	Raising & lining of existing canal	High-level canal	Purchase of land	Prof. design & support	Total Cost with lining
Option 10	9.55	25.48	1.24	0	0	14.68	5.39	**56.34**
Option 14b	20.56	71.00	15.89	43.54	77.5	47.31	29.31	**305.11**
Options 10+14b	**30.11**	**96.48**	**17.13**	**43.54**	**77.5**	**61.99**	**34.7**	**361.45**

The URV for this option is given in **Table 13.16**.

Table 13.16 │ Option 15: Right-bank canal URV in R/m^3

Item	Discount Rate New Farmers 8%
Total comparative capital cost (R million)	361.44
Annual operating cost (R million/annum)	12.97
NPV Cost (R million)	518.61
Unit Reference Value (R/m^3)	1.82

13.7.6 Ecological Impact

Sensitivity: Medium: The riparian zone of the Doring River is mapped as a CBA 1 with smaller ESA1 areas supporting watercourse protection along tributaries to the main rivers. There are no mapped threatened ecosystems along the new canal route.

Mitigation: Use existing disturbed areas as far as possible. Mitigation measures should be advised by a freshwater ecologist in areas where watercourses are affected by construction activities. Rehabilitation of disturbed areas along the canal alignment is very important. Refer to the mitigation of the relevant areas (areas 9, 10, 11 and 12) discussed above.

13.7.7 Summary of Option 15: New Right Bank canal

This option has a good location and a medium URV, although there are moderate opportunity costs as a result of the moderately-high water losses (15%). Environmental concerns are moderate and there are no water quality concerns. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

This option will provide the benefit of significantly reducing the risk of failure of the whole LORGWS, and removing the bottleneck caused by the current limiting capacity of the Trawal canal section. The implementation of this option requires that funding for betterments needs to be available.

14 Zone 5, Olifants River from Klawer to Coast

This chapter describes the options for abstraction from the Olifants River from Klawer to the Coast.

Water can be released from the Bulshoek Weir down the Olifants River and be pumped either directly for irrigation, or to farm dams. The slightly poorer quality water from the Doring River tributary and the saline return flows from the irrigated lands, that increase the river salinity dramatically along the river below Klawer during the dry months, will influence the extent to which water could be abstracted for irrigation below the confluence of the Olifants and Doring rivers. Below the extent where abstracted river water could be used directly for irrigation, irrigation will get more expensive, due to the need to provide conveyance infrastructure (canal / pipeline) or alternatively to improve water quality through treatment/low-pressure desalination.

14.1 Option 16: Klawer

14.1.1 Layout of Option 16: Klawer

The option layout is shown in **Figure 14.1**.

14.1.2 Description of Option 16: Klawer

The proposed Klawer irrigation area of 1 449 ha is located just north-west of Klawer between the National Road N7, the R362 regional road (between Klawer and Vredendal), and south of the Biedouw River. Distribution of water will be done by pumping water released from Bulshoek Weir from the lower Olifants River.

This option involves the construction of a ±3.5 km long, 800 mm diameter steel rising main from the pump station located at the pumping point at the Olifants River to the farm dam. The pumping head from the river to the dam is 110 m.

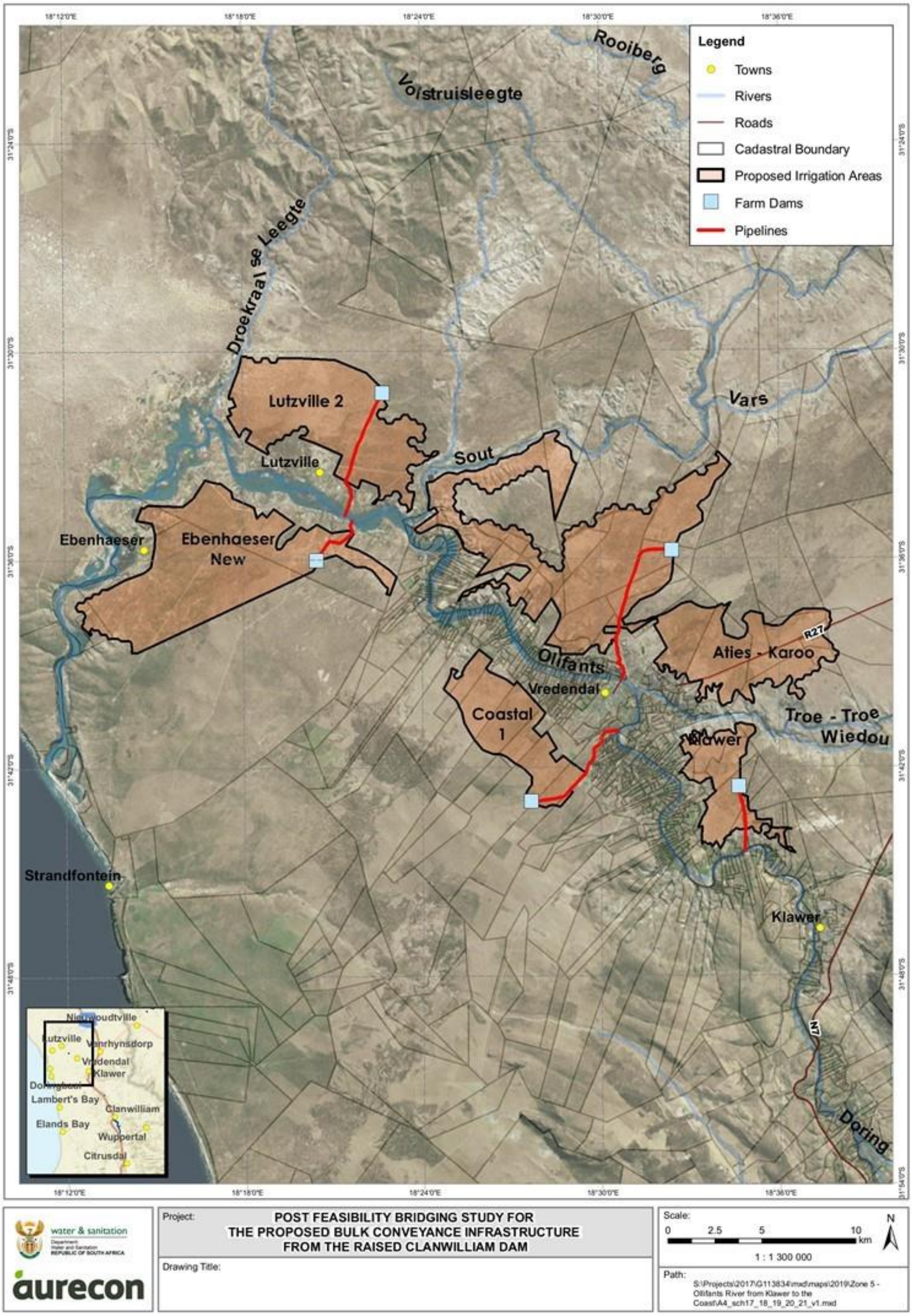

Figure 14.1: Layout of options in Sub-area 5 – Olifants River from Klawer to Coast

14.1.3 Net Water Requirements and Losses

The water requirement is 14.67 million m^3/a.

Total losses are 6.16 million m^3/a.

14.1.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst on average) for the seven (7) summer months of irrigation, a balancing dam of 12.0 million m^3 is required, in addition to the farm dam used for operational storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

14.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.1**. The URV for this option is given in **Table 14.2**.

Table 14.1 | Option 16: Klawer Comparative Capital Costs in million Rand

Pipeline	Pump station	Balancing Dam	Farm dam	Purchase of land	Prof. design & support	Total Cost
23.04	55.77	340.64	2.95	30.57	11.82	464.79

Table 14.2 | Option 16: Klawer URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	464.79
Annual operating cost (R million/annum)	9.52
NPV Cost (R million)	591.08
Unit Reference Value (R/m^3)	3.48

14.1.6 Ecological Impact

Sensitivity: **High:** A very small pocket of CBA 1 remains in the centre of the reduced development area. Watercourses occurring along the south eastern section of the site have been designated as ESA 1 and ESA 2. The eastern half of the site falls into the Knersvlakte protected area expansion under the NPAES programme.

Recommendation: Avoid CBA areas and watercourse corridors. These areas would require freshwater and botanical specialist inputs to determine appropriate mitigation for development as well as no-go areas. Avoid NPAES areas (subject to consultation with CapeNature and possibly DEA).

14.1.7 Summary of Option 16: Klawer

This option has high environmental concerns and a high URV. The option also has very high water losses of over 40%, because of mainly river conveyance losses in the lower Olifants River below Bulshoek Weir, and a high leaching requirement. This option has high opportunity costs as a result of these high water losses. The need for large balancing storage to store winter water and to blend it with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Klawer scheme should be considered.

This scheme possibly holds potential for the development of 7.5 ha plots, given its location between Klawer and Vredendal. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

14.2 Option 17: Aties-Karoo

14.2.1 Layout of Option 17: Aties-Karoo

The option layout is shown in **Figure 14.1**.

14.2.2 Description of Option 17: Aties-Karoo

The Aties-Karoo area is the block of land bordered roughly by the National Road N7, the Hol/Vars Rivers, and the R27 regional road (between Vredendal and Vanrhynsdorp). A small portion of this area falls within public land, while the remainder is privately-owned.

An irrigable area of 4 500 ha has been used for calculations, although more than 10 000 ha in the Aties-Karoo area is suitable for irrigation development.

Distribution will be done by releasing water from Bulshoek Weir and pumping it from the lower Olifants River. This option involves the construction of a ±8.88 km long, 1 300 mm diameter rising main from the pump station located at the pumping point at the Olifants River, to the farm dam. The pumping head from the river to the dam is 119 m.

14.2.3 Net Water Requirements and Losses

The water requirement is 45.56 million m^3/a.

Total losses are 20.50 million m^3/a.

14.2.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst on average) for the seven (7) summer months of irrigation, a balancing dam of 4.3 million m^3 is required, in addition to the farm dam used for operational storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

14.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.3**. The URV for this option is given in **Table 14.4**.

Table 14.3 | Option 17: Aties-Karoo Comparative Capital Costs in million Rand

Pipeline	Pump station	Balancing Dam	Farm dam	Purchase of land	Prof. design & support	Total Cost
143.04	224.45	120.51	9.17	95.00	55.60	**647.73**

Table 14.4 | Option 17: Aties-Karoo URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	647.73
Annual operating cost (R million/annum)	29.15
NPV Cost (R million)	1 032.09
Unit Reference Value (R/m^3)	1.97

14.2.6 Ecological Impact

Sensitivity: **Medium:** ESA 1 and ESA 2 features occur across the site along watercourse corridors. Smaller sections along the eastern boundary of the site falls into the Knersvlakte protected area expansion in terms of the NPAES.

Recommendation: Avoid watercourse corridors. These areas would require freshwater and botanical specialist inputs to determine appropriate mitigation for development as well as no-go areas. Avoid NPAES areas (subject to consultation with CapeNature and possibly DEA).

14.2.7 Summary of Option 17: Aties-Karoo

The option has high environmental concerns and a medium URV, which can be ascribed to the large scale of the scheme. Very high water losses of 45% will be experienced, mainly because of river conveyance losses in the lower Olifants River below Bulshoek Weir, with resultant high associated opportunity cost. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Aties-Karoo scheme is to be considered. This scheme holds potential for 7.5 ha plots, given its relative closeness to Vredendal.

14.3 Option 18: Ebenhaeser New

14.3.1 Layout of Option 18: Ebenhaeser New

The option layout is shown in **Figure 14.1**.

14.3.2 Description of Option 18: Ebenhaeser New

This potential irrigation area adjoins the Ebenhaeser settlement. Distribution will be done by releasing water from Bulshoek Weir and pumping it from the lower Olifants River. Close to 1 800 ha of the northern portion of this area is state land.

The evaluation of this option was done for an irrigable area of 4 500 ha, although the actual area of irrigable land for this option is close to 6 000 ha.

This option involves the construction of a ±3.35 km long, 1 300 mm diameter steel rising main from the pump station located at the pumping point. The pumping head from the river to the farm dam is 109 m.

14.3.3 Net Water Requirements and Losses

The water requirement is 43.76 million m^3/a.

Total losses are 23.24 million m^3/a.

14.3.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst on average) for the seven (7) summer months of irrigation, a balancing dam of 15.7 million m^3 is required, in addition to the farm dam used for operational storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

14.3.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.5**. The URV for this option is given in **Table 14.6**.

Table 14.5 | Option 18: Ebenhaeser New Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Prof. design & support	Total Cost
54.03	202.11	445.97	9.56	95.00	108.25	924.93

Table 14.6 | Option 18: Ebenhaeser New URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	924.93
Annual operating cost (R million/annum)	28.45
NPV Cost (R million)	1 304.26
Unit Reference Value (R/m^3)	2.49

14.3.6 Ecological Impact

Sensitivity: **Medium:** ESA 1 and ESA 2 features occur across the site, mainly along watercourse corridors. The most western section of the site however falls within an ESA 1, which is classified as a climate change corridor. A small section to the south east falls within the Knersvlakte protected area expansion in terms of the NPAES.

Recommendation: Avoid the ESA 1 area to the west, as well as the NPAES focus area to the south east of the study area. All watercourse corridors should be buffered by a specialist and avoided as far as possible. Development should be limited to outside the 1:100-year floodline of the streams in the study area.

14.3.7 Summary of Option 18: Ebenhaeser New

This option has high environmental concerns and a medium URV, which is ascribed to the large scale of the scheme. Very high water losses of over 50% will be experienced, because of river conveyance losses in the lower Olifants River below Bulshoek Weir, and a high leaching requirement. This option has very high opportunity costs as a result of these high water losses. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Ebenhaeser scheme should be considered.

This scheme may hold potential for the development of 7.5 ha plots, given its relative closeness to Lutzville. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

14.4 Option 19: Lutzville 2

14.4.1 Layout of Option 19: Lutzville 2

The option layout is shown in **Figure 14.1**.

14.4.2 Description of Option 19: Lutzville 2

Distribution will be done by releasing water from Bulshoek Weir and pumping it from the lower Olifants River on the right bank. The land is mainly privately-owned.

The irrigable area, located to the north of Lutzville, is 4 145 ha.

This option involves the construction of a ±7.1 km long, 1 300 mm diameter steel rising main from the pump station located at the pumping point at the Olifants River. The pumping head from the river to the farm dam is 129 m.

14.4.3 Net Water Requirements and Losses

The water requirement is 41.97 million m^3/a.

Total losses are 20.4 million m^3/a.

14.4.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst on average) for the seven (7) summer months of irrigation, a balancing dam of 19.1 million m^3 is required, in addition to the farm dam used for operational storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

14.4.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.7**. The URV for this option is given in **Table 14.8**.

Table 14.7 | Option 19: Lutzville 2 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Prof. design & support	Total Cost
114.18	173.60	548.01	8.45	87.52	126.62	1 058.39

Table 14.8 | Option 19: Lutzville 2 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	1 058.39
Annual operating cost (R million/annum)	26.29
NPV Cost (R million)	1 378.75
Unit Reference Value (R/m^3)	2.84

14.4.6 Ecological Impact

Sensitivity: **Medium:** ESA 1 and ESA 2 features occur across the site, mainly along watercourse corridors.

Recommendation: All watercourse corridors should be buffered by a specialist and avoided as far as possible. Development should be limited to outside the 1:100-year floodline of the streams in the study area.

14.4.7 Summary of Option 19: Lutzville 2

This option has moderate environmental concerns and a high URV. Very high water losses of over 50% will be experienced, mainly because of river conveyance losses in the lower Olifants River below Bulshoek Weir, and a high leaching requirement. This option has high opportunity costs as a result of these high water losses. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Lutzville 2 scheme is to be considered.

This scheme may hold potential for the development of 7.5 ha plots, given its relative closeness to Lutzville. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

14.5 Option 20: Use of Spare Capacity in the Naauwkoes Canal Section - Klawer

14.5.1 Layout of Option 20: Canal Spare Capacity - Klawer

The option layout is shown in **Figure 14.2**.

14.5.2 Description of Option 20: Canal Spare Capacity - Klawer

Certain sections of the Lower Olifants canal still have some spare capacity, because of the way that the canal has been constructed. This situation offers the potential for additional flows to be released from the Bulshoek Weir down the Olifants River and to then be pumped into identified canal sections with spare capacity, for irrigation water to be distributed via existing canal infrastructure. Refer to **Figure 14.3** that indicates the various canal sections of the Lower Olifants canal.

An evaluation was done of the spare capacity in the left bank canal sections, i.e. the Main (Trawal), Naauwkoes, Vredendal and Sandkraal canal sections. The information on the carrying capacity from the 2004 LORWUA study was found to be incorrect, and the evaluation was based on information on historical canal flows and LORWUA's current estimate of the carrying capacity of canal sections. It is evident that the main canal (Trawal section) has very limited, if any spare capacity during the summer months. The Sandkraal canal section is also restrictive, with little spare capacity. Indications are that there is spare capacity in the Naauwkoes canal section, even during the summer months. A similar pattern has been detected for the Vredendal canal, albeit to a lesser extent. There is however some concern that the historical flows provided by LORWUA may indicate greater spare canal capacity than may actually be the case. This would need to be further evaluated.

The estimated flow capacities of the various canal sections are indicated in **Table 14.9**.

Table 14.9 | Capacities of canal section

Maximum flows	Main canal	Naauwkoes	Vredendal	Sandkraal
Max flow capacity in m^3/hr	26 800	9 740	6 516	2 750
Max flow capacity in m^3/week	4 502 400	1 636 320	1 094 688	462 000

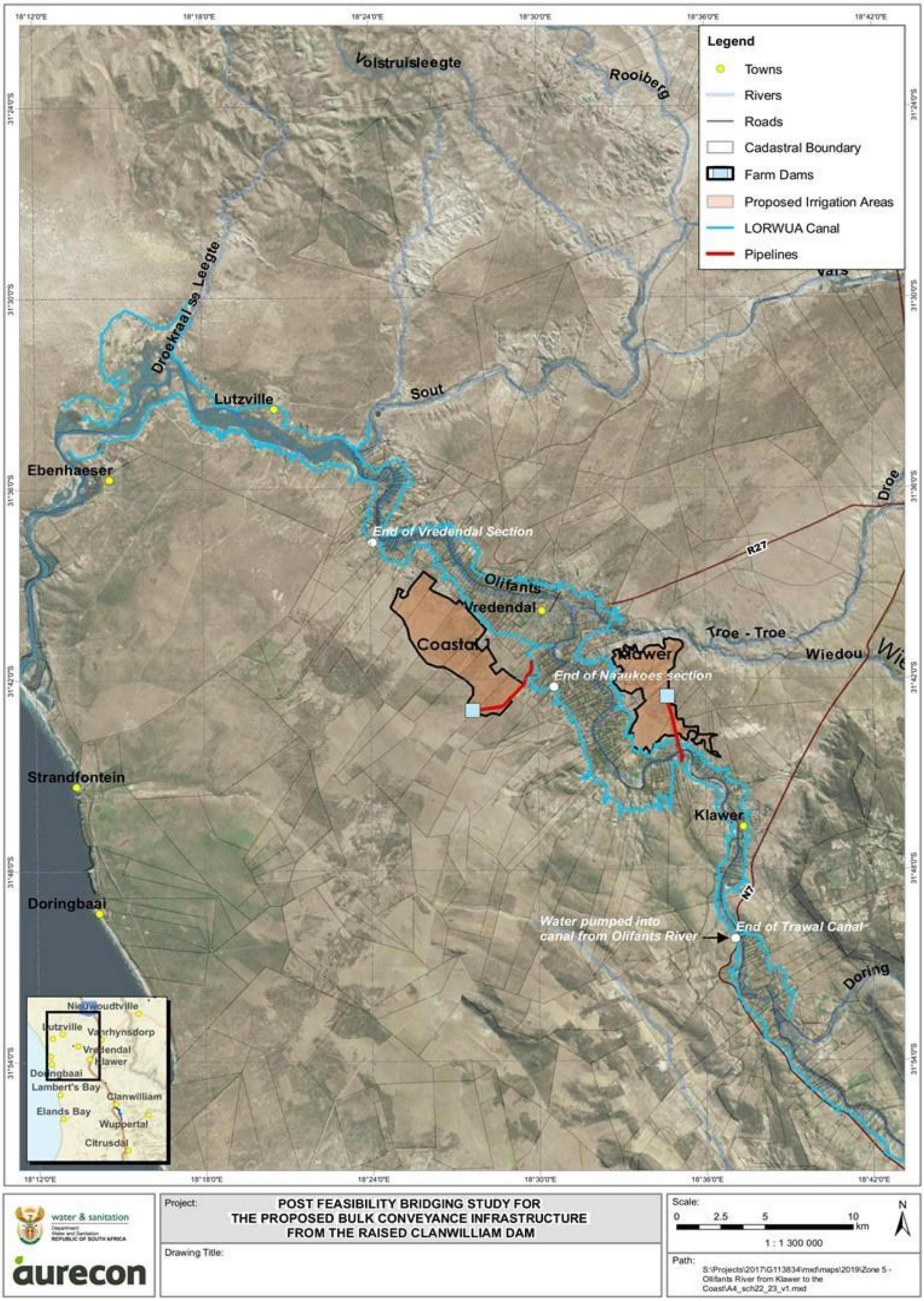

Figure 14.2 │ Layout of Options 20 and 21: Canal Spare Capacity – Klawer and Coastal 1

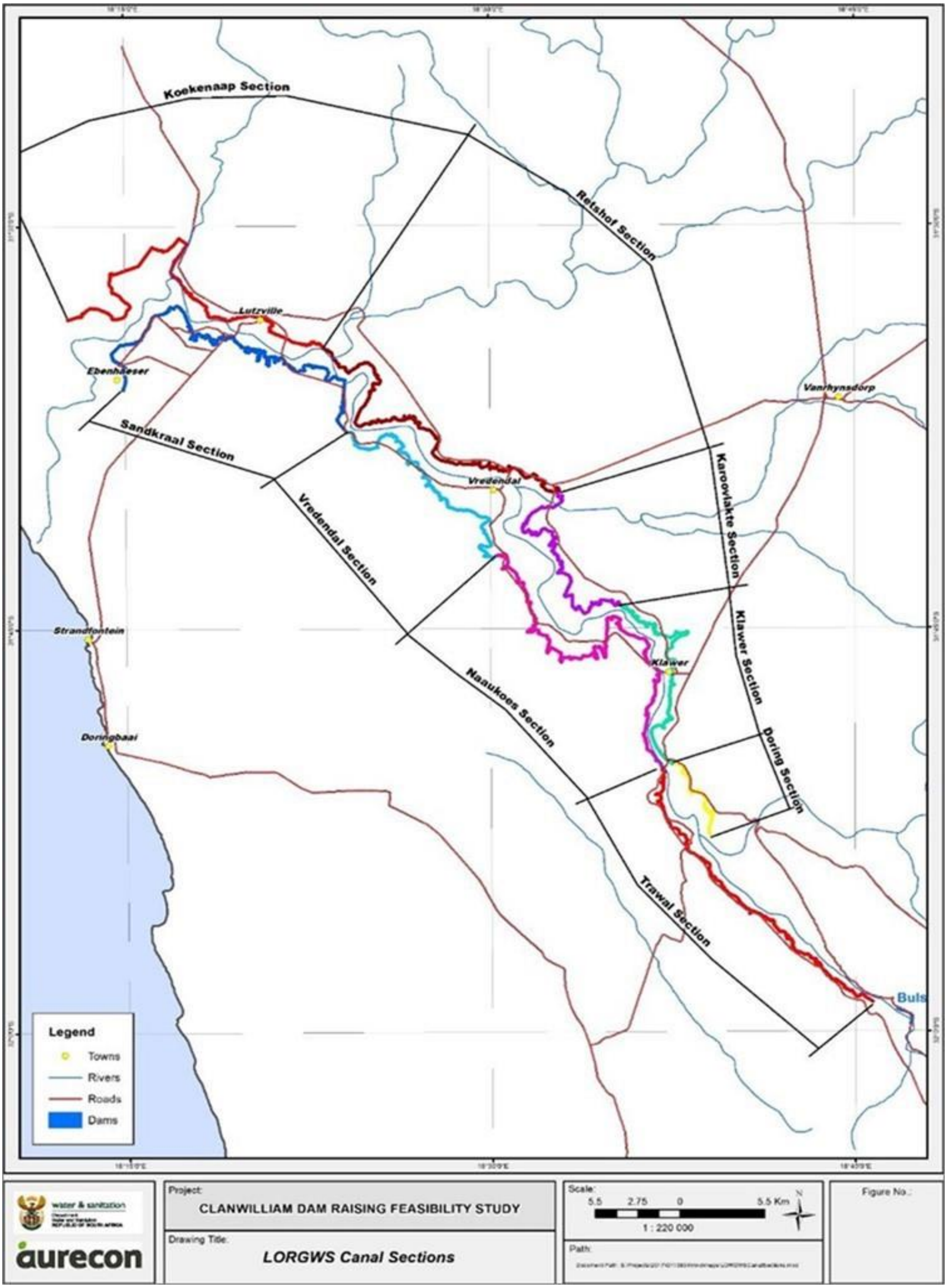

Figure 14.3 │ Canal Sections of the Lower Olifants Canal

Additional flow in the existing would increase the risk of canal failure. Lining of such canal sections is a way to reduce the risk, although this is not a very practical measure, due to construction constraints.

For this development option, it has been assumed that the Klawer irrigation area will be irrigated.

Two sub-options were considered. For Sub-option 20a, it has been assumed that the full Klawer irrigation area of 1 449 ha will be irrigated and that a 15 km section (with increased flows) of the Naauwkoes canal section will be concrete-lined. For Sub-option 20b, a scaled-down area of 818 ha will be irrigated, and no canal lining has been allowed for.

Option 20a involves the construction of a ±0.38 km long, 600 mm diameter steel rising main from the pump station, located at the pumping point from the Olifants River at 'Verdeling' (where the N7 highway crosses the river), to transfer additional water into the Naauwkoes canal section, at a pumping head of 44 m. At the abstraction point from the canal, a very small balancing dam and reject will be constructed.

Distribution from the canal to the farm dam involves the construction of a ±3.9 km long, 1 000 mm diameter steel rising main. The pumping head from the river to the dam is 77 m. For Sub-option 20b, the distribution from the canal to the farm dam will be done through a 700 mm diameter steel rising main, while the rest of the scheme will be similarto Sub-option 20a.

14.5.3 Net Water Requirements and Losses

The water requirements are the following:

- Option 20a: 14.67 million m^3/a.
- Option 20b: 8.28 million m^3/a.

Total losses are the following:

- Option 20a: 5.72 million m^3/a.
- Option 20b: 3.23 million m^3/a.

14.5.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A small disadvantage of this option will be the slightly poorer water quality at the abstraction site, compared to water quality in the Lower Olifants canal, because of mixing of good quality water from Bulshoek Weir with the more saline Doring River water, as well as saline irrigation return flows between Bulshoek Weir and the abstraction site. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably deteriorate slightly to an Acceptable category (EC 25 - 75 mS/m, TDS 160 - 480 mg/l).

The impacts on domestic users that take water directly from the canal would probably be minimal. As the abstraction point from the river is located not that far downstream of the Doring River confluence, the impacts on salinity would be limited to the last few weeks of the dry season when the Doring River becomes moderately saline.

14.5.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.10** for Option 20a and in **Table 14.11** for Option 20b. The URVs for this (development) option is given in **Table 14.12**. The URV has been calculated for the development option with the lowest cost (Sub-option 20b - no betterments).

For the division of the cost of lining the canal between existing and new irrigators, it has been assumed that 15% of the existing irrigators from the Lower Olifants canal will derive benefit from the lining of the canal sections, as well as all new irrigators.

Table 14.10 │ Option 20a: Canal Spare Capacity - Klawer Comparative Capital Costs in million Rand

Cost distribution	Pipelines	Pump stations	Balancing dam & Farm dam	Lining of existing canal	Purchase of land	Prof. design & support	Total Cost with lining
Development	17.39	35.26	13.00	139.00	30.57	13.99	**249.22**
Betterment	0	0	0	176.00	0	44.13	**220.12**
TOTAL	**17.39**	**35.26**	**13.00**	**315.00**	**30.57**	**58.12**	**469.34**

Table 14.11 │ Option 20b: Canal Spare Capacity – Klawer Scaled-down Comparative Capital Costs in million Rand

Pipelines	Pump stations	Balancing dam & Farm dam	Purchase of land	Lining of existing canal	Prof. design & support	Total Cost
20.14	30.37	7.33	15.54	0	9.69	83.07

Table 14.12 | Option 20: Canal Spare Capacity: Klawer URV in R/m^3

Item	Option 20a: Discount Rate 8%	Option 20b: Discount Rate 8%
Total comparative capital cost (R million)	249.22	83.07
Annual operating cost (R million/annum)	6.77	3.83
NPV Cost (R million)	316.16	141.51
Unit Reference Value (R/m^3)	1.86	1.47

14.5.6 Ecological Impact

Sensitivity: High: The whole area where the pipeline is located (to abstract water from the river and transfer to the canal) is mapped as a CBA 1 and ESA 2 along the river riparian zone. It also falls within the floodplain of the Olifants River. The area of abstraction from the canal to transfer to a farm dam is partially mapped as ESA 1 and ESA 2 for watercourse protection.

Recommendation: A freshwater ecologist would have to be consulted and site assessments undertaken to determine the impact of the pipeline construction on the ecological functioning of the riparian zones and watercourse corridors. Proper rehabilitation of the pipeline routes would be very important as well as post-construction monitoring and invasive alien vegetation removal.

14.5.7 Summary of Option 20: Canal Spare Capacity - Klawer

This option has high environmental concerns and a low (Option 20b) to medium (Option 20a) URV. High water losses will be experienced, because of high river conveyance losses in the lower Olifants River below Bulshoek Weir and a high leaching requirement. This option has high opportunity costs as a result of the high water losses (40%).

Water quality will vary from ideal to acceptable. This scheme may hold potential for the development of 7.5 ha plots, given its location between Klawer and Vredendal. There is some concern of the effect of the additional head on the integrity of the old canal, although this will be mitigated if the full capacity of the Naauwkoes canal section is not used. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate. The uncertainty regarding the actual spare capacity in the canal would need to be clarified.

14.6 Option 21: Use of Spare Capacity in the Naauwkoes / Vredendal Canal Sections - Coastal 1

14.6.1 Layout of Option 21: Canal Spare Capacity - Coastal 1

The option layout is shown **Figure 14.2**.

14.6.2 Description of Option 21: Canal Spare Capacity - Coastal 1

Is has been estimated that up to an additional 4 767 ha can be irrigated by utilising the full spare capacity in the Naauwkoes and Vredendal canal sections. Such additional flows would increase the risk of canal failure. Lining of such canal sections is a way to reduce the risk, although this is not a very practical measure, due to construction constraints.

For this Option, it has been assumed that the full Coastal 1 irrigation area, located near Vredendal on the left bank of the Olifants River, will be irrigated.

Two sub-options were considered. For Sub-option 21a, it has been assumed that the full Coastal 1 irrigation area of 2 235 ha will be irrigated and that a 37 km section (with increased flows) of the Naauwkoes and Vredendal canal sections will be concrete-lined. For Sub-option 20b, a scaled-down area of 818 ha will be irrigated, and no canal lining has been allowed for.

Sub-Option 21a involves the construction of a ±0.38 km long, 1 000 mm diameter steel rising main from the pump station located at the pumping point from the Olifants River at 'Verdeling' (where the N7 highway crosses the river) to transfer additional water into the Naauwkoes canal section, at a pumping head of 44 m. At the abstraction point from the canal, a very small balancing dam and reject will be constructed.

Distribution from the canal to the farm dam involves the construction of a ±4.9 km long, 1 000 mm diameter steel rising main. The pumping head from the canal to the dam is 77 m.

Sub-option 21b involves the construction of a ±0.38 km long, 600 mm diameter steel rising main from the pump station located at the pumping point from the Olifants River at 'Verdeling' (where the N7 highway crosses the river) to transfer additional water into the Naauwkoes canal section, at a pumping head of 44 m. At the abstraction point from the canal, a very small balancing dam and reject will be constructed.

Distribution from the canal to the farm dam involves the construction of a ±1.2 km long, 600 mm diameter steel rising main. The pumping head from the canal to the dam is 78 m.

14.6.3 Net Water Requirements and Losses

The water requirements are the following:

- Option 21a: 22.63 million m^3/a.
- Option 21b: 8.28 million m^3/a.

Total losses are the following:

- Option 21a: 8.82 million m^3/a.
- Option 21b: 3.23 million m^3/a.

14.6.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A small disadvantage of this option will be the slightly poorer water quality at the abstraction site, compared to water quality in the Lower Olifants canal, because of mixing of good quality water from Bulshoek Weir with the more saline Doring River water, as well as saline irrigation return flows between Bulshoek Weir and the abstraction site. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably deteriorate slightly to an Acceptable category (EC 25 - 75 mS/m, TDS 160 - 480 mg/l).

The impacts on domestic users that take water directly from the canal would probably be minimal. As the abstraction point from the river is located not that far downstream of the Doring River confluence, the impacts on salinity would be limited to the last few weeks of the dry season when the Doring River becomes moderately saline.

14.6.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.13** for Option 21a and in **Table 14.14** for Option 21b. The URVs for this option is given in **Table 14.5**. The URV has been calculated for the development option with the lowest cost (Sub-option 21b - no betterments).

For the division of the cost of lining the canal between existing and new irrigators, it has been assumed that 30% of the existing irrigators abstracting from the Lower Olifants canal will derive benefit from the lining of the canal sections, as well as all new irrigators.

Table 14.13 │ Option 21a: Canal Spare Capacity – Coastal 1 Comparative Capital Costs in million Rand

Cost distribution	Pipelines	Pump stations	Balancing dam & Farm dam	Lining of existing canal	Purchase of land	Prof. design & support	Total Cost with lining
Development	49.06	106.07	20.04	322.18	47.18	29.06	**573.59**
Betterment	0	0	0	504.82	0	121.27	**626.08**
TOTAL	**49.06**	**106.07**	**20.04**	**827.00**	**47.18**	**150.33**	**1 199.67**

Table 14.14 │ Option 21b: Canal Spare Capacity - Coastal 1 scaled-down Comparative Capital Costs in million Rand

Pipelines	Pump stations	Balancing dam & Farm dam	Purchase of land	Lining of existing canal	Prof. design & support	Total Cost with lining
6.08	36.84	7.33	15.54	0	7.54	**73.33**

Table 14.15 │ Option 21: Canal Spare Capacity - Coastal 1 URV in R/m^3

Item	Option 21a Discount Rate 8%	Option 21b Discount Rate 8%
Total comparative capital cost (R million)	573.59	73.33
Annual operating cost (R million/annum)	19.10	4.46
NPV Cost (R million)	786.19	144.55
Unit Reference Value (R/m^3)	**3.01**	**1.51**

14.6.6 Ecological Impact

Sensitivity: **Low:** ESA 1 and ESA 2 features occur across the site along the watercourse corridors.

Recommendation: Avoid ESA 1 and ESA 2 along watercourse corridors as far as possible. Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.

14.6.7 Summary of Option 21: Canal Spare Capacity - Coastal 1

This option has Low environmental concerns. Option 21a has a high URV, while Option 21b has a low URV. High water losses will be experienced (both sub-options), because of high river conveyance losses in the lower Olifants River below Bulshoek Weir and a high leaching requirement. This option has high opportunity costs as a result of the high water losses (40%). Water quality will vary from ideal to acceptable.

The implementation of this option can be considered an option to be combined with Schemes 20 and 22. There is some concern of the effect of the additional head on the integrity of the old canal, although this will be mitigated if the full capacity of the Naauwkoes and Vredendal canal sections is not used.

This scheme may hold potential for the development of 7.5 ha plots, given its closeness to Vredendal. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate. The uncertainty regarding the actual spare capacity in the canal would need to be clarified.

14.7 Option 22: Use of Spare Capacity in the Naauwkoes / Vredendal Canal Sections - Ebenhaeser

14.7.1 Layout of Option 22: Ebenhaeser

The option layout is shown in **Figure 14.4**.

14.7.2 Description of Option 22: Ebenhaeser

The Ebenhaeser Community Project is located approximately 12 km from Lutzville. Ebenhaeser is scheduled under LORWUA for 257 ha of water rights that needs to be distributed to 153 plots (1.68 ha each) plus a commercial farmer with 8.6 ha. The water is delivered to an existing balancing dam at the end of the canal system. A pumped scheme to deliver the water under pressure is currently being constructed. The expectation from those who do not currently have rights to land and water in the community is high.

It is proposed (and there is already a planned layout of plots) that the area on this land will be expanded by at least 170 hectares. Some of this will replace land that cannot be rehabilitated and for which water is already scheduled. There is also other land that could be irrigated in the vicinity.

The successful land claim lodged by the Ebenhaeser Community has resulted in thirteen farm parcels being handed over to Ebenhaeser Community Project Association during March 2019;

with further farms to be handed over in future (44 farms are part of the longer-term restitution deliberations). In order to formulate this option with limited information, it has been assumed that the long-term incremental water requirement of the restitution farms will be 200 ha of the envisaged about 400 ha. The water allocations to these farms are currently inadequate. For example, there is a 14 ha farm with no water allocation, and a 62 ha farm with a 13 ha allocation.

The community has noted that in 1925 the government promised the people from Ebenhaeser access to 500 morgen (about 400 hectares) of irrigation water, which has not been honoured up to today. The expectation from the Ebenhaeser community is therefore that they receive priority. The area for augmentation of irrigation at or close to the existing Ebenhaeser community project has thus been assumed to be another 200 ha (i.e. somewhat in excess of the additional 143 ha required to provide the pronised 400 ha).

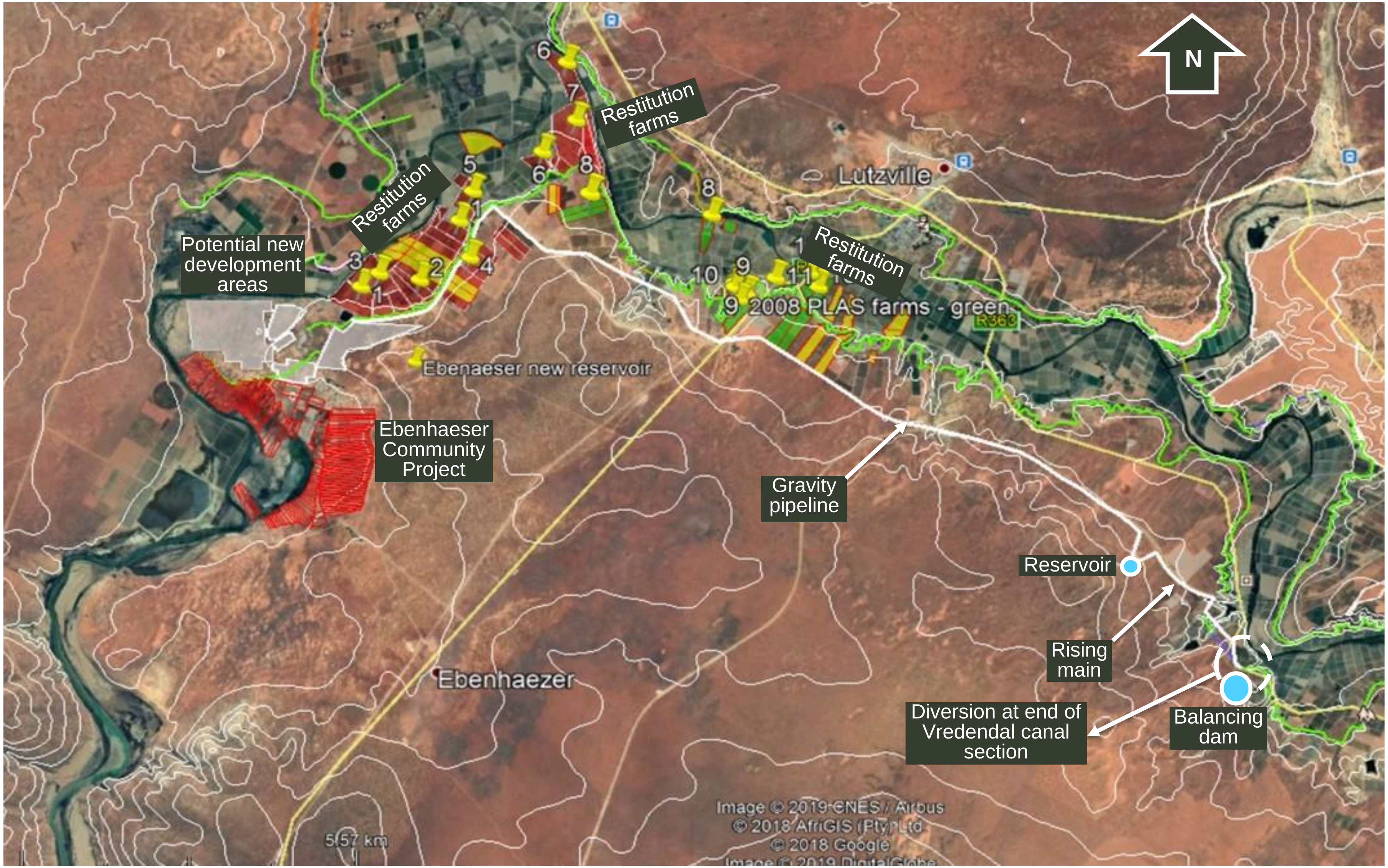

Figure 14.4 | Layout of Option 22: Ebenhaeser

The Naauwkoes, Vredendal and Sandkraal canal sections have some spare capacity because of the way that the canal has been constructed, although this is very limited in the summer months. Water can be released from the Bulshoek Weir down the Olifants River and can be pumped into the Naauwkoes canal section at 'Verdeling' (where the N7 highway crosses the Lower Olifants canal).

A 376 m long, 450 mm diameter pipeline is required to transfer water into the canal. From there water will flow in the existing Naauwkoes and Vredendal canal sections. At the end of the Vredendal canal section water will be diverted to a new balancing dam next to the canal that provides 30 days of balancing storage. Water will then be pumped, at a pumping head of 47 m, via a 450 mm diameter, 3.3 km long uPVC rising main, to a 5.6 Mℓ balancing reservoir. From there, water will be gravitated via a 315 mm, 16.6 km long uPVC gravity pipeline to the balancing dam located at Ebenhaeser.

14.7.3 Net Water Requirements and Losses

The incremental water requirement is 4.05 million m^3/a.

The total losses are 1.58 million m^3/a.

14.7.4 Water Quality

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A small disadvantage of this option will be the slightly poorer water quality at the abstraction site, compared to water quality in the Lower Olifants canal, because of mixing of good quality water from Bulshoek Weir with the more saline Doring River water, as well as saline irrigation return flows between Bulshoek Weir and the abstraction site. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably deteriorate slightly to an Acceptable category (EC 25 - 75 mS/m, TDS 160 - 480 mg/l).

The impacts on domestic users that take water directly from would probably be minimal. As the abstraction point from the river is located not that far downstream of the Doring River confluence, the impacts on salinity would be limited to the last few weeks of the dry season when the Doring River becomes moderately saline.

14.7.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 14.16**. The URV for this option is given in **Table 14.17**.

Table 14.16 | Option 22: Ebenhaeser Comparative Capital Costs in million Rand

Pipelines	Pump stations	Farm dam & balancing dam	Reservoir	Purchase of land	Prof. design & support	Total Cost
45.28	18.17	3.58	20.59	0.95	15.69	**120.19**

Table 14.17 | Option 22: Ebenhaeser URV in R/m³

Item	Discount Rate 8%
Total comparative capital cost (R million)	120.19
Annual operating cost (R million/annum)	3.20
NPV Cost (R million)	158.94
Unit Reference Value (R/m³)	3.39

14.7.6 Ecological Impact

Sensitivity: Medium: The whole area where the pipeline is located to abstract water from the river below Bulshoek weir and transfer to the canal is mapped as a CBA 1 along the river riparian zone. It also falls within the floodplain of the Olifants River, which is mapped as a wetland. The rising main pipeline from the canal to the reservoir in some sections falls within areas mapped as CBA 1, ESA 1 and ESA 2. Along the gravity pipeline towards Ebenhaeser are a number of small sections mapped as ESA 1 and ESA 2 aimed at watercourse protection.

The entire area is mapped as Namaqualand Strandveld, which is classified as Least Threatened (LT). The new reservoir site is located in an area which does not indicate any apparent environmental sensitivity. On the western side of the proposed new plots at Ebenhaeser is an area that falls within a CBA 1, which is approximately 70 ha in extent. This area is also bordered by a wetland to the west, north and south. The reasons for this sensitivity in the CBA area include Arid Estuarine and Inland Salt Marshes, wetland and watercourse protection and vegetation type.

Recommendation: A freshwater and estuarine ecologist would have to be consulted and site assessments undertaken to determine the impact of the pipeline construction and development plots on the ecological functioning of the riparian zones, nearby wetlands, estuaries, salt pans and watercourse corridors. A botanical specialist would also have to be consulted to confirm the vegetation type and species of concern along the pipeline route and development footprints. Proper rehabilitation of the pipeline routes would be very important as well as post-construction monitoring and invasive alien vegetation removal.

14.7.7 Summary of Option 22: Ebenhaeser

This option has Medium environmental concerns and a High URV. Water quality will vary from ideal to acceptable. High water losses will be experienced, because of high river conveyance losses in the lower Olifants River below Bulshoek Weir and a high leaching requirement. This option has high opportunity costs as a result of the high water losses (40%).

This option, albeit expensive, provides an opportunity to meet the needs of the Ebenhaeser community. This includes both incremental provision of water to farms handed over to the community in terms of a successful restitution process, as well as to augment the existing community project. This option can also be considered for implementation combined with options 20 and 21, depending on the exact extent of spare capacity in the existing canal sections.

There is some concern of the effect of the additional head on the integrity of the old canal. The uncertainty regarding the actual spare capacity in the canal would need to be clarified.

15 Zones 4 and 5, LORGWS (Bulshoek) Canal

This Chapter describes options relating to increased irrigation from the LORGWS canal.

15.1 Option 23: Replace All or Sections of the LORGWS Canal with a Pipeline with Increased Capacity

15.1.1 Layout of Option 23: Replace Canal with Pipeline

The option layout is shown in **Figure 15.1**.

15.1.2 Description of Option 23: Replace Canal with Pipeline

An alternative to replacing sections of the canal with a new lining would be to replace all sections of the existing Lower Olifants canal with a pipeline. Such a pipeline will have a very large diameter, reducing in size in a downstream direction. The practicality of implementing this option would be problematic for a number of reasons. The space to install such a large pipeline is very limited and the canal must continue to supply water to the area. It would not be possible to shut down the scheme to install the pipeline. Although impractical, this option has been investigated in order to obtain a comparative cost.

This option will supply water for irrigation under pressure to the Zypherfontein 1, Zypherfontein 2, Trawal, Melkboom, Klawer and Coastal 1 irrigation areas, as well as existing irrigators. The irrigable area considered for this Option is 6 257 ha.

The pipeline from Bulshoek Weir on the left bank of the Olifants River (from Bulshoek Weir to Ebenhaeser) would involve the construction of a ±91.7 km long, steel gravity pipeline. The first section of the pipeline will have a 3.3 m diameter, reducing to 1.0 m diameter for the last section.

The pipeline on the right bank of the Olifants River (from Verdeling past Koekenaap), branching from the Bulshoek main pipeline at 'Verdeling' would involve the construction of a ±82.9 km long, 2.0 m diameter steel gravity pipe system, reducing to 1.2 m diameter.

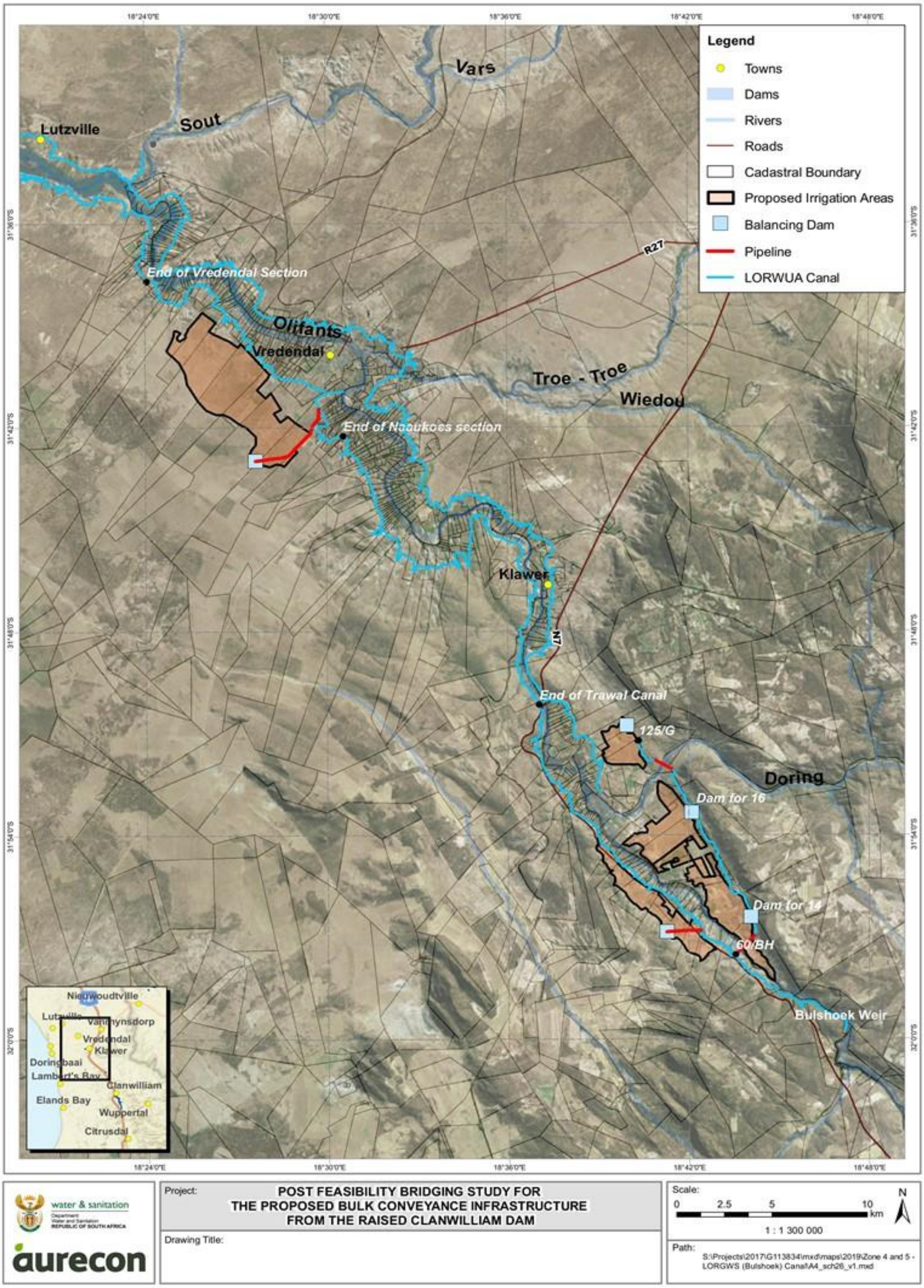

Figure 15.1 │ Layout of Option 23: Replace Canal with Pipeline

The pipeline to replace the existing canal on the right bank to the confluence of the Olifants and Doring rivers (would branch off from the Bulshoek main pipeline. This involves the construction of a ±7.4 km long, 800 mm diameter steel gravity pipe system.

15.1.3 Net Water Requirements and Losses

The water requirement is 60.51 million m^3/a.

Total losses are 4.84 million m^3/a.

15.1.4 Water Quality

The water quality is good. A leaching requirement of 13% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

15.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 15.1**. The URV for this option is given in **Table 15.2**.

The division of the comparative capital cost between existing irrigators (betterments) and new irrigators (development) was done according to the factor of new water allocations to new total use (existing irrigation water use plus new allocations).

Table 15.1 │ Option 23: Replace Canal with Pipeline Comparative Capital Costs in million Rand

Cost distribution	Pipelines	Balancing Reservoir	Farm dams	Purchase of land	Prof. design & support	Total Cost
Development	2 353.93	141.48	12.4	122.95	144.79	**2 949.09**
Betterment	4 184.77	251.52	0.00	0.00	922.85	5 359.14
TOTAL	**6 538.7**	**393.0**	**12.4**	**122.95**	**1 067.64**	**8 308.23**

Table 15.2 | Option 23: Replace Canal with Pipeline URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	2 949.09
Annual operating cost (R million/annum)	66.61
NPV Cost (R million)	3 446.89
Unit Reference Value (R/m^3)	5.34

15.1.6 Ecological Impact

Sensitivity: **Medium:** The sensitivity would depend on whether the pipeline would fall within the same footprint of the current canal or whether new areas will be disturbed, and where these areas would be. It will however not be practical or possible to use the canal footprint. the sensitivity of the pipeline route and associated footprint of construction camps, roads, stockpile areas, turning circles, etc. would be medium to high, depending on location. There would also be a socio-economic impact due to existing development being affected by the pipeline route.

There is also a section with endangered vegetation along Options 5 and 6. Work within the regulated area of a watercourse or wetland would have to be authorised by DWS and freshwater specialist inputs would be required.

Recommendation: Follow roads / existing canal where possible. Avoid CBA 1 areas and threatened ecosystems which contain endangered vegetation. The pipeline route should be planned together with a botanical and freshwater specialist to avoid sensitive areas and agree on suitable areas to be used for stockpiling, turning, construction camps, etc.

The heritage value of the canal should also be determined by including Heritage Western Cape in the planning process, to determine authorisation requirements and possible specialist studies from a heritage perspective for the entire canal route.

15.1.7 Summary of Option 23: Replace Canal with Pipeline

This option has moderate to high environmental concerns, but a very high URV and large capital requirement. Water losses will be low. In addition to the very high comparative cost and URV, this option would be very impractical to construct through an area that is already developed.

15.2 Option 24: Increase Capacity of LORGWS Canal and Other Betterments

15.2.1 Layout of Option 24: Increase Canal Capacity

The option layout is shown in **Figure 15.2**.

15.2.2 Description of Option 24: Increase Canal Capacity

This option involves increasing the capacity of the canal system by raising the canal or increasing its profile. If the canal had a larger carrying capacity, more water could be made available for irrigation downstream of the Bulshoek Weir, especially since the bulk of suitable irrigation areas is located very low down in the Olifants River catchment.

This option will supply water for irrigation via the raised/lined sections of the existing Lower Olifants canal, and will supply the Zypherfontein 1, Zypherfontein 2, Trawal, Melkboom, Klawer and Coastal 1 irrigation areas, as well as existing irrigators. For each of the new irrigation areas, water will be diverted from the canal and stored in small balancing dams next to the canal, from where it will then be pumped to the respective farm dams of the new irrigation areas. The left bank canal will be raised/lined to accommodate the increased flows, from Bulshoek Dam to the offtake from the canal to the Coastal 1 irrigation area. The canal sections to be raised/lined will be the Trawal, Naauwkoes and Vredendal canal sections.

It will be a significant challenge to undertake construction on the canal/s while water needs to flow to irrigators. This would require a bypass during construction, which is disruptive and very expensive. Another approach could be to construct new canal sections, depending on the availability and accessibility of land, and joining them into the existing canal. The joining of new canal sections to existing badly degraded concrete lining is not good practice and should generally be avoided.

The need for required betterments for critical, degraded sections of the canal system is documented in the *Existing Infrastructure and Current Agricultural Development* Report of this study. These betterments could potentially increase the capacity of some canal sections so that additional irrigation flows can reach new agricultural development areas.

The irrigable area for this option is 6 257 ha.

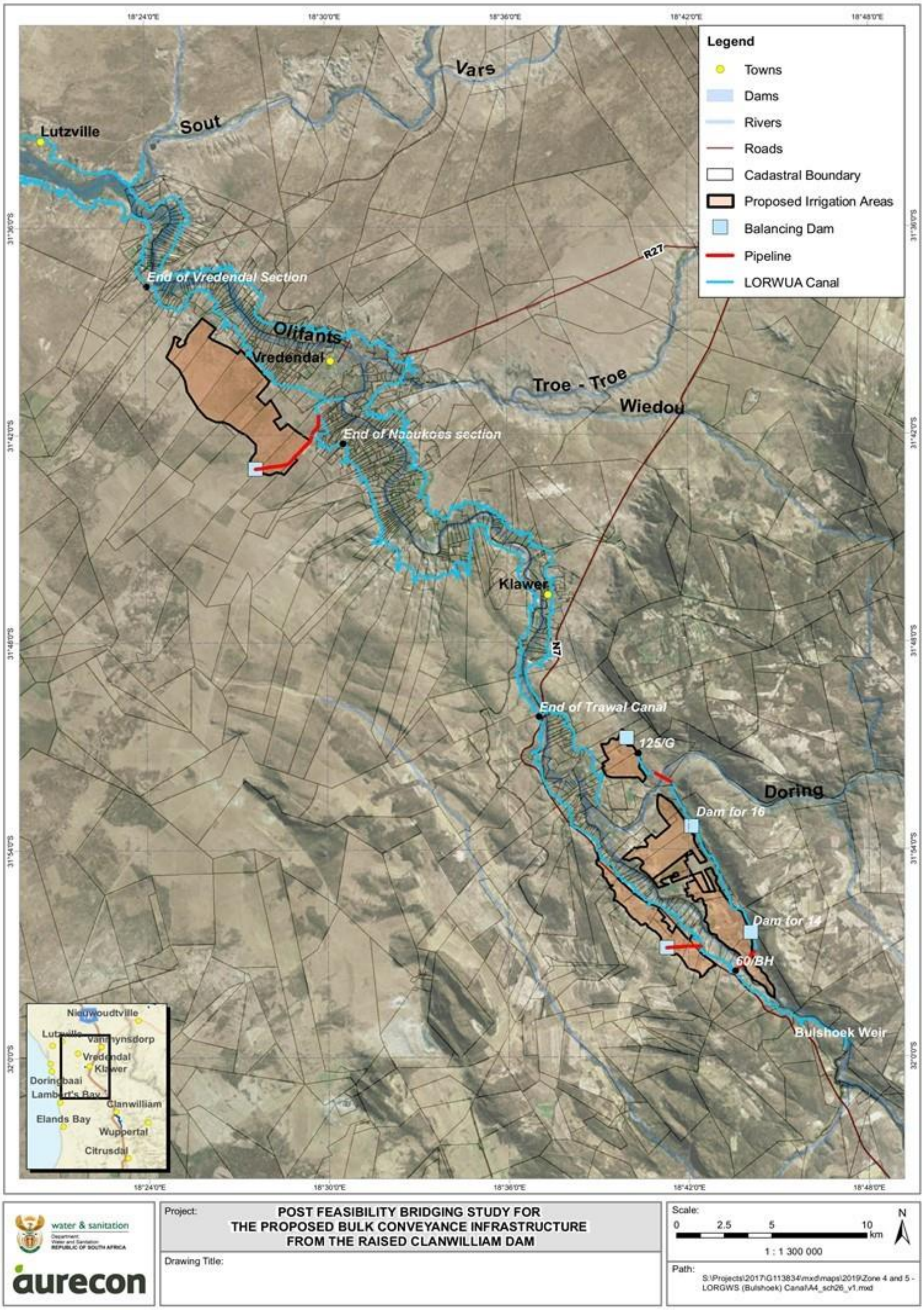

Figure 15.2 │ Layout of Option 24: Increase Canal Capacity

15.2.3 Net Water Requirements and Losses

The water requirement is 60.51 million m^3/a.

Total losses are 9.08 million m^3/a.

15.2.4 Water Quality

The water quality is good. A leaching requirement of 13% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

15.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 15.3**. The URV for this option is given in **Table 15.4**.

The division of the comparative capital cost between existing irrigators (betterments) and new irrigators (development) was done according to the factor of new water allocations to new total use (existing irrigation water use plus new allocations).

Table 15.3 | Option 24: Increase Canal Capacity Comparative Capital Costs in million Rand

Cost distribution	Pipelines	Balancing Reservoir	Farm dams & balancing dams	Purchase of land	Raising & lining of canal	Prof. design & support	Total Cost
Development	101.13	179.17	17.54	122.95	413.12	111.41	**945.32**
Betterment	0	0	0	0	806.88	121.03	927.91
TOTAL	**101.13**	**179.17**	**17.54**	**122.95**	**1220.00**	**232.44**	**1 873.23**

Table 15.4 | Option 24: Increase Canal Capacity URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	945.32
Annual operating cost (R million/annum)	24.10
NPV Cost (R million)	1,173.76
Unit Reference Value (R/m^3)	1.92

15.2.6 Ecological Impact

Sensitivity: **Low:** If the existing canals are used.

Recommendation: Use the existing canal footprint as far as possible. If any natural areas or watercourses would be affected, then specialist input would be required. The heritage value of the canal should also be determined by including Heritage Western Cape in the planning process, to determine authorisation requirements and possible specialist studies from a heritage perspective for the entire canal route.

15.2.7 Summary of Option 24: Increase Canal Capacity

This option has Low environmental concerns and a low URV. There are concerns relating to an increase in flow in the existing canal, without significant refurbishment, as the canal infrastructure is currently in a poor condition. The lining of the existing canal is expected to be very challenging. This option would rely on the availability of betterment funds.

16 Meetings with Land Owners and Communities

Once the evaluation of the irrigation development options was complete, an initial identification of the preferred development options was done. This was discussed at the 13 February 2019 Project Steering Committee meeting, but preferred options have not yet been approved.

It was noted that the preferred development options typically cross several farms in private ownership. To proceed to feasibility design of these preferred options, the designers need to understand whether they need to design for large government water schemes, following the expropriation of private land, or whether allowance should be made for some owners who want to enter into a joint-venture with HDI farmers for new irrigation areas, and that such design be done at a farm level. An alternative is also that the private development be left to such farmers. The institutional model/s to be selected for implementation thus influences the approach to design. As these institutional models are unknown at this stage, it was proposed that the best way to limit this uncertainty is to meet with land owners, to try and get clarity on the way forward.

A site visit to the study area was hence arranged from 14 to 16 May 2019 and four separate meetings were held with land owners (geographical clusters of preferred options) or communities over a three-day period, to get clarity and to limit changes to options that may excessively influence the feasibility design. The meetings are indicated in **Table 16.1**.

Table 16.1 | Meeting held with land owners / communities

Date	Venue	Options / WUA
14 May 2019	Augsberg Farm. Department of Agriculture lecture room	Clanwilliam WUA Option 1 Jan Dissels Option 2 Abstraction from Clanwilliam Dam
15 May 2019	Augsberg Farm. Department of Agriculture lecture room	Clanwilliam WUA Option 4 Pumping from Olifants River - Zandrug Option 5 Abstraction from Bulshoek Weir
15 May 2019	LORWUA office, Vredendal	LORWUA Option 15 Right Bank Canal, including:

Date	Venue	Options / WUA
		• 9 Zypherfontein 1 • 10 Trawal • 11 Zypherfontein 2 • 12 Melkboom Option 20 Klawer Option 21 Coastal 1
16 May 2019	Ebenhaeser hall	Option 22: Ebenhaeser land owners and restitution beneficiaries
6 June 2019	Aurecon, Cape Town	Option 6: Jakkals River Irrigation Scheme (JRIS) and Graafwater (2 options) • 6a Pipeline transfer to Jakkals River (original proposed scheme) • 6b Pipeline via secondary road Option 7: Provision of water to coastal towns Option 8: Provision of water to JRIS, Graafwater, Lamberts Bay and Elands Bay

The objectives of these four meetings were to inform land owners and the WUAs about progress with the study to date, and specifically to inform them of the option/s on their land, as well as the desired outcomes of the project. The meetings also served to sensitise the land owners to project activities to follow, such as topographical surveys and geotechnical investigations. Maps were provided to the land owners indicating the locations of the preferred options.

It was indicated to the land owners that, following the meetings, the Department will decide on the options to be investigated further. It was stressed to the land owners that the meetings to discuss specific options does not confirm that their area will be one of the final irrigation options selected, and that there was no confirmation that they qualify for any additional water. It was also explained that other land owners or HDIs would not be excluded from the water application process.

The meetings were exploratory in nature. The intention was to gather information needed for the more comprehensive feasibility study, so that informed decisions can be made and the approach to future implementation of new irrigation schemes refined. This information included more information about specific land owners.

While some clarity and information were obtained at these meetings, it became evident that further information was needed to be able to define the preferred irrigation areas with more accuracy. The following questions were posed to farm owners by email to attempt to obtain the required information:

- Inform us if you are not interested in such a development at all - this is a current indication and we realise that interest will change with time.
- Notify us of those portions, indicated on the maps as possible land for irrigation projects, which are not suitable (too steep, rocky, etc.).
- Provide information on nearby areas not indicated on the maps, but which will benefit from potential irrigation development or expansion. There may also be dryland areas that have already been plowed but not indicated as possible future irrigation areas. This also applies to areas on nearby properties that may not be indicated on the maps. Keep in mind that some critical areas identified as critical biodiversity areas (CBAs) may potentially be developed if there are trade-offs. Information is available from the detailed farm planning already done by some landowners.
- Provide more information on possible HDI projects. These include hectares, type of crop planned, etc.
- We would also like to hear if there are any existing irrigation developments on properties (non-HDI) that cannot / will not be intensively developed when additional water allocations become available, so that the possible level of further development is not over-estimated.
- Please also let us know if there are any existing properties on which the irrigation needs have changed. For example, potatoes that will no longer be intensively developed and properties where it is planned to switch to other crops.

Many land owners have responded with the information as requested. This information, along with the information collected in the meetings, can be used to refine irrigation areas of relevant irrigation development options at the start of the feasibility design phase.

A separate meeting was held on 6 June 2019 to discuss the findings of the options located outside the Olifants River catchment. This meeting with representatives of the Sandveld Investment & Development Co. Ltd (SANID) Water provided feedback on the specific options that were evaluated and the outcomes.

17 Comparative Evaluation and Screening of Options

17.1 Criteria for Comparative Evaluation and Screening

The following screening criteria were identified for the comparative evaluation of schemes:

- Scheme location and size,
- Water loss percentage / irrigable area,
- NPV, URV and URV adjusted for the water loss factor,
- Opportunity costs,
- Environmental impacts,
- Risks,
- Social aspects and impacts,
- Practical implementation.

17.2 Comparative Evaluation of Options

The key features of the evaluated, short-listed options are documented in **Table 17.1**.

The following scheme features have been included in the table for comparison purposes:

- Scheme numbers, names and irrigable areas.
- Incremental water requirements, water losses and water loss percentages (total loss as a percentage of irrigation water requirements). Water loss percentages have been indicated as either low, medium or high.
- Costs: Comparative capital costs, NPVs, URVs, and URVs adjusted for the total water loss per option, both for irrigation development and betterment costs, where applicable. The adjusted URVs take into account the total water losses. The adjusted URVs are calculated by multiplying the unadjusted URVs by (1 + total water loss / net water requirement) for each option. The URVs and adjusted URVs have been indicated as either low, medium or high.
- The adjusted URVs are proxies for the (lost) opportunity costs associated with options that have high water losses.

- Environmental impacts, indicated as low, medium or high.
- Extent and type of implementation risks:
  - Water losses for river conveyance in the Olifants River below Bulshoek Weir and the Jakkals River. Estimated losses are of low confidence and are dependent on the extent of released flows relative to river channel size and climatic/weather conditions. Should actual river conveyance losses exceed estimations, this would make irrigation schemes that include river conveyance less feasible.
  - The significant extent of private land ownership and the associated acceptance of converting the use of land that is currently irrigated (and has associated water use authorisations) to higher-value crops.
  - Structural integrity of the existing canal. This is relevant where sections of the existing Lower Olifants canal will be used to convey flow to new irrigation areas, either with no alterations, or raised, or raised and lined.
  - Implementation and operational challenges of the new schemes.
  - The nature of the institutional implementation models and buy-in from existing farmers.
  - Political support for very costly schemes that will require continuous funding to sustain it. This will divert funds from more feasible schemes with a larger number of beneficiaries (in the context of this project) and divert funds from the fiscus in general.
  - Sources of funding for bulk water infrastructure of new irrigation developments or for betterments.
- Social development schemes, i.e. opportunities for either the development of 7.5 ha plots for social upliftment, or land restitution / augmentation of the existing Ebenhaeser scheme.

Table 17.1 | Comparative Evaluation of Options

#	Scheme name	Zone	Irrigable Area (90%) (ha)	Incremental Requirement (Mm^3/s)	Total losses (Mm^3/a)	Incr. Req + Losses (Mm^3/a)*	Loss %**	Total Capital Cost (R million)	Total Capital NPV Cost (R million)	Total NPV Cost (R million)	Capital Cost Betterments (R million)	Total NPV Cost Betterments (R million)	Capital Cost HDI Farmers (R million)	Total NPV Cost HD Farmers (R million)	URV (R/m^3)	URV (R/m^3) adjusted for losses	Environmental impact	Risks	Opportunity for 7.5ha plots / Land Restitution
1	**Jan Dissels**	2	148	0.87	0.00	0.87	0%	13.9	16.3	23.1			13.9	23.1	1.47	1.47	Medium	Low, some existing irrigation (leased land)	Yes
2	**Clanwilliam**	2	549	4.77	0.00	4.77	0%	38.3	48.1	73.7			38.3	73.7	1.26	1.26	Medium	Limited area of existing irrigation & land ownership	Yes
3	**Transfer of lower JD irrigators**	2	-	0.00	0.00	1.00	0%	0.0	0.0	0.0			0.0	0.0	0.00	0.00	Low	Very low	
4	**Zandrug**	2	1219	8.69	0.56	9.25	5%	84.6	103.5	144.1			84.6	144.1	1.11	1.17	High	Large area of existing irrigation & land ownership	Partial
5	**Bulshoek**	2	354	2.93	0.16	3.10	5%	33.3	40.3	57.6			33.3	57.6	1.52	1.60	Medium	Some existing irrigation & land ownership	
6a	JDRIS + Graafwater	3	3187	10.27	5.44	15.71	53%	544.4	684.9	1196.1			544.38	1196.07	10.05	15.38	High	Political support, (lost) opportunity cost	
6b	JDRIS + Graafwater	3	3187	10.27	0.31	10.58	3%	488.1	558.7	807.8			488.1	807.8	6.79	6.99	High	Political support	
7	Coastal towns - Elands Bay and Lamberts Bay	3	0	0.37	0.01	0.38	3%	86.7	81.2	92.6			86.7	92.6	21.61	22.19	High	More expensive than alternative sources	
8	JDRIS + Graafwater + Coastal towns	3	3187	10.63	0.32	10.95	3%	565.9	636.2	904.7			565.9	904.7	7.34	7.56	High	Political support	
9	**Zypherfontein 1**	4	888	7.94	2.30	10.24	29%	65.1	81.8	127.2			65.1	127.2	1.38	1.78	Medium	Land ownership, (lost) opportunity cost	
10	**Trawal**	4	695	6.64	1.92	8.56	29%	56.3	69.3	105.8			56.3	105.8	1.38	1.78	Medium	Land ownership, (lost) opportunity cost	
11	**Zypherfontein 2**	4	658	6.28	1.82	8.10	29%	58.4	70.0	104.6			58.4	104.6	1.44	1.86	Medium	Land ownership, (lost) opportunity cost	
12	**Melkboom**	4	333	3.45	1.00	4.45	29%	38.0	45.5	67.6			38.0	67.6	1.69	2.18	Medium	Land ownership, (lost) opportunity cost	
13	Options 10-11-12 (pipe from Bulshoek)	4	2241	21.40	1.07	22.47	5%	529.9	556.5	726.4			529.9	726.4	2.93	3.08	Medium	Land ownership	
14a	Options 10-12-13 (8km raised canal)	4	1878	17.93	2.69	20.62	15%	274.8	255.8	366.0			274.8	366.0	1.76	2.02	Medium	Canal structural integrity & land ownership	
14b	**Options 10-12-13 (8km raised & lined canal)**	4	1878	17.93	2.69	20.62	15%	504.8	547.3	669.0	199.7	256.2	305.1	412.8	1.99	2.29	Medium	Land ownership	
15	**New Right Bank canal & Options 10-11-12-13**	4	2574	24.31	3.69	28.25	15%	875.5	829.0	1027.3	514.0	508.7	361.4	518.6	1.82	2.10	Medium	Funding of betterments & land ownership	
16	Klawer	5	1449	14.67	6.16	20.83	42%	464.8	480.7	591.1			464.8	591.1	3.48	4.94	High	Water quality, land ownership, (lost) opportunity cost	
17	Aties Karoo	5	4500	45.56	20.50	66.06	45%	647.7	694.4	1032.1			647.7	1032.1	1.97	2.86	Medium	Water quality, land ownership, (lost) opportunity cost	Yes
18	Ebenhaeser New	5	4500	45.56	23.24	68.80	51%	924.9	974.7	1304.3			924.9	1304.3	2.49	3.76	Medium	Water quality, land ownership, (lost) opportunity cost	
19	Lutzville 2	5	4145	41.97	21.40	63.37	51%	1058.4	1074.1	1378.7			1058.4	1378.7	2.84	4.29	Medium	Water quality, land ownership, (lost) opportunity cost	
20a	Naauwkoes canal sections - Klawer + canal lining	5	1449	14.67	5.72	19.66	39%	469.3	426.8	515.5	220.1	199.3	249.2	316.2	1.86	2.59	High	Land ownership, (lost) opportunity cost	Yes
20b	Naauwkoes canal section - Klawer scaled-down	5	818	8.28	3.23	11.51	39%	82.7	97.3	142.6			82.7	142.6	1.49	2.07	High	Canal structural integrity & land ownership, (lost) opportunity cost	Yes

#	Scheme name	Zone	Irrigable Area (90%) (ha)	Incremental Requirement (Mm³/s)	Total losses (Mm³/a)	Incr. Req + Losses (Mm³/a)*	Loss %**	Total Capital Cost (R million)	Total Capital NPV Cost (R million)	Total NPV Cost (R million)	Capital Cost Betterments (R million)	Total NPV Cost Betterments (R million)	Capital Cost HDI Farmers (R million)	Total NPV Cost HD Farmers (R million)	URV (R/m³)	URV (R/m³) adjusted for losses	Environmental impact	Risks	Opportunity for 7.5ha plots / Land Restitution
21a	Naauwkoes/Vredendal canal sections - Coastal 1 + canal lining	5	2235	22.63	8.82	30.32	39%	1199.7	1104.1	1354.7	626.1	568.5	573.6	786.2	3.01	4.18	Low	Land ownership, (lost) opportunity cost	Yes
21b	**Naauwkoes/Vred canal sections - Coastal 1 scaled-down (818ha)**	5	818	8.28	3.23	11.51	39%	73.3	92.9	144.6			73.3	144.6	1.51	2.10	Low	Canal structural integrity, land ownership, (lost) opportunity cost	Yes
21c	**Coastal 1 small (818ha) Post-RB Canal *****	5	818	8.28	1.24	9.52	15%	53.7	63.3	93.2			53.7	93.2	0.97	1.12	Low	Canal structural integrity, land ownership	Yes
21d	**Naauwkoes/Vred canal sections - Coastal 1 scaled-down 2 (450ha)**	5	450	4.56	1.78	6.34	39%	38.8	48.7	74.3			38.8	74.3	1.41	1.96	Low	Canal structural integrity, land ownership, (lost) opportunity cost	Yes
22a	**Naauk/Vred canal sections - Ebenhaeser restitution & expansion**	5	400	4.05	1.58	5.63	42%	120.2	121.9	158.9			120.2	158.9	3.39	4.27	Medium	Canal structural integrity, land ownership, (lost) opportunity cost	Yes
22b	**Ebenhaeser rest & expansion river loss reduction Post-RB canal *****	5	400	4.05	0.61	4.66	18%	111.2	108.6	142.5			120.2	142.5	3.04	3.35	Medium	Canal structural integrity, land ownership	Yes
23	Replace canal with pipeline	5	6257	60.51	4.85	167.48	8%	8308.2	7122.8	8138.1	5359.1	4691.2	2949.1	3446.9	5.34	5.77	Medium	Funding of betterments & land ownership	Yes
24	Raise Lower Olifants canal + canal lining	5	4809	46.51	6.98	53.48	20%	1873.2	1666.5	1988.2	927.9	814.5	945.3	1173.8	1.92	2.21	Low	Funding of betterments & land ownership	Yes

** In addition to existing allocations*

*** In addition to existing losses*

**** Opportunity for 7.5ha plots / Land Restitution / Existing Ebenhaeser*

***** Not considering a contribution cost to the Right Bank canal*

17.3 Screening of Options

Based on the comparative evaluation the following deductions have been made.

17.3.1 Sub-area 1: Olifants River catchment upstream of Clanwilliam Dam

No options are recommended for this sub-area.

It is recommended that prospective irrigators in this sub-area continue to apply for water use authorisations for the use of water for irrigation, in the Olifants River valley upstream of the Clanwilliam Dam, according to the existing procedure. Since there is very little scope for additional irrigation development upstream of Clanwilliam Dam without creating more on-farm balancing storage, water for new irrigation in this sub-area would likely need to be abstracted from the Olifants River in winter and stored in new/enlarged off-channel farm dams. This is expected to be an expensive option.

Several dam sites were identified in the Olifants/Doring River Basin Study (DWAF, 1998), and were considered as possible storage dams to supply existing users and to allow for possible future development. This option will not be further evaluated in this study, but farmers will not be excluded from applying for water use authorisations according to the standard application procedure.

17.3.2 Sub-area 2: Clanwilliam Dam, Olifants River catchment from Clanwilliam Dam to and including Bulshoek Weir

The following four development options are **recommended** for feasibility-level design, totalling incremental water requirements + losses of 17.99 million m^3/a:

- **Option 1:** Jan Dissels
- **Option 2:** Clanwilliam
- **Option 4:** Zandrug
- **Option 5:** Bulshoek.

The Jan Dissels, Clanwilliam and Zandrug options, in addition, can be considered for the development of 7.5 ha plots, being located within a reasonable distance from Clanwilliam town. All these options are attractive from a financial perspective, as well as efficient use of water, considering their low water losses.

The **Transfer of Water Use Authorisations, Option 3**, for three farms of lower Jan Dissels River irrigators, to the Olifants River is **recommended**. This allocation will be from the 25% portion of the additional yield from the raised Clanwilliam Dam for improving the assurance of supply of existing users. The existing total water allocations of the 3 farmers are 1.0 million m^3/a. This option is expected to relieve pressure on the lower Jan Dissels River in summer and contribute to the improvement of the ecological condition of the lower Jan Dissels River. The option has no cost or water quality implication.

17.3.3 Sub-area 3: Schemes located wholly outside the Olifants River catchment

Evaluation of **Option 6a Jakkals River Irrigation Scheme Project (JRIS)** (including urban water supply to the town of Graafwater), which was identified by the Sandveld Investment & Development Co. Ltd (SANID) Water, indicates that this option will be excessively expensive (the most-costly of all the options evaluated) with excessively high water losses of over 50%, with a significant lost opportunity cost. The scheme would further be challenging to implement, due to it being an inter-basin transfer scheme, and is therefore not recommended for further analysis.

The following three additional options that were evaluated are all comparatively very expensive:

- **Option 6b:** Alternative JDRIS + Graafwater option
- **Option 7:** Supply to coastal towns
- **Option 8:** JDRIS + Graafwater + Coastal towns.

Option 7 is excessively expensive when compared to other urban water supply schemes and is more expensive than alternative sources such as the development of groundwater or seawater desalination.

These three options are not recommended for further analysis.

17.3.4 Sub-area 4: Olifants River catchment from Bulshoek Weir to Lutzville

Various supply options for four irrigation areas (Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom) have been evaluated in this sub-area, totalling incremental water requirements + losses from 22.7 to 31.36 million m^3/a respectively, depending on the type of conveyance:

- **Option 9:** Zypherfontein 1, supplied from Olifants River
- **Option 10:** Trawal, supplied from Olifants River
- **Option 11:** Zypherfontein 2, supplied from Olifants River
- **Option 12:** Melkboom, supplied from Olifants River
- **Option 13:** Options 10-11-12 (pipeline from Bulshoek Weir)
- **Option 14a:** Options 10-12-13 (8 km raised canal, syphon and small right-bank canal)
- **Option 14b:** Options 10-12-13 (8 km raised & lined canal, syphon and small right-bank canal)
- **Option 15:** New Right Bank canal replacing Trawal canal section & supplying irrigation areas 10-11-12-13

It is evident that a pipeline from Bulshoek Weir to supply these irrigation areas is too expensive when compared to the other conveyance options and it is therefore not recommended for further analysis.

The remaining conveyance alternatives to supply these four areas are shown in **Table 17.2**.

Table 17.2 | Comparison of NPV costs for Sub-area 4 conveyance alternatives

Conveyance alternative	Loss %	Total NPV Cost (R million)	Total NPV Betterments Cost (R million)	Total NPV Cost HDI Farmers (R million)	URV (R/m³)	URV (R/m³) adjusted for losses
9-12, Pumping from the Olifants River	29%	405		405	1.38-1.69	1.78-2.18
14b: 8 km raised and lined canal to 3 areas + 10: river supply to Trawal area	15%	669	256	413	1.99	2.29
15: New Right Bank canal replacing existing Trawal canal section + supplying all 4 new areas	15%	1027	509	519	1.82	2.10

Pumping from the Olifants River (Options 9 to 12) is the least expensive alternative, but with the highest losses. When other factors are taken into consideration, this is not necessarily the best conveyance approach, as this alternative will have significant opportunity costs, related to the high water losses, and associated implications for riverine ecology ascribed to the released flows from Bulshoek Weir.

Additional flows via sections or portions of the existing Lower Olifants canal should preferably only be considered along with the raising/lining of the existing canal sections, to limit the risk of canal failure. When there is adequate spare summer flow capacity in certain canal sections, it may not be necessary to line the canal sections. The lining of the existing canal will pose practical implementation problems, given the short periods of downtime available. For this reason, *Option 14a: 8 km raised canal to 3 irrigation areas* is not considered for further analysis.

Option 15: Right Bank Canal offers a conveyance option at a NPV of only 20% more than supply from the Olifants River, with 14% lower losses and reduced opportunity costs. It avoids the negative aspects of summer release flows impacting on the Olifants River and has a simpler operation. Given the low confidence in river loss estimations, any option that involves river releases from Bulshoek Weir introduces a high uncertainty and an associated risk that river losses could be higher than estimated.

The existing Lower Olifants canal is in a very poor state and places the entire LORGWS at significant risk of supply failure. This irrigation option, with an associated betterment capital cost of R 514 million and a total betterment NPV of R 509 million, presents a unique opportunity to cost-effectively replace the Trawal (main canal) section of the Lower Olifants canal, and safeguard the economy of the region.

Option 15: Right Bank Canal is therefore **recommended** for feasibility-level design.

17.3.5 Sub-area 5: Olifants River catchment from Klawer to the Coast

It is evident that supply to the identified large irrigation options in this sub-area, from released flows to the lower Olifants River is not desirable. The options are very expensive and will have very high water losses. There will be significant opportunity costs associated with these options, due to the high water losses. The evaluation undertaken has further demonstrated that scaled-down versions of these options supplied from the Olifants River would not be viable, because of the resulting poor water quality of summer releases at such abstraction points. At some point all irrigation water requirements should need to be pumped in the winter. The following options to supply water from the Olifants River are therefore **not recommended** for further analysis:

- **Option 16:** Klawer
- **Option 17:** Aties Karoo
- **Option 18:** Ebenhaeser New
- **Option 19:** Lutzville 2

17.3.6 Sub-area 5: Use of spare capacity in canal sections

Various sub-options have been identified to make use of the spare capacity in the left-bank Naauwkoes and Vredendal canal sections.

The following two large water supply schemes have been considered:

- **Option 20a:** Naauwkoes canal section - Klawer + canal lining
- **Option 21a:** Naauwkoes/Vredendal canal sections - Coastal 1 + canal lining

The lining of these existing canal sections was included in these options as such large additional flows via these canal sections add to the risk of canal failure. The lining of the existing canal will also pose practical implementation problems, given the short periods of downtime. The options have high associated river losses and medium to high costs. Opportunity costs will however be significant.

The Klawer irrigation area will in addition have high environmental impacts and require a syphon through the Olifants River, although the conveyance distance would be shorter. Both of these options offer the opportunity to develop 7.5 ha plots, being located close to the town of Vredendal. There is significant uncertainty whether additional large volumes required by these options can be conveyed via the existing canals, and there are also sufficient other options with better potential. These schemes should not be considered further, due to the practical implementation problems posed by the lining of the existing canal, given the short periods of downtime available.

Several sub-options for scaled-down irrigation schemes, that do not include lining of the canal sections, have further been considered. The following scaled-down irrigation options were considered:

- **Option 20b:** Naauwkoes canal section – Klawer Scaled-down (818 ha) scheme
- **Option 21b:** Naauwkoes/Vredendal canal sections – Scaled-down (818 ha) Coastal 1 scheme
- **Option 21c:** Coastal 1 scaled-down (818 ha) *Post-RB Canal*
- **Option 21d:** Naauwkoes/Vredendal canal sections - Coastal 1 scaled-down 2 (450 ha)

These schemes could be considered further, with the extent of such potential development determined by the actual extent of spare capacity in the various canal sections. The schemes have high associated river losses, but relatively low costs. Opportunity costs will however be significant.

The Klawer irrigation area will in addition have high environmental impacts and will require a syphon through the Olifants River, although the conveyance distance would be shorter. These options offer the opportunity to develop 7.5 ha plots, being located close to the town of Vredendal. They are more attractive if implemented following the implementation of Option 15: Right Bank Canal, as water losses will be significantly reduced. Should the option be implemented once a new Right Bank canal has been constructed, it will be more attractive financially.

Sub-options for irrigation supply to the Ebenhaeser community farmers – a combination of supply to restitution farms as well as augmentation of the existing community scheme, that does not include lining of the canal sections, have been considered:

- **Option 22a:** Naauwkoes/Vredendal canal sections – Ebenhaeser restitution and expansion of existing scheme
- **Option 22b:** Naauwkoes/Vredendal canal sections – Ebenhaeser restitution and expansion of existing scheme: *Post-Right Bank canal*

These schemes can provide an existing HDI community with additional water for restitution as well as expansion, meeting an existing need. The schemes have high associated river losses and high relative costs. Associated opportunity costs will be significant. While environmental impacts are medium, these will be mitigatable. Should the option be implemented after a new Right Bank canal has been constructed, it will become slightly more attractive.

The pipeline to Ebenhaeser may have other benefits such as potentially also supplying water to existing irrigators (if they will buy into the scheme) in high season when the Sandkraal canal section is limiting flow, although this may be tempered by the increased risk to the structural integrity of the canal. Exchange of water use between the existing canal and the pipeline can potentially also be done for practical or financial reasons for water provision to the restitution farms, where this is feasible, and an opportunity presents itself.

These options seem to have a high priority from a social perspective. All the development proposed are however HDI directed. By supplying this area, it would mean less HDI development in total. The difference though is that the Ebenhaeser community have a long-standing requirement for additional water, and the first of the restitution farms, which require allocations to augment the existing scheduled water, have been handed over to community recipients, with more to follow. These schemes should therefore be considered further.

17.3.7 Lower Olifants canal

The following options to replace the Lower Olifants canal and supply the additional irrigation water requirements have been considered

- **Option 23:** Replace canal with pipeline
- **Option 24:** Raise and line Lower Olifants canal

Replacing the LORGWS Canal with a pipeline (Option 23), with increased capacity, will be extremely expensive and is not recommended.

Option 24 is a less attractive alternative to Option 15: Right Bank Canal, considering the significant technical challenges associated with its implementation. Comparatively, Option 15 will have a shorter implementation time, offer the opportunity for a proper design of the canal section, be less disruptive and implementation will introduce increased operational flexibility.

18 Recommendations

18.1 Approach to Selection of Preferred Options

The following screening approach has been adopted, to identify the preferred irrigation development options:

1) Develop combinations of development options, hereafter called "Suites" up to the limit of 61.1 million m^3/a (= water requirements + losses).
2) Identify screening criteria and apply to the Suite of options.
3) Propose phases of development and associated budgeting implications.
4) Compare alternatives and recommend the preferred Suite.
5) Make recommendations for feasibility-level analysis and further issues to address.

18.2 Implementation alternatives

Three implementation alternatives (suites of options) have been assessed to illustrate the combinations of options, as shown in **Table 18.1** on the following page.

Table 18.1 | Alternative Implementation Phasing

			Suite 1 - Low cost, high river release				Suite 2 - incl small Trawal options canal				Suite 3 - incl Right-bank canal			
Option #	Scheme name	Zone	Incremental requirement + losses (Mm³/a)*	Phase A	Phase B	Phase C	Incremental requirement + losses (Mm³/a)*	Phase A	Phase B	Phase C	Incremental requirement + losses (Mm³/a)*	Phase A	Phase B	Phase C
1	Jan Dissels	2	0.87	0.87			0.87	0.87			0.87	0.87		
2	Clanwilliam	2	4.77	4.77			4.77	4.77			4.77	4.77		
3	Transfer of lower JD irrigators	2												
4	Zandrug	2	9.25	9.25			9.25	9.25			9.25	9.25		
5	Bulshoek	2	3.10	3.10			3.10	3.10			3.10	3.10		
9	Zypherfontein 1	4	10.24		10.24									
10	Trawal	4	8.56	8.56			8.56	8.56						
11	Zypherfontein 2	4	8.10		8.10									
12	Melkboom	4	4.45		4.45									
14b	Options 9-11-12 (8km raised & lined canal)	4					20.62		20.62					
15	New Right Bank canal & areas 9-10-11-12	4									28.25		28.25	
21c	Coastal 1 small (818ha) Post-RB Canal ***	5	6.34			6.34					9.52			9.52
21d	Naauwkoes/Vred canal sections - Coastal 1 scaled-down 2 (450ha)	5					6.34			6.34				
22a	Naauk/Vred canal sections - Ebenhaeser restitution & expansion	5	5.63	5.63			5.63	5.63			5.63	5.63		
22b	Ebenhaeser rest & expansion river loss reduction Post-RB canal ***	5									-0.97		-0.97	
	Water Requirements + Losses (Mm³/a)		**66.97**	37.84	22.80	6.34	**64.80**	37.84	20.62	6.34	**66.79**	29.28	27.99	9.52
	Incremental Water Requirements + Losses (Mm³/a)		**61.31**	32.18	22.80	6.34	**59.14**	32.18	20.62	6.34	**61.13**	23.62	27.99	9.52
	Water Requirements (Mm³/a)		**55.84**	33.61	17.67	4.56	**56.10**	33.61	17.93	4.56	**59.56**	26.97	24.31	8.28
	Incremental Water Requirements (Mm³/a)		**50.18**	27.95	17.67	4.56	**50.44**	27.95	17.93	4.56	**53.90**	21.31	24.31	8.28
	Losses (Mm³/a)		**11.13**	4.23	5.12	1.78	**8.70**	4.23	2.69	1.78	**7.23**	2.30	3.69	1.24
	Water Loss %		**20%**	13%	29%	39%	**16%**	13%	15%	39%	**12%**	9%	15%	15%
	Water Loss Fraction		**0.20**	0.13	0.29	0.39	**0.16**	0.13	0.15	0.39	**0.12**	0.09	0.15	0.15
	Hectares of new irrigation		**5,694**	3,365	1,879	450	**5,693**	3,365	1,878	450	**6,062**	2,670	2,574	818
	Phase % of (Req. + Losses)		**100%**	56%	34%	9%	**100%**	58%	32%	10%	**100%**	44%	42%	14%
	Development Capital Cost (R million)		**R530**	R330	R161	R39	**R674**	R330	R305	R39	**R689**	R273	R361	R54
	Betterment Capital Cost (R million)		**R103**	R0	R0	R103	**R200**	R0	R200	R0	**R514**	R0	R514	R0
	Total Capital Cost (incl. Betterments) (R million)		**R633**	R330	R161	R142	**R873**	R330	R505	R39	**R1,203**	R273	R875	R54
	Development NPV Cost (R million)		**R920**	R547	R299	R74	**R1,104**	R547	R413	R145	**R1,017**	R405	R519	R93
	Betterment NPV Cost (R million)		**R0**	R0	R0	R0	**R256**	R0	R256	R0	**R509**	R0	R509	R0
	Total NPV Cost (incl. Betterments) (R million)		**R920**	R547	R299	R74	**R1,360**	R547	R669	R145	**R1,526**	R405	R1,027	R93
	Development Capital Cost apportionment by Phase & Suite (%)		**100%**	62%	30%	7%	**100%**	49%	45%	6%	**100%**	40%	52%	8%
	Development NPV Cost apportionment by Phase & Suite (%)		**100%**	59%	33%	8%	**100%**	50%	37%	13%	**100%**	40%	51%	9%
	Development NPV Cost per hectare (R 1,000/ha)		**R162**	R162	R159	R165	**R194**	R162	R220	R321	**R168**	R152	R201	R114
	JD allocation moved to Olifants River		**1.00**	1.00			**1.00**	1.00			**1.00**	1.00		

18.3 Recommendation of Options

From the different phasing options, shown in **Table 18.1**, Phasing Suite 3 offers the opportunity to irrigate the largest area (6 062 ha). The development cost per hectare is marginally more expensive than that of Phasing Suite 1 (the lowest capital cost suite). Phasing Suite 3 further offers the unique opportunity to, in part, address the most significant risk currently posed to the Lower Olifants River Government Water Scheme (LORGWS), namely the very poor structural integrity of the canal system. This suite of options includes replacement of the main (Trawal) canal section with a new right bank canal, from Bulshoek Weir up to 'Verdeling', where the canal splits. This betterment would also offer the opportunity to lessen the restriction to flow in the main canal.

The following irrigation development options are recommended for feasibility design evaluation, based on the comparative evaluation and screening of identified options, to a total of 61.1 million m^3/a:

1) Option 1: Jan Dissels; pumping from Clanwilliam Dam.
2) Option 2: Clanwilliam; pumping from Clanwilliam Dam.
3) Option 4: Zandrug; pumping from the Olifants River.
4) Option 5: Bulshoek; pumping from Bulshoek Weir.
5) Option 15: Right Bank Canal; replacing the existing Trawal section of the Lower Olifants canal with increased capacity, supplying four new irrigation development areas (Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom) in the Trawal area and any increased downstream supply.
6) Options 20/21/22: Use of spare capacity in the Naauwkoes/Vredendal canal sections, supplying a combination of the restitution farms to be allocated to Ebenhaeser farmers, augmenting the existing Ebenhaeser community scheme, and potentially supplying a scaled-down Coastal 1 area near Vredendal (or possibly a scaled-down Klawer area), depending on the confirmation of spare capacities in canal sections.

In addition, the following option is recommended, from the 25% portion of the additional yield from the raised Clanwilliam Dam for improving the assurance of supply of existing users:

7) Option 3: Transfer of Jan Dissels River Water Use Authorisations to the Olifants River.

All the recommended options, with perhaps the exception of the Bulshoek option (Option 5), provides significant opportunity for the development of small (assumed 7.5 ha) plots, being located reasonably close to towns. These options also provide the opportunity to support a restitution scheme or an existing HDI scheme (Ebenhaeser).

The development phases, as shown in **Table 18.1**, or a variation thereof, are recommended as the preferred options. This should be revisited following the Feasibility Design of the preferred options.

The options located closest to the Clanwilliam Dam, especially those options located upstream of the Bulshoek Weir, are the most attractive options, as water can be provided for irrigation at low cost with limited losses.

While a rigorous process has been followed to identify the preferred development options, there is a possibility that some private landowners, whose lands do not fall within the current identified scheme areas, may be interested in HDI development schemes. Such, likely smaller in extent, HDI schemes could still apply for additional water through the application process for water authorisations, if such schemes are deemed feasible. This should be encouraged especially in the area between Clanwilliam Dam and Bulshoek Weir.

While it is evident that many existing land owners are interested in HDI irrigation development schemes, there still seems to be significant uncertainty among them, until the completion of the raising of the dam is more certain, and cost implications (tariffs) are better understood.

Considering the current level of knowledge of planned HDI developments, the development of such schemes are more likely to be a combination of private development (one or more farms per venture), and community supply, specifically the Ebenhaeser restitution farms and some augmentation of the irrigation at Ebenhaeser. The requirement for the development of one or more government irrigation scheme may only become clear with greater clarity of the likely uptake by existing land owners committed to HDI developments.

At this stage, options that can be designed as part of this study are the Jan Dissels option (in close cooperation with the Augsberg Agricultural School), the Right Bank canal, and the Ebenhaeser option. The remainder of the options will likely be private developments. It is expected that private land owners will incrementally apply for HDI development schemes along with their HDI partners.

It may be a requirement that land should also be made available to commercial black irrigators who do not wish to enter into a joint-venture arrangement with existing landowners, i.e. the development of a government water scheme. It is noted that the preferred irrigation options above Bulshoek Weir are so interwoven with existing irrigated areas, as well as land that can be more intensely farmed with permanent crops, that these options do not lend themselves well to development as government water schemes.

Should there be a need to identify and design a government water scheme at this stage, the four irrigation areas located in the Trawal area, namely Zypherfontein 1 and Zypherfontein 2, Trawal and Melkboom, (or portions thereof) should rather be considered, as these options contain large tracts of undeveloped land in private ownership. Certain portions of these areas could be supplied by gravity from a new Right Bank main canal, but, for most of these areas, water would need to be pumped from the new canal. Since this land is privately-owned, an option will be for government to acquire the land. It is therefore proposed that, as part of Option 15, an irrigation development option, or options, in the Trawal area be examined that can be developed as a government water scheme.

18.4 Further issues to address

Issues to address during feasibility design are the following:

- Revisit the spare flow capacities in the Naauwkoes and Vredendal canal sections, given the discrepancies between statements made by LORWUA officials and the spare capacity seemingly indicated by the evaluation of historical flows.
- Undertake an assessment of the risk associated with increasing the flow in the existing Naauwkoes and Vredendal canal sections.
- Refine the irrigable areas with information supplied by farmers and confirmation of the slopes. For the options not taken to the feasibility design stage, such information should be summarised for potential future use.
- Determine the actual water requirements of the Ebenhaeser restitution farms. This will be a process that should consider existing crops, irrigation methods and other relevant factors. To be on an equal footing with existing farmers, the original allocation of 12 200 m^3/ha may need to be used for calculations. While only some farms have been handed over, the requirements of future farms to be handed over also need to be considered.
- Evaluate the requirement for additional water supply to the Ebenhaeser community.
- Consider that most of the preferred options cover large areas that vary significantly in elevation, and that supplying new irrigation in the lower-lying areas will be less costly, and therefore more attractive than to supply the full option areas. This could be unpacked further, perhaps in a phased approach.
- Apart from the recommended options, it is likely that small feasible BEE schemes, especially for the expansion of existing farms, could eventually be submitted by existing farmers as part of licence applications. This should be kept in mind as an alternative to developing the most expensive land for irrigation, within the recommended options.
- The splitting of capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators) should be revisited, to ensure equity. This should preferably include a risk analysis of the current distribution system versus an upgraded one, and include economic and social implications of system failures, and the likelihood of these occurring over an economic period. In addition, the legal obligations on DWS to ensure that the infrastructure remains functional should be clarified.

- The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations. Options analysis has confirmed that the ecological impact and environmental issues relating to new development significantly influence and limit the scope of development options. Dialogue around these issues should take place between departments as soon as possible. While a detailed botanical assessment of the potential development areas will provide insight, this has not been allowed for in this study.
- In order to obtain greater clarity on funding options, it is suggested that DWS arrange a meeting with National Treasury to discuss implementation approaches. For this purpose, it will be necessary to have information at hand regarding economic and job creation implications of new investment, as well as the risks towards the economy and labour of potential canal failures if betterments are not undertaken. These will be determined during the Socio-Economic Impact Analysis phase of this Bridging Study.
- Adequate information is available for the following reports to be produced, using the layouts and costs of the preferred suite of options and the identified impacts:
    - Socio-Economic Impact Analysis Sub-Report
    - Agricultural Production and Farm Development Report
    - Socio-Economic Impact Analysis Report
- The topographic and geotechnical surveys should proceed for:
    - Option 1 Jan Dissels, following finalisation of the option area,
    - New Right Bank canal, which forms part of Option 15,
    - Option 22 Ebenhaeser restitution and expansion,
    - Potentially for an irrigation area to be identified for a government water scheme in the Trawal area.

  Options 1 and 22 should be better defined before these activities can proceed. The topographic survey for the New Right Bank canal can immediately proceed, likely using Light Detection and Ranging (LIDAR). The geotechnical survey can follow once the route of the new canal section has been confirmed.

19 References

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APPENDIX A: LONG LIST OF OPTIONS

The following Long List of potential options were identified:

Zone 1: Olifants River catchment upstream of Clanwilliam Dam

- Olifants River catchment upstream of Clanwilliam Dam

Zone 2 - Clanwilliam Dam and Jan Dissels River:

- Jan Dissels
- Abstraction from Clanwilliam Dam

Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir:

- Transfer of lower Jan Dissels River scheduled allocations to the Olifants River
- Pumping from Olifants River - Zandrug
- Abstraction from Bulshoek Weir
- Using the full capacity of the Clanwilliam Canal
- Increase the capacity of the Clanwilliam Canal
- Replace Clanwilliam Canal with a pipeline
- Pumping from the Olifants River (Schemes 6, 7 and 8)
- Pumping from the Olifants River (Schemes 9 and 10)
- Pumping from Clanwilliam Dam, near the new road bridge (Clanwilliam 2)

Zone 3 - Options Located Outside the Olifants River Valley:

- Jakkals River Irrigation Scheme (JRIS) and Graafwater (2 options)
    - Pipeline transfer to Jakkals River (original proposed scheme)
    - Pipeline via secondary road
- Provision of water to coastal towns
- Provision of water to JRIS, Graafwater, Lamberts Bay and Elands Bay

Zone 4 - Olifants River below Bulshoek Weir to Trawal

- Release at Bulshoek and pump from river: Zypherfontein 1
- Release at Bulshoek and pump from river: Trawal
- Release at Bulshoek and pump from river: Zypherfontein 2
- Release at Bulshoek and pump from river: Melkboom
- Pipeline from Bulshoek and pump to farm dams: Trawal and Zypherfontein 1 and 2 areas

- Raised (and lined) canal from Bulshoek and pumped to canal on right bank: Zypherfontein 1 and 2 and Melkboom area (2 options):
    - 8km of raised Trawal canal section
    - 8km of raised and lined Trawal canal section
- Syphon and Right-bank canal to replace Trawal canal section and supply Zypherfontein 1 and 2 and Melkboom areas
- New main canal section from Bulshoek on Right Bank of Olifants River

Zone 2, 4 and 5

- Changes in crops

Zone 5 - Olifants River from Klawer to the Coast

- Klawer
- Klawer 2
- Klawer 3
- Aties-Karoo
- Ebenhaeser New
- Lutzville 1
- Lutzville 2
- Coastal 1
- Coastal 2
- Schemes 29 Use of spare capacity in the Karoovlakte canal section
- Use of Spare Capacity in the Naauwkoes canal section – Klawer (2 options):
    - Full Klawer area with portion of Naauwkoes canal section lined
    - Scaled-down (818ha) Klawer area with no canal lining
- Use of Spare Capacity in the Naauwkoes/Vredendal canal sections – Coastal 1 (4 options):
    - Full Coastal 1 area with lined Naauwkoes/Vredendal canal sections
    - Scaled-down (818ha) Coastal 1 area with no canal lining
    - Scaled-down (818ha) Coastal 1 area – Post Right-bank Canal
    - Scaled-down 2 (450ha) Coastal 1 area with no canal lining
- Use of Spare Capacity in the Naauwkoes/Vredendal canal sections – Ebenhaeser restitution and augmentation:
    - Pre-Right Bank canal
    - Post Right-bank Canal

Zones 4 and 5: LORGWS (Lower Olifants River) Canal

- Replace all or sections of LORGWS canal with a pipeline with increased capacity
- Increase capacity of LORGWS canal and other betterments
- Increase Abstraction from Existing Canals
- High volume low head lifting pump stations
- Replace all or sections of LORGWS Canal with increased capacity canal
- Additional farm dams along the canal
- Provision of additional balancing dam/s along the canal
- Increase Winter Use from Existing Canals
- Reducing losses in the LORGWS canal / refurbishment of the canal system

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