GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET

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Institution where Information is held:	SRK Consulting					
Branch of Institution:	East London					
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B: TYPE OF INFORMATION

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	Specify Other:					
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	Specify Other:					

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	33.95806	24.30171

	Yes	No	Complete	Incomplete
Lithological & Construction Logs				
Hydrocensus Data				
Pump Testing Data				
Chemical Water Analysis Data				
Geohydrological Data				
Spring Data				
Remote Sensing Data				
Map Data				

Comments:

Reviewed by: Date: Signed:

Koukamma Drought Relief Programme

Kareedouw and Joubertina Feasibility Study and Hydrogeological Exploration:

May 2007

Report Prepared for

Department of Water Affairs and Forestry

Report Prepared by

SRK Consulting
Engineers and Scientists

Koukamma Drought Relief Programme

Kareedouw and Joubertina Feasibility Study and Hydrogeological Exploration: May 2007

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Executive Summary

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1 Introduction

The towns of Kareedouw and Joubertina, in the Langkloof Valley, Eastern Cape Province regularly experience the interruption of municipal water supply and often experiences several days during the week with no water supply. A drought relief programme has been initiated by the Department of Water Affairs and Forestry (DWAF) to investigate the hydrogeology around the towns as per tender W8783.

Currently the majority of water for the towns is obtained from a catchment area at Drie Krone, a perennial stream to the east of Kareedouw and the Joubertina Dam which is 6.4 km to the south of Joubertina. The water from a catchment area at Drie Krone, to the south west of Kareedouw, is piped to the 3 storage dams west of the town. A borehole also occurs in the eastern part of Kareedouw, but the borehole is disused and in the poor state of repair. The Joubertina Dam currently only supplies $^1/_9$ of Joubertina's municipal water while the remainder of the water is for agricultural irrigation purposes. Numerous farm dams, used solely for irrigation of crops also occur in and around Joubertina but are privately owned and occur on private land. Given the limited water supply for municipal resources, additional sources are required to augment the current bulk water supply to both the towns of Kareedouw and Joubertina.

This report presents the findings of the hydrogeological investigation, involving the feasibility and initial geohydrological exploration (geophysics only) phases of the tender.

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2 Project Brief and Programme

2.1 Background of the project

Following a request for a proposal for Tender W 8783, in January 2007, SRK Consulting (SRK) were appointed on the 25th January 2007 by DWAF to conduct the first phase of a hydrogeological investigation for the towns of Kareedouw and Joubertina.

2.2 Nature of the brief

The project terms of reference for the initial two phases of work was for the feasibility study and geophysical site investigation.

The feasibility study involves the following:

- Evaluation of all available and applicable groundwater data and geohydrological information and
- National and provincial database queries, with the aim of prioritizing proposed target areas and evaluating all existing data and reports.
- Remote sensing and aerial photography with the aim of detail structural analysis.
- Site characterisation and hydrogeological mapping to confirm desk to p analyses.
- Identification of all possible existing boreholes, springs and streams by on-site hydrocensus identifying all existing water sources.
- Identification of higher potential zones.

The first part of the hydrogeological phase involving geophysical site identification comprises the following:

- Performing a geophysical investigation with the aim of delineating geological structures such as faults and shear zones and other relevant geological contact zones within the target area.
- Identification of drilling targets with will be prioritised.
- Reporting on the estimated drilling depth and expected geological formation to be encountered.

The above target identification and prioritisation will then lead to the completion of phase two of the project – the hydrogeological phase which will involve exploration drilling, borehole testing and final geohydrological reporting. The methodology, procedures and approach are followed as laid out in Tender W 8783.

2.3 Previous groundwater investigations

A single surface water investigation is known to have been carried out for the Joubertina area and a regional water audit of the Koukamma Municipal has been done and a 1991 groundwater investigation in Kareedouw was found. The water audit for the Koukamma Municipality was

carried out by SRK in 2005 and includes the Langkloof valley. The reports reviewed are listed below:

- Ninham Shand Report 400184/3983. October 2005. Surface Water Availability Assessment in Joubertina, Krakeel and Louterwater – technical report for the Koukamma Municipality.
- SRK Report 181464. March 1991. Kareedouw Groundwater Investigation – drilling report for Louw Strydom & Partners.
- SRK Report 344171. March 2005. Koukamma Municipality Water Audit, Hydrogeological Investigation – technical report for Ninham Shand (regional hydrogeological characterisation of the Koukamma municipal area and identification of target areas).

Other data accessed are the National Groundwater Database for existing borehole data, the 1:50 000 Hydrogeological Map series of the Republic of South Africa DWAF Sheet 3321 Oudtshoorn 1st Edition (1999), the 1:50 000 Hydrogeological Map series of the Republic of South Africa DWAF Sheet 3324 Port Elizabeth 1st Edition (1998), 1:250 000 Geological Map Series 3324 Port Elizabeth and the 1:250 000 Geological Map Series 3322 Oudtshoorn.

2.4 Work programme

The timing and principal stages of the project are presented below.

- January 2007: project scoping and proposal submitted to DWAF;
- 25 January 2007: project appointment by DWAF;
- February 2007: desk top study, reconnaissance site visit and project meeting with local municipality;
- February 2007: hydrocensus;
- February 2007: target selection;
- February 2007: initial geophysics of targets (mag only);
- March 2007: Report compilation, desk top study;
- April 2007: Geophysics completed (max-min), report compilation and
- May 2007: Report Completed.

2.5 Project team

The SRK project team comprised the following:

- Gordon Maclear – principal hydrogeologist and project manager;
- Karen Burgers – senior geoscientist involved in the running of the project;
- Trevor Whisken – groundwater technician responsible for the hydrocensus and community liaison;
- Jaco Pretorius & Mathias Varinyu – field technicians responsible for geophysical analysis; and
- Vuyokazi Balani – office administrator responsible for budget control and accounting.

The assistance received from the communities of Kareedouw and Joubertina during the initial phase of the project, the hydrocensus, is gratefully acknowledged.

3 Study Area

The towns of Kareedouw and Joubertina are situated on the R62 in the Langkloof Valley. Joubertina occurs ~35 km west of Kareedouw and the location of both towns is shown in Figure 1.

Figure 1: Location Map of the towns of Kareedouw and Joubertina along the R62

The Langkloof Valley is a narrow structural valley with the lowest elevation representing a fold axis of a syncline the arms of which rise to steeply inward dipping, Table Mountain Group (TMG) ridges. The predominant farming activity of the Joubertina area is fruit farming and associated agricultural services, while mixed vegetable and cattle farming occurs around Kareedouw.

Kareedouw is located on the border between the K90A and K90B quarternary catchments along the Krom River in the lowest part of the valley. Three streams run to the east and west of the town, into the Krom River. The stream to the east of the town runs from an underground spring and catchment in the Kareedouw Mountains. This stream flows all year round and water is pumped from this stream to augment the municipal water supply. The streams to the west of the town are non-perennial and were not flowing at the time of the hydrocensus. These two western streams arise in catchment areas in the Kareedouw Pass and from Die Krone. The mean annual precipitation for the town, from 1955-2005, is show in Figure 2[1]. The mean annual precipitation is 722 mm with the average number of rainfall days numbering 65.

Joubertina is located within the L82D quaternary catchment and lies between the western Wabooms River and eastern Twee River. These rivers run from catchment in the north and flow south into the Kouga River to the north of Joubertina. The Krom River which runs through the centre of the Langkloof Valley does not occur at surface near Joubertina, possibly due to the number of farm

[1] Data supplied by the Port Elizabeth branch of the South African Weather Services

dams. The mean annual precipitation for the town, from 1979-2005, is show in Figure 2[1]. The mean annual precipitation is 496 mm with the average number of rainfall days numbering 96.

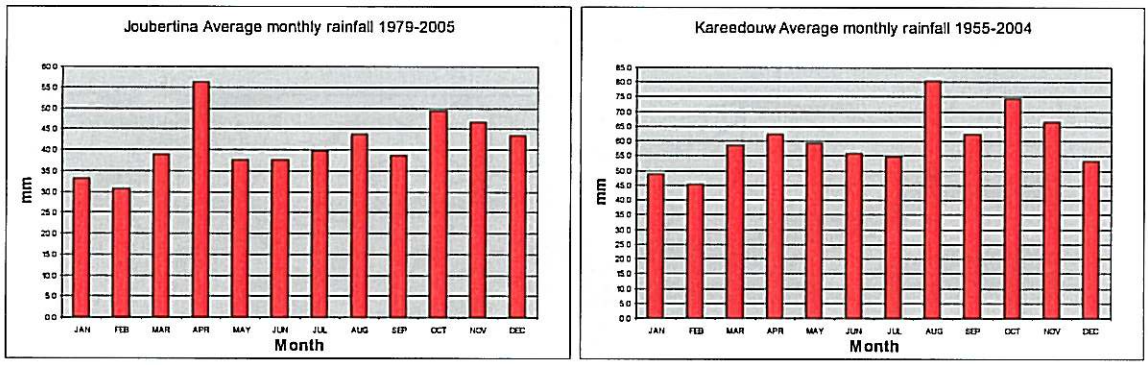

Figure 2: Average monthly rainfall for Kareedouw and Joubertina (SA Weather Services)

The towns of Kareedouw and Joubertina straddle the fold axis of the syncline making up the Langkloof Valley. The Langkloof Valley is part of the Cape Fold Belt a mountain range characterised by intense folding and associated fracturing of the TMG sandstones, producing a regional, fractured rock (secondary) aquifer of moderate to good groundwater development potential. The syncline forming the Langkloof Valley is a regional west-northwest – east-southeast striking structure with well developed smaller folds developed along the outer limbs of the fold. This regional structure, folding and geology are shown in Figure 3 and 4 of the Port Elizabeth[2] and Oudtshoorn Geological maps[3].

The Langkloof Valley is characterised by rocks of the Table Mountain and Bokkeveld Groups which form part of the Cape Supergroup. The central syncline in the valley causes the intensely folded rocks to be mirrored on either side of the valley. The centre and lowest elevation of the valley contains shales and siltstones of the Gydo Formation (Ceres Subgroup, Bokkeveld Group). Sandstone beds of the Baviaanskloof Formation (Nardouw Subgroup, Table Mountain Group) outcrop on either side of the Gydo Formation, and further up the mountain slopes the quartzitic sandstones of the Skurweberg Formation and weathered sandstones of the Goudini Formation occur (Nardouw Subgroup, Table Mountain Group). The Cederberg Formation forms a thin band of shales and which seldom outcrops before the topography rises to the north and south of the towns and is capped by hard quartzitic sandstone of the Peninsula Formation (Table Mountain Group). Table 1 lists the geological legend of rocks found in the Langkloof Valley.

The shales and siltstones of the Gydo Formation tend to weather to clayey residual soils and erode more easily than the underlying quartzitic sandstones of the Nardouw Subgroup. This fact together with the greater structural deformation in the synclinal fold axis cause the Gydo Formation to occur at the lowest elevation in the valley. Folding within the Table Mountain Group sediments has had a profound effect on structure of the rocks. Folding has resulted in the formation of joints that produce a blocky rock mass and in which voids are common. These zones of structural deformation with

[2] South African Geological Survey. 1991. 1 : 250 000 geological map series – Sheet 3324 Port Elizabeth

[3] South African Geological Survey. 1979. 1 : 250 000 geological map series – Sheet 3322 Oudtshoorn

jointing, fracturing and where folding is intersected create areas of great potential for fracture rock aquifers and are thus targeted in this study.

Localised Quaternary alluvial deposits occur along the Krom River, Wabooms River and Twee Riviere River valleys with the development of shallow residual soils along the valley floor and partial up the sides of the ridges.

Table 1: Geological legend for geological maps represented by Figures 3 and 4

Period	Super Group	Group	Subgroup	Formation	Description	Rock Label	
Quarternary					Alluvial Valley deposits		
Devonian		Bokkeveld	Ceres	Gydo	Black to brown shale, subordinate siltstone, fossiliferous	Dg	Dg
Silurian	Cape	Table Mountain	Nardouw	Baviaansklo of	Impure feldspathic sandstone, subordinate shale	S-Db	Sb
				Skurweberg (Kouga)	Whitish weathering, medium to coarse grained, quartzitic sandstone, feldspathic near the top, profusely cross-bedded, subordinate shale	Ss	Sk
				Goudini (Tchando)	Brownish weathering sandstone, fine to coarse grained; shale	Sg	St
Ordovician				Cederberg	Shale; arenaceous shale	Oc	Oc
				Peninsula	While to pale grey massive and laminar and cross-bedded medium to coarse grained quartzitic sandstone	Op	Op

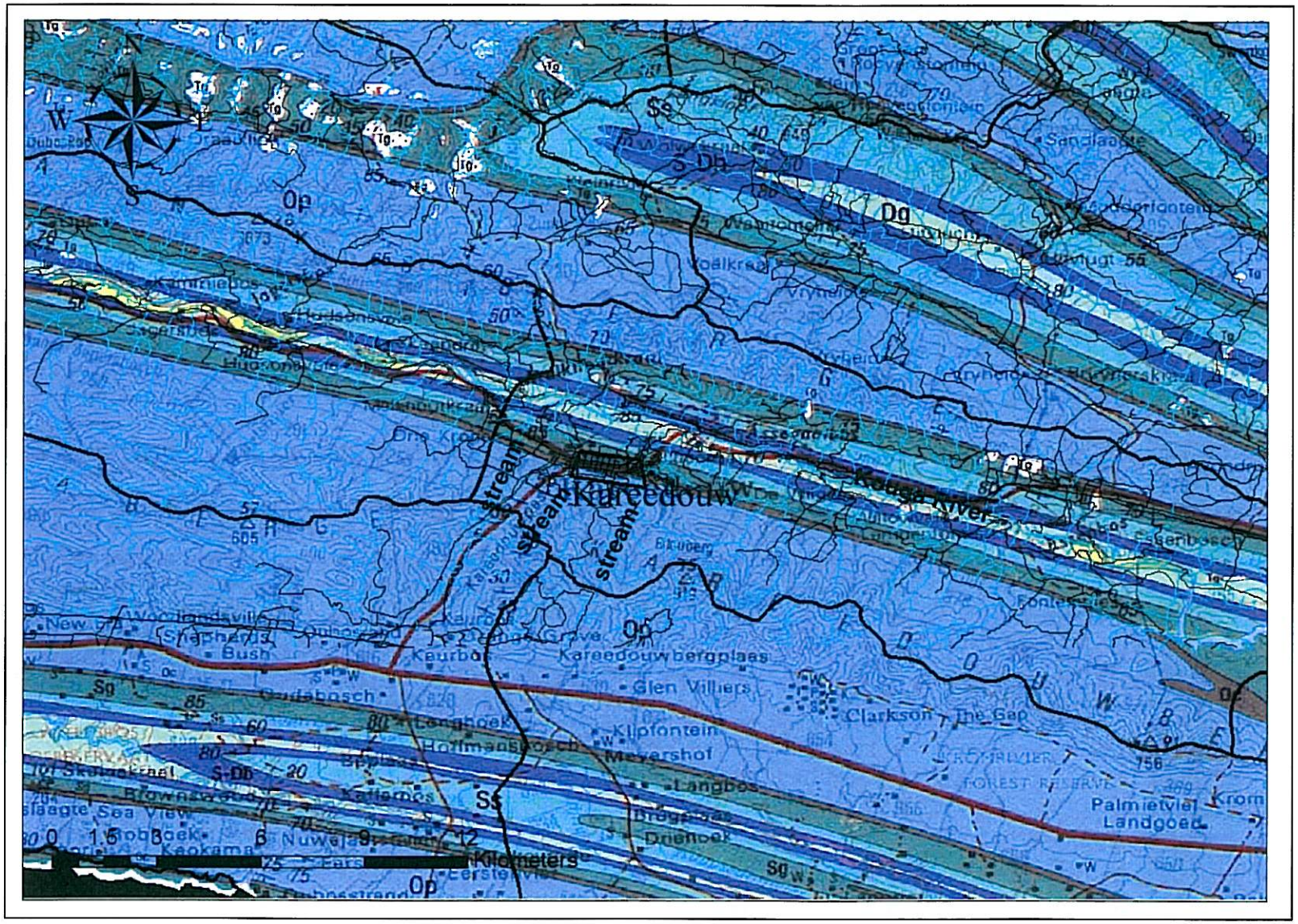

Figure 3: Geology surrounding the town of Kareedouw (Port Elizabeth geology sheet 3324), showing rivers, roads and Quarternary catchment areas

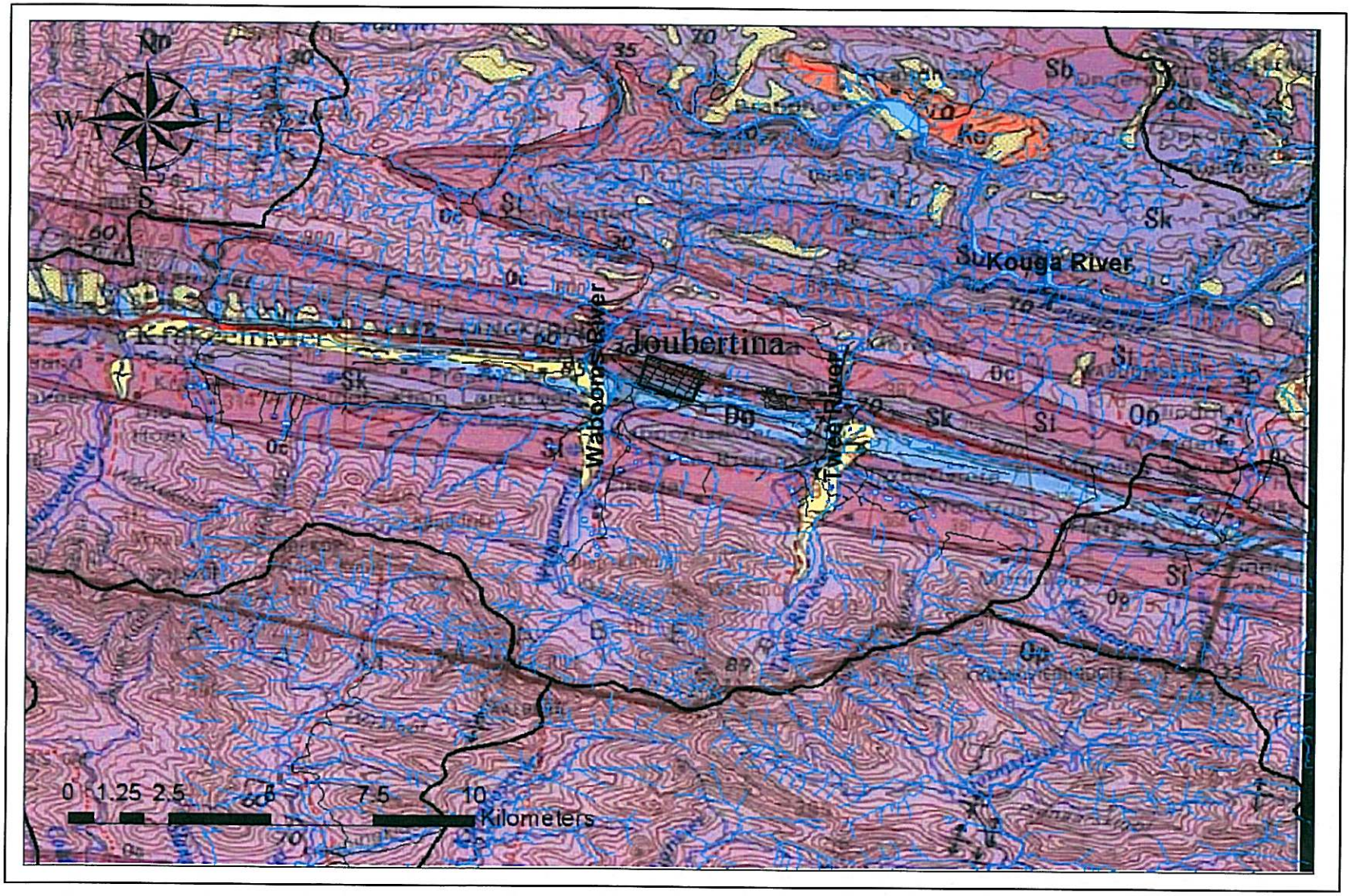

Figure 4: Geology surrounding the town of Joubertina (Oudtshoorn geology sheet 3322), showing rivers, roads and Quarternary catchment areas

4 Project Results

The results of the 1st phase of the work, the feasibility investigation – the desk study, hydrocensus and target selection along with geophysics are presented in the following sections.

4.1 Desk study

Previous hydrogeological investigations carried out in the area (refer to Section 2.3) were reviewed prior to carrying out the field work. A regional water audit was done in the Langkloof valley, a surface water study for Joubertina was also performed and a 1991 groundwater investigation for Kareedouw provided information and locations for the existing boreholes in well field to the east of the town. The surface water study has little relevance to this investigation as the study details the capacity and potential for increasing capacity of all the farm dams and main town dam to the south of Joubertina. However, a recommendation of this study was that groundwater augmentation be considered to meet shortfalls during critical periods. The regional hydrogeological study provided much useful information (SRK Report 344171) with regards to geology, hydrogeological investigation, structure, topography, aerial photo/satellite coverage and areas suitable for groundwater development.

The Kareedouw groundwater investigation provided information regarding two boreholes drilled close to the existing pumping borehole (currently in a state of disrepair). The boreholes were drilled into sandstones to a depth of 140 m and 70 m respectively and both yielded 2 L/s of water. The first borehole close to the existing pumping borehole was not equipped and has since been overgrown by vegetation and possibly collapsed, while the 2nd borehole appears to have been drilled on the property of a local landowner and is currently in use. The groundwater from these boreholes showed low total dissolved solids and a low EC of 20 mS/m. A high iron content of 11-12 mg/L was determined from the boreholes and the report recommends boreholes in this highly weathered fracture aquifer be fully lined with casing and also recommends PvC casing be used due to the high iron content. The boreholes were not cased during the drilling.

The regional hydrological survey indicated that the elevated parts of the Langkloof Valley, namely the ridges and mountains are unfavourable for groundwater development due to low recharge conditions and inaccessibility by drill rigs. As a result the low lying areas in the valleys are more suitable for groundwater development. The areas of the valleys underlain by high salinity, low permeability rocks of the Bokkeveld Group siltstones and shales, were excluded from this result. This study also included groundwater information, topographic and geological characterisation and lineament mapping. Further information from the report indicated that the groundwater aquifer contained within the Table Mountain Group is typically fresh and suitable for domestic and municipal usage, though it tends to be high in dissolved iron and therefore soft and corrosive. Maps from this report are shown in Figures 4-5 which represent satellite coverage and areas suitable for groundwater development, respectively. Recent satellite coverage does not extend to the town of Kareedouw and the older images were used during target selection.

During this phase of the project aerial photographs were ordered from Chief Directorate: Surveys and Mapping and assessed for structural features and intersection of structural features that could be seen by remote sensing and from satellite photographs. The topography and geology of the area was investigated from topographic maps (3323DD & 3423BB Joubertina – 1:50 000, 1998 and 3324CC Witelsbos & 3324CD Kareedouw – 1:50 000, 1977) and geological maps (1:250 000 Geological Map Series 3322 Oudtshoorn and 1:250 000 Geological Map Series 3324 Port Elizabeth). The hydrogeological maps (1:50 000 Hydrogeological Map series of the Republic of South Africa DWAF Sheet 3321 Oudtshoorn, 1st Edition, 1999 and 1:50 000 Hydrogeological Map series of the Republic of South Africa DWAF Sheet 3324 Port Elizabeth, 1st Edition, 1991) together with the National Groundwater Database (NGWD) showed that the Kareedouw and Joubertina areas contain fractured rock aquifers with borehole yields between 0.1-2 l/s on average but with reported boreholes up to 7-10 l/s. These fractured rock aquifers of the Table Mountain Group contain numerous faults, joints, fractures and the intersection of folds with structural features can be targeted for groundwater development whereas boreholes in the Bokkeveld shales is likely to be less successful due to the lack of interbedded sandstones and fractures. Few boreholes occur in NGWD around the towns of Kareedouw and Joubertina and an attempt to find all the boreholes to resurvey was made during the hydrocensus.

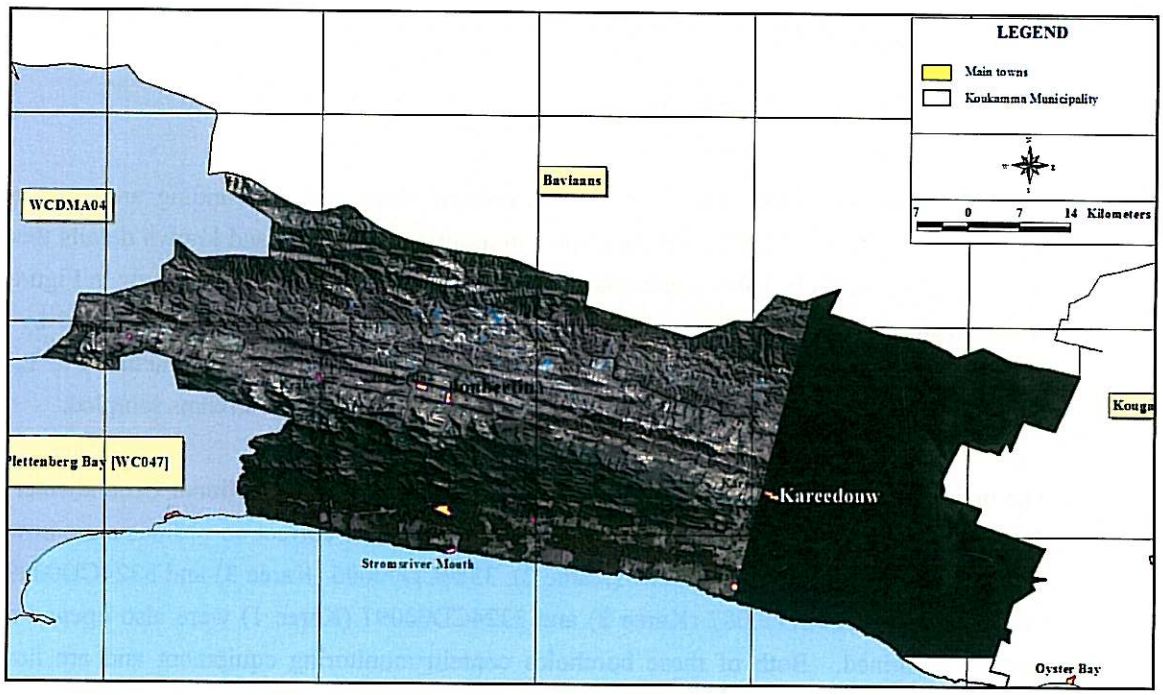

Figure 5: Satellite coverage of the area over the Langkloof valley under investigation (SRK Report 344171)

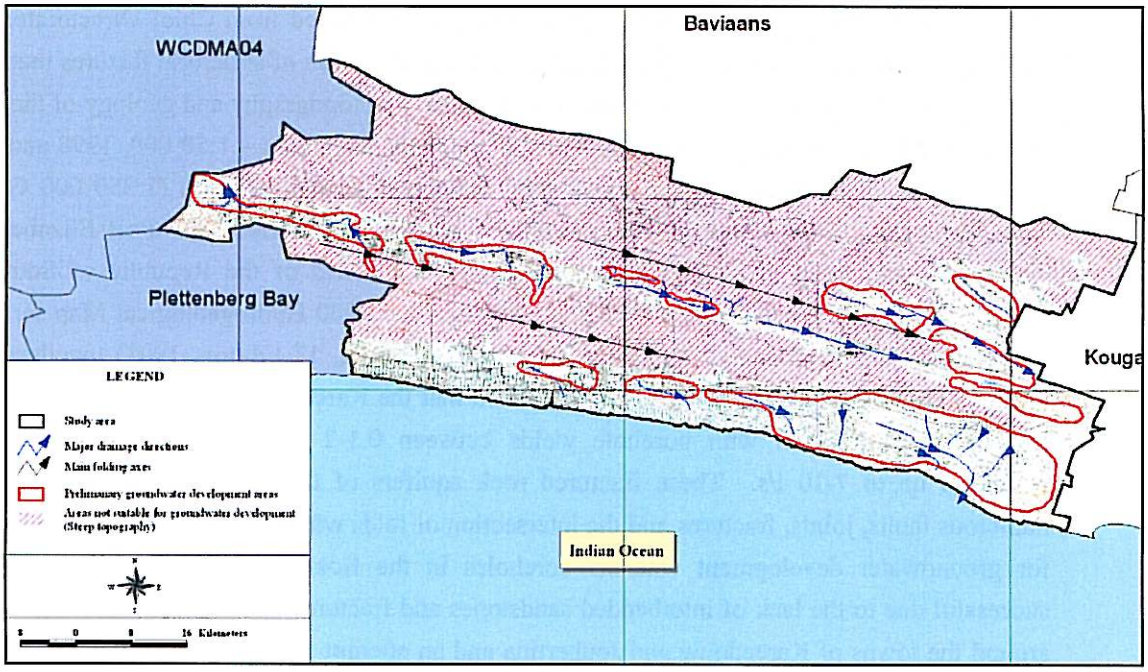

Figure 6: Proposed areas suitable for groundwater development in the western part of the Eastern Cape Province (SRK Report 344171)

4.2 Hydrocensus - Kareedouw

A hydrocensus and water survey of the Kareedouw town and surrounding area was conducted between 7-12 February 2007. The boreholes in around Kareedouw and known details thereof from the NGWD are listed in Table 2 and shown on the topographic map of Kareedouw in Figure 7. Most of the details for finding these and all other boreholes in Kareedouw were provided by the local community for the location of the water sources detailed below in Table 3. Included in Table 3 is a list of the boreholes found in the Kareedouw area as well, springs and streams sampled.

The majority of the boreholes found during a desk top study of the National Groundwater borehole database have highly in-accurate co-ordinates (Table 2). The correct co-ordinates are now listed in Table 3 for boreholes 3324CD00087 (Karee 2), 3324CD00096 (Karee 3) and 3324CD00097 (Karee 1). Boreholes 3324CD00087 (Karee 2) and 3324CD00097 (Karee 1) were also opened and water levels determined. Both of these boreholes contain monitoring equipment and are not used as production boreholes. The Municipal water manager Tertius Mohr informed us that the boreholes are sampled on a monthly basis by a technician from DWAF in Craddock. No records of these boreholes are available at the municipal offices in Kareedouw with the last records dating back to 1996. The location of boreholes 3324CD00001, 3324CD00002 and 3324CD00035 south of these boreholes could not be found due to the large degree of in-accuracy of the borehole co-ordinates and are probably overgrown by vegetation. The local community could not help with the location of these boreholes either. Borehole 3324CD00095 within the town may be listed amongst those already surveyed but due to largely in-accurate co-ordinates it cannot be reconciled with the boreholes listed in Table 3. Borehole 3324CD00077 on farm 268 could also not be found, this borehole may no longer be in use and abandoned. The above mentioned borehole 3324CD00096

(Karee 3) is currently idle and in a state of disrepair. No records exist of when this borehole was last used and the water is recorded as being extremely iron-rich, reddish in colour and the borehole is blocked or the pump malfunctioning. The electrical cabling and fence around this borehole have also been vandalised and no management or upkeep of the borehole has occurred for some time.

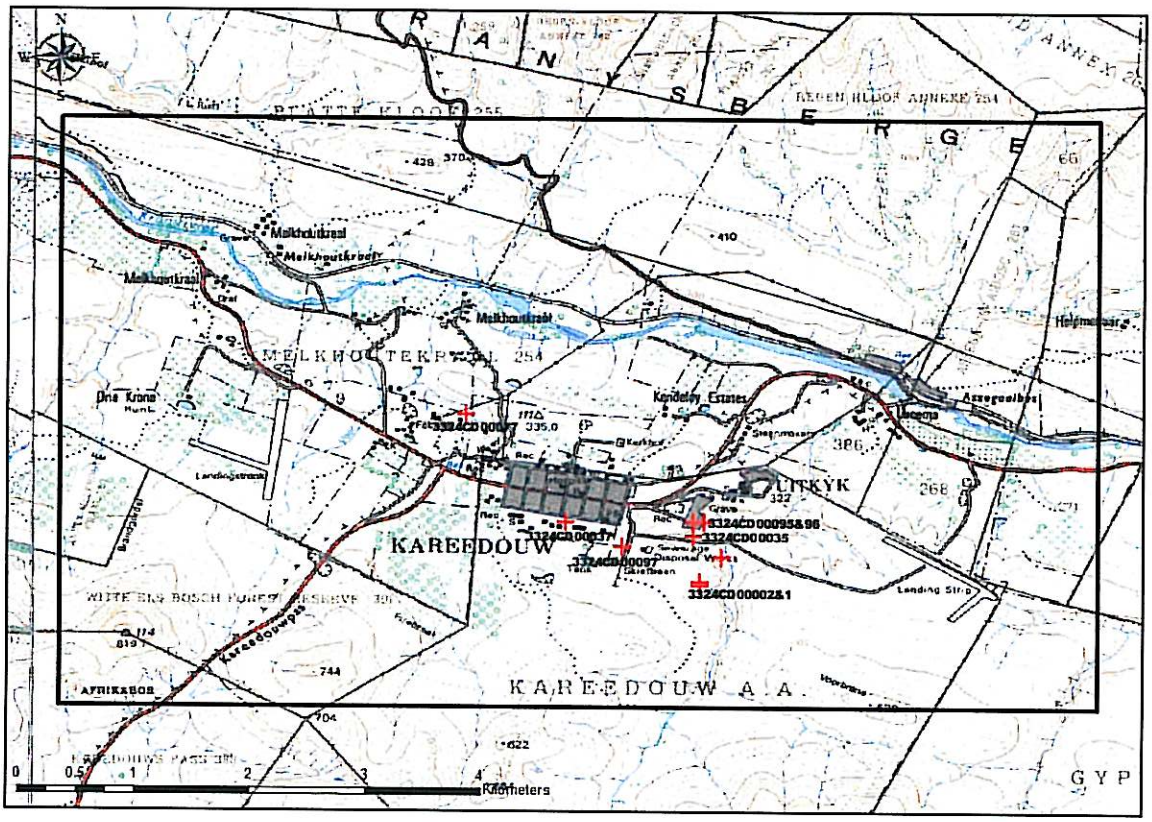

Figure 7: The topographic map of the area for hydrocensus around the town of Kareedouw with the location of the 9 boreholes obtained from the NGWD

Table 2: NGWD list of boreholes in the Kareedouw area

Site ID no.	3324CD00001	3324CD00002	3324CD00035	3324CD00037	3324CD00077	3324CD00087	3324CD00095	3324CD00096	3324CD00097
Map no.	1	'2	'35	'37	'160021	'87	'95	'96	'97
X	24.301667	24.301667	24.303333	24.295556	24.283333	24.301111	24.291111	24.301944	24.301111
Y	-33.958611	-33.958889	-33.956667	-33.955833	-33.945556	-33.953889	-33.953889	-33.953889	-33.955000
Altitude	260	280	260	340	200	430	450	460	430
Co-ord accuracy	2	2	4	2	2	4	4	4	4
Site type	Borehole	Borehole	Borehole	Borehole	Borehole	Borehole	Borehole	Borehole	Borehole
Registration No.					160021				
Discharge Rate (l/s)									
Farm No.					268				
Site Name	Kareedouw	Kareedouw	Kareedouw	Kareedouw	Plaas 268	Kareedouw	Kareedouw	Kareedouw	Kareedouw
Use			Domestic - all purposes		Agric - stock watering only				
Equipped	no	no	no	submersible pump	no				
Depth (m)				165	165				
Diameter (m)	82	154	50	57	48				

Numerous members of the Kareedouw community have drilled boreholes on their own property due to the inconsistent municipal supply of water (community members have mentioned having no water

supply up to 3 times per week). Water supply interruption may be due to leaking pipes or lack of management of the water resources – many reasons were given and is the subject of much speculation by community members. During the hydrocensus numerous community members approached the SRK technician to enquire about siting and drilling of boreholes for private use thus indicating a definite water problem in the town.

Currently a member of the Kareedouw community Jacques du Plessis of Country Wide Drilling has been drilling boreholes in the community. Du Plessis has a strong well on his property (Duples in Table 3) with a yield of 3 L/s. Many of the boreholes drilled within the north-west of the town close to the R62 appear to be in shale, whereas in the south boreholes are drilled in sandstone and the water appears to contain less iron and have stronger yields (*i.e.* boreholes Coet and Hark).

Three water storage dams exist to the west of the town at Drie Krone. The water levels in these dams are extremely low and water is pumped, for municipal usage, from these dams on a regular basis. Water is collected in the Drie Krone catchment area and a pipe line runs from Drie Krone to these storage dams.

A spring (Karee spr1) running along the eastern border of the town shows extremely consistent flow and should possibly be utilised more as it is currently pumped for 24 hours/day with no drop in water level. This spring is reported to be extremely strong and runs all year long, even when pumped consistently.

Kareedouw shows considerable and consistent reserves of water from springs to the west and east of the town and from catchment areas within the Kareedouw Mountains to the south. Water supply to the town appears to be inconsistent possibly due to aging infrastructure rather than a lack of water. Better and dedicated management of the water resources and supply capacity to the residents of Kareedouw will go a long way towards solving much of the water problems in the town. Currently water management, at the municipality, is a part-time responsibility along with other items such as legal and town planning responsibilities. The location of the boreholes found during the hydrocensus is shown in Figure 8.

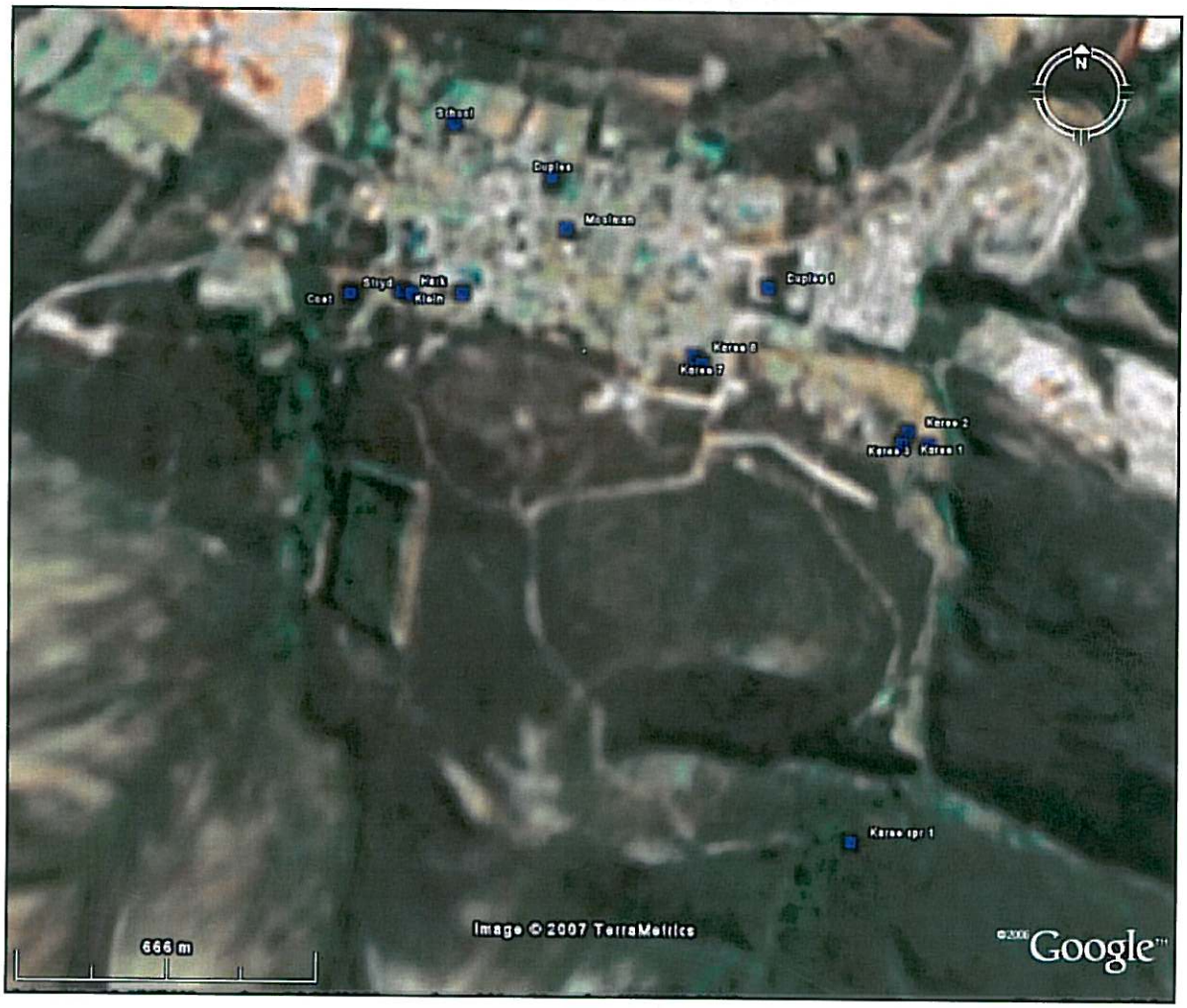

Figure 8: Old satellite imagery (therefore unfocussed) showing the location of all boreholes and springs within the town of Kareedouw

Table 3: List of existing boreholes (used and abandoned), springs and streams in the Kareedouw area

Borehole	Allocated Number	Latitude	Longitude	Altitude	EC	Water Level	pH	TDS	Depth	Yield	Equipment	Comment
				Mamsl	mS/m	mbs			mbs	l/s		
Borehole	Karee 1 3324CD00097	33.95806	24.30171	351	-	4.3	-	-		-	Orphamedes meter	Records from 1996, monitored by DWAF from Cradock
Borehole	Karee 2 3324CD00087	33.95775	24.30193	347	-	16.2	-	-		-	Kabellange monitor	Records from 1996, monitored by DWAF from Cradock
Borehole	Karee 3 3324CD00096	33.95809	24.30277	334	-	21.1	-	-	100	-	Submersible pump	Hole is blocked/pump broken, pump at 70 m, water is red and iron rich, pipes rusted
Borehole	Karee 8	33.95582	24.29482	343	-	No access	-	-	-	6	Submersible pump	Poor usage water iron rich and red,
Spring	Karee Spr	33.97566	24.29500	381	13	N/A	-	-		12	Weir	Water from Drie Krone kloof feeds to town in 10 inch pipe line
Spring	Karee spr 1	33.96873	24.29987	354	30	N/A	-	-		8	Weir	East of the town runs past water treatment works, spring pumped into main line through 10 inch pipe line , pumps 24hrs/day
Borehole	Karee 7 3324CD00037	33.95599	24.29506	344	25	No access	-	-	57	0.5	Submersible pump	Domestic and irrigation use, pumps directly into municipal lines to water treatment, serviced 2x a year, 165 mm diameter hole
Borehole	Coet	33.95413	24.28362	337	35	15	-	-	-	0.5	Submersible pump	6 inch PvC casing, pump cycle 10 hrs/day 2x per week, domestic and irrigation use
Borehole	Hark	33.95411	24.28533	341	40	6	-	-	14	0.5	Submersible pump	Cased with 6 inch PVC, Pumps 2 hrs/day domestic use and garden irrigation use only
Borehole	Stryd	33.95417	24.28564	342	40	6.5	-	-	25	0.5	Submersible pump	Pumps 2 hrs/day garden irrigation use only
Borehole	Klein	33.95415	24.28728	339	45	5	-	-	40	0.4	Submersible pump	Pumps 2 hrs/day domestic/garden irrigation use only
Borehole	Duples	33.95079	24.29012	312	-	6	-	-	70	3	Submersible pump	Owner of Country Wide Drilling, drilled clay then black shale, pumps 6hrs/day
Borehole	Duples 1	33,95384	24.29729	321	-	23	-	-	90	0.5	Submersible pump	Drilled sand and clay, strong sulphur smell. Pumps 1.5 hrs/day
Borehole	School	33.94928	24.28685	312	-	8	-	-	60	1.5	Submersible pump	Pumps 10 hrs every 2nd day
Borehole	Moolman	33.95228	24.29063	315	-	-	-	-	-	-	Open casing	Pump pulled for repaired, hole blocked at 37 m, red iron rich
Borehole	3324CD00001	33.958611	24.301667	260	-	-	-	-	82	-	none	Unable to locate co-ordinates too in-accurate
Borehole	3324CD00002	33.958889	24.301667	260	-	-	-	-	154	-	none	Unable to locate co-ordinates too in-accurate
Borehole	3324CD00035	33.956667	24.303333	260	-	-	-	-	50	-	none	Unable to locate co-ordinates too in-accurate, domestic use
Borehole	3324CD00077	33.945556	24.283333	200	-	-	-	-	48	-	none	Unable to locate co-ordinates too in-accurate farm 268 used for stock watering only, 165 mm diameter borehole
Borehole	3324CD00095	33.953889	24.291111	450	-	-	-	-	-	-	-	Unable to locate co-ordinates too in-accurate

4.3 Hydrocensus – Joubertina

A hydrocensus and water survey of the Joubertina town and surrounding area was conducted between 7-11 February 2007. All boreholes close to Joubertina and known details thereof from the NGWD are listed in Table 4. Much communication between the local community and the

hydrocensus technician, Trevor Whisken occurred and the local community were extremely helpful regard the location of the water sources detailed in Table 5. Included in Table 5 are the location of boreholes found in the Joubertina area as well as springs and streams sampled. Also included are the locations of boreholes from the NGWD which have been resurveyed or if their location could not be found a reason why has been given.

The town of Joubertina predominantly receives municipal water from the Joubertina Dam 6.4 km to the south of the town. The water allocation of the dam stands at $^{1}/_{9}$ for municipal usage and $^{8}/_{9}$ for agricultural irrigation use. However, during dry periods when more water is required for municipal usage, irrigation must be scaled down and the resultant unemployment of local workers would be catastrophic for the community as the farming community is the predominant employer in the town.

The Joubertina Dam contains a system of V-notches to regulate the water flow into the river which is then used for irrigation (Figure 8). These notches were however destroyed in the October 2006 floods and have not yet been repaired. The dam catchment is such that after a single good rainfall the dam is full to overflowing. The dam structure, however, has not been regularly maintained or management of the dam is lacking, as some years ago a flash flood occurred after the vegetation around the dam was burnt in a veldt fire and as a result the dam has silted up. Currently two large sand islands can be seen 1 m below the dam surface indicating a large amount of sand within the dam resulting in a considerable reduction of the volume of water contained in the dam. The foundation of the dam wall was designed for the wall to be raised 1 metre if need be. Private finance has been offered for this purpose as well as dredging of the dam, which could be done relatively easily except for along the inside of the dam wall (refer Johan van der Mescht – Africon Engineers). Development at the Joubertina golf course to the north along the river, will involve building a sewage treatment plant and the owner of the golf course has offered to dredge the dam and treat town sewage at the golf course plant in order to reuse such treated water. Besides a water shortage, there appears to be a sewage problem in town with overflow at some sites (retirement centre) which poses a groundwater contamination and town health issue.

Pipelines which supply water to the concrete reservoirs on the ridge north of Joubertina have been reported to contain breaks or considerable leakage. This appears to be an ongoing problem as staff have been employed to dig trenches to guide the pooling water away from the road and pipes to the river. Because of these leaks the municipality is unable to fill the concrete reservoirs. The leaking pipes were fixed some time ago but backfill of the repaired pipes collapsed or once again caused breaks.

Figure 9 shows that there are numerous dams in and around the town of Joubertina all of which supply water for agricultural irrigation purposes. This topographic map of Joubertina also shows the location of the four NGWD boreholes close to the town for checking during the hydrocensus, the details of which are listed in Table 4.

Figure 9: The Joubertina Dam showing the low level of the dam in February and the V-notch system regulating dam flow

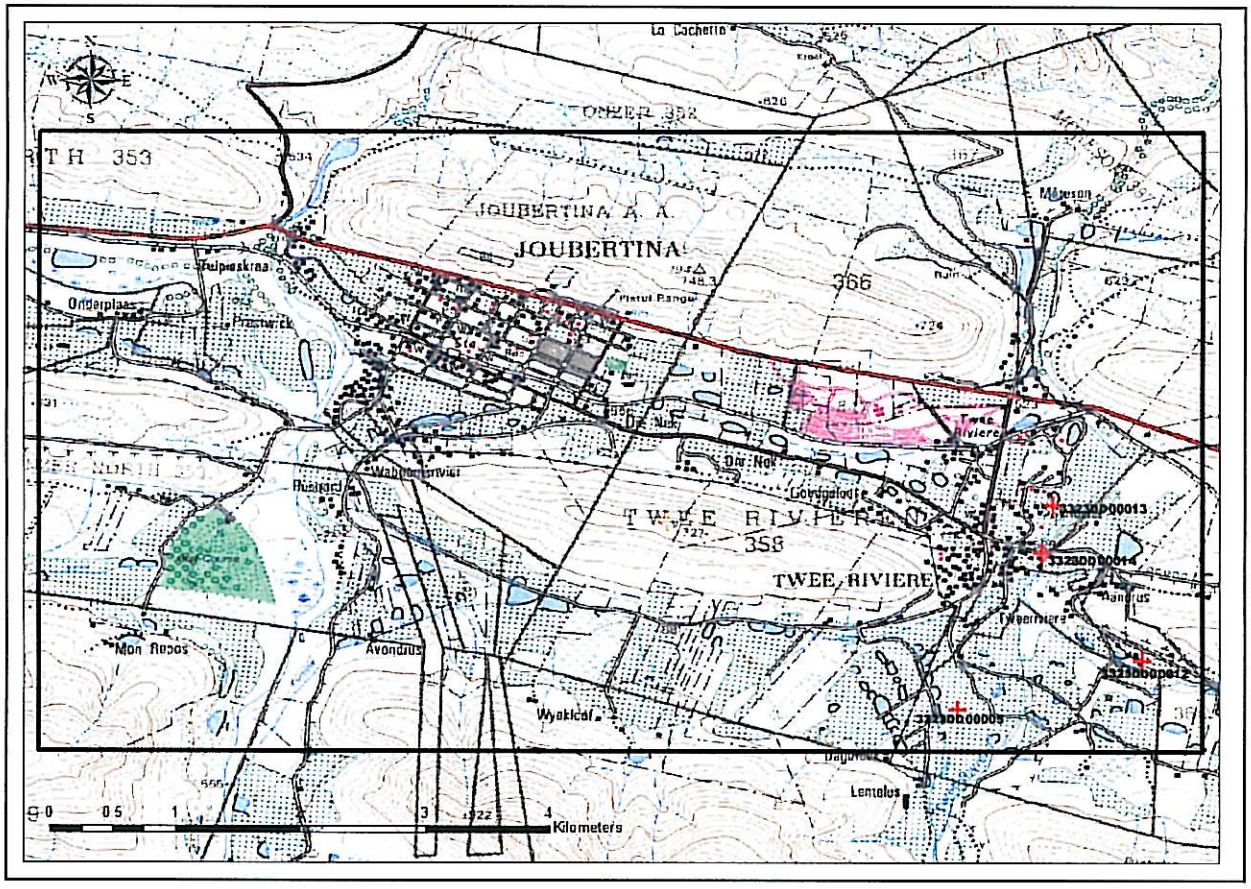

Figure 10: The topographic map of the area for hydrocensus around the town of Joubertina with the location of the 4 boreholes obtained from the NGWD

Table 4: NGWD list of boreholes and fountains/springs in the Joubertina area

Site ID no.	3323DD00005	3323DD00012	3323DD00013	3323DD00014
Map no.	'5	'12	'13	'14
X	23.890278	23.903611	23.897222	23.896389
Y	-33.852500	-33.848889	-33.837778	-33.841111
Altitude	520	540	520	520
Co-ord accuracy	1	1	1	1
Site type	Fountain/spring	Borehole	Fountain/spring	Borehole
Registration No.				
Discharge Rate(L/s)	4	1.1		4.1
Farm No.	349	358	358	358
Site Name	Sanddrift	Twee Riviere	Twee Riviere	Twee Riviere
Use	Agric & domest	Agric & domest	Agric & domest	Agric & domest
Equipped	no	submersible pump	no	mono-type pump
Depth (m)		52		47
Diameter (m)		152		152

Numerous community members also have private boreholes within the town. Within the town the boreholes contain clear, strong (1.5-4 L/s) fresh flow with little evidence of iron concentration. Most of the private boreholes have not been tested for human consumption and are used for domestic and garden irrigation. These boreholes were drilled by a contractor from Beaufort West who drilled into sandstone. In the western part of Joubertina (Devos 3, Kenn, Stryd 4) the water is strong, fresh with no visible iron concentration. Further west in the town and towards Twee Reviere the water shows a reddish colour and metallic taste indicating iron concentration. East of the Lanne borehole the water is solely used for garden irrigation or secondary purposes and not domestic consumption due to the decrease in water quality. Many of the boreholes towards the west also show collapse, silting up and structural problems indicating a less competent host rock – possibly shale. Many of the wells in the western part of Joubertina appear to have been drilled by Country Wide Drilling and show little or no development. The Devos well has collapsed and another site has been indicated on this property of Danie de Vos by a water diviner as a strong water site. Mr de Vos has given permission for drilling on his property for municipal sources of water should a site prove viable. The collapse and description of the rock however indicates his land may lie on shale rather than the more competent sandstone. This site is just south of the town's water reservoirs. Table 3 lists all the boreholes and information that could be gathered about water sources during the hydrocensus. The location of boreholes and water sources within Joubertina is shown in Figure 8, those at Twee Reviere in Figure 9 and all the boreholes and location of the town dam in Figure 10.

To the east Twee Reviere is a farming community and the community does not appear to utilise municipal water. Most of the community pump water from the Twee Riviere River to the numerous storage dams or tanks that can be seen in this area. The river provides catchment from the kloofs to the south.

The only boreholes from the DWAF database were seen in the Twee Reviere area. Two of the borehole sites were confirmed 3323DD00012 and 3323DD14 and are still in use. The co-ordinates were highly in-accurate and have now been corrected. The springs recorded by site 3323DD00005

and 3323DD00013 could not be found and information from the local community indicate these springs are no longer running or have been covered by land developed for farming.

Figure 11: The location of boreholes and river sample (Kraaltjie) within the town of Joubertina

The river sampled in the kloof north of the Kraaltjie guest house (Wabooms River) and a potential site for drilling is agreed, by the chairman and 2 other members of the local water and irrigation board, as an excellent site as they stated that when the river shows no surface, the big pool in the river rises by as much as a metre. This pool has been pumped continuously but the water level has not dropped even during dry periods. An approach to the owner of the land indicated she is unopposed to the idea of drilling for municipal water on the land as the guest house receives municipal water for land irrigation and use at the guest house.

At Twee Reviere the new cold store warehouse, owned by Du Toit from Ceres, has 2 boreholes (Dutoit 1 and 2). These borehole are new and were drilled to get water for the cold store condensers and to irrigate the surrounding land. Across the road Wilco, a transport company also has 1 borehole which is used for washing trucks and irrigating the gardens. These boreholes were drilled by Country Wide Drilling, based in Kareedouw, and appear to be drilled in shales as these boreholes were cased to 18-20 m due to collapse of the upper portion. Iron concentration and a reddish colour to the water was reported by the Wilco manager Willie Mills.

Figure 12: The location of boreholes and river (Twee River) at Twee Reviere

The fact that many community members have their own boreholes due to lack of municipal supply indicates there is indeed a water problem in the town of Joubertina. Dedication of the dam water predominantly to irrigation indicates the priority for the dam water. The problems with supply pipes and the municipal dam indicate a lack of dedicated water resource management. It appears as though the dedicated management of the water resources is first and foremost needed along with augmentation of the municipal water supply by groundwater. The groundwater resources will, however, have to be managed properly in order that this resource is properly maintained, equipped, fed into the towns water supply and supply pipes are properly maintained.

Table 5: List of existing and disused boreholes, springs and streams in and around the town of Joubertina

Borehole	Allocated Number	Latitude	Longitude	Altitude	EC	Water Level	pH	TDS	Depth	Yield	Equipment	Comment
				Mamsl	mS/m	mbs			mbs	l/s		
Borehole	Devos 3	33.82126	23.84976	555	18.8 @ 21°	N/A	6.12	134	108	1.5	Submersible	20 m of 165 mm casing used for domestic & garden
Borehole	Kenn	33.82251	23.84983	542	30.1 @19.2°	12.6	6.9	234	100	1	Submersible	Cased to 18 m used only for garden use
Borehole	Lanne	33.82307	23.85291	549	245 @ 22,2°	13	6,6	237	90	1.5	Submersible	Cased to 165 mm, oxidized red in colour, garden use only
Borehole	Vanmes	33.82303	23.85394	550	240 @ 23°	15	6.3	320	60	0.5	Submersible	Can pump for 1 hour only then stops, oxidised red in colour, metallic taste and smell
Borehole	Stryd 4	33.82182	23.85075	550	160 @ 22°	13.5	6,3	143	60	0.4	Submersible	Clean, clear water, pump old and unreliable, garden use only
Borehole	Stryd 5	33.82162	23.85488	564	30 @19.7°	23.7	6.8	167	100	0.4	Submersible	Water struck at 85 m, garden use mostly but some domestic
Borehole	Kritz	33.82048	23.89303	538	143	17	-	-	90	1.5	Submersible	Pump depth 65 m, red in colour, taste & smells metallic, used once a week to fill tanks
Borehole	Dutoit 1	33.83046	23.89381	529	-	6.5	-	-	120	3	Submersible	165 mm casing to 30 m, not in use yet drilled for use with cold storage facility and irrigation
Borehole	Dutoit 2	33.83085	23.89330	535	-	8.5	-	-	120	2.5	Submersible	165 mm steel casing to 18 m, to be used for irrigation and cold storage
Borehole	Wilco	33.83070	23.89428	528	-	5.5	-	-	90	1.5	Submersible	Red in colour, tested to be sufficient for human consumption, to be used to washing trucks and irrigation
Concrete reservoirs	Water works	33.82934	23.86493	561	-	N/A	-	-	-	-	N/A	Town water works
Borehole	Mills	33.82450	23.86452	591	-	13.5	-	-	90	-	Submersible	Poor water quality, not in use due to pump malfunction, to be used for irrigation
Borehole	Devos	33.82365	23.86190	584	-	18.1	-	-	-	-	Open casing	steel casing rusted and collapsed into well – blocked
Borehole	Buys 1	33.82926	23.86505	564	-	13	-	-	70	-	Open casing	165 mm steel casing rusted and collapsed into well – blocked
Borehole	Buys 2	33.82874	23.86474	568	-	15.5				0.5	Submersible	Oxidised red water, 165 mm casing, irrigation use only
Spring	3323DD00005	33.85250	23.890278	520	-	-	-	-	-	4	none	DWAF spring not able to locate, in-accurate co-ordinates, domestic & agricultural use
Borehole	3323DD00012	33.84903	23.90326	535	-	-	-	-	52	1.1	Submersible pump	Used 3x per week for irrigation,, 152 mm diameter borehole
Spring	3323DD00013	33.837778	23.897222	-	-	-	-	-	-	-	none	No longer running, river now used for irrigation, co-ordinate in-accurate
Borehole	3323DD00014	33.84134	23.89591	522	-	-	-	-	47	4.1	Submersible	Used for irrigation and washing of vehicles, 152 mm diameter borehole
River	Kraaltjie (	33.81770	23.84221	482	13.9 @ 17.1°	N/A	6.9	67.4	N/A	N/A	N/A	Sample taken on north side of road bridge below the housed
River	Twee Riviere	33.83101	23.89876	509	44.4 @ 20°	N/A	7.4	310	N/A	N/A	N/A	Sample taken on south side of road bridge below rail bridge
Dam	Town Dam	33.87702	23.82921	606	18.6	N/A	-	-	N/A	N/A	N/A	Water running but levels are low and dam silted up

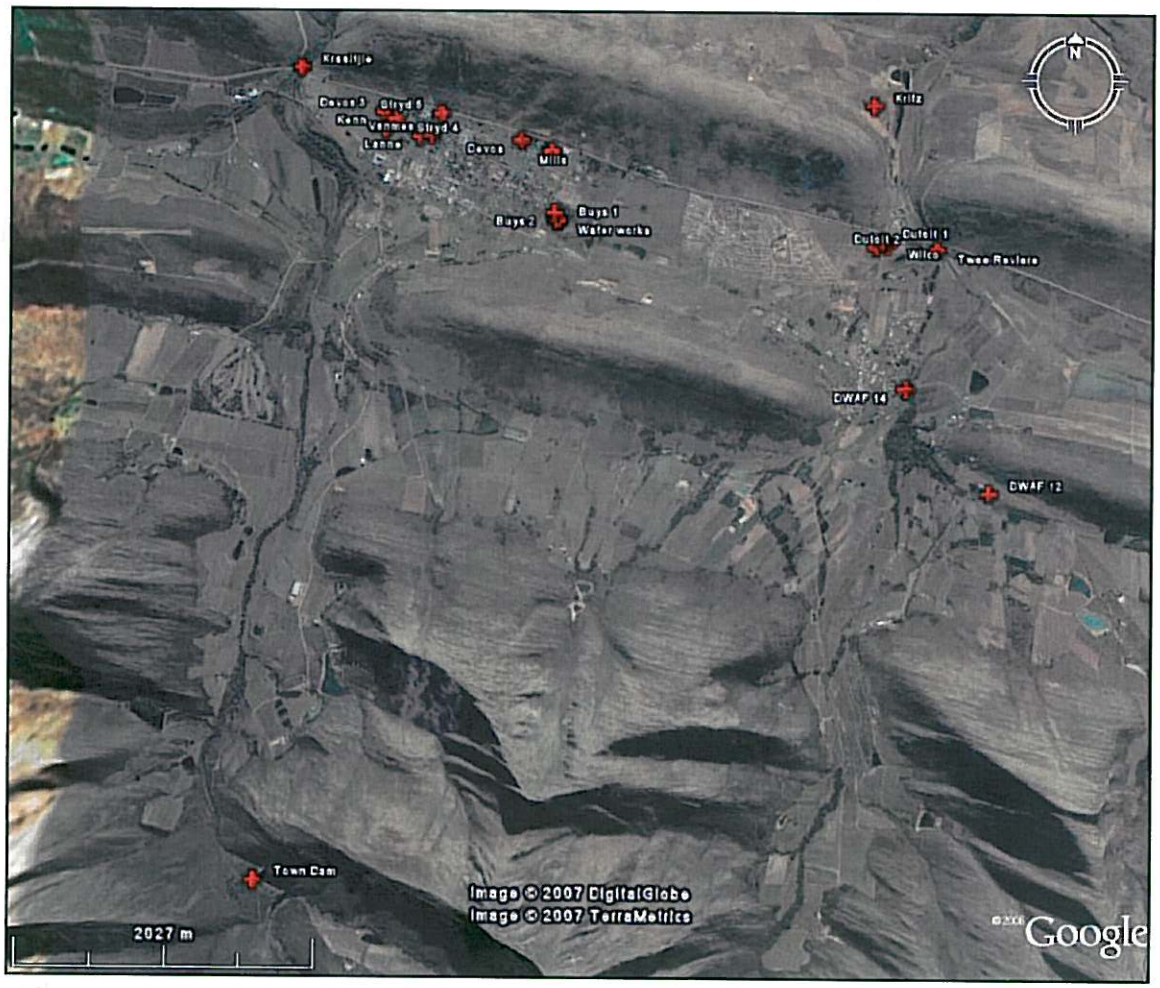

Figure 13: Aerial photography of area around Joubertina covered in the hydrocensus, all boreholes and the town dam are indicated

4.4 Target Selection

The following factors, besides geology, structure and hydrogeological potential were considered to be important during the selection of groundwater targets:

- Proximity to storage facilities – water storage dams or reservoirs;
- Accessibility to the target sites for drill rigs and vehicles;
- Existing proven water resources in the area and
- Consideration of land ownership and drilling permission – with regards to the location of municipal land.

After the initial site visit and during the start of the hydrocensus, four target areas comprising 6 potential drill targets were located for further investigation in Kareedouw. These target areas comprise Drie Krone (DK1 & DK2), Drie Krone Dam (DK3) to the west of the town, Kareedouw Well field (KAREE4) in Kareedouw and the Airfield (AIRF5) to the east of the town. All of these targets are located on the southern side of the R62 as the northern side of the valley is fairly inaccessible with respect to roads, large portions of municipal land occurs on the southern side of the

road and north of the R62 the valley drops down towards it's lowest point and the geology changes from competent sandstone to weathered Bokkeveld shales before rising sharply to sandstone once again. All of these targets are indicated on the aerial photographs and satellite images in Appendix B. Details of the targets investigated further, at Kareedouw, are as follows:

- **DK1:** Narrow fracture zone running in a south-north direction cross-cutting the east-west strike of the cream coloured to brownish weathered, medium to coarse grained quartzitic sandstone. The target fracture zone runs perpendicular to a track leading from the Kareedouw storage dams towards Drie Krone and to a pipeline (plastic) from the Drie Krone catchment to the storage dams. The target structure occurs parallel and adjacent to a fence line. Sandstone outcrop occurs over the target area and the fracture zone is indicated by joints, micro-shears and narrow (0.5-2 cm), annealed white quartz veining cross-cutting the sandstone bedding. The target continues to the south for a fair distance with the quartz veining becoming more pronounced 150 m south of the dirt track. This quartzitic sandstone represents the Goudini formation and may be close to the contact with the underlying Cederberg shales. Shearing has occurred along the sandstone bedding planes which are dipping steeply to the north with a near vertical dip angle. This target area occurs on municipal land and no access problems exist as a dirt track cuts the target area.
- **DK2:** Fracture zone running north-south at the head (upgradient) of a deep north-south trending gully extending from a shallow drainage channel running from the catchment at Drie Krone north towards the Krom River. This is represented by north-south oriented quartz veining and joints occurring perpendicular to the east-west strike of the sandstone bedding. This target is parallel but 220 m to the west of DK1. The same Goudini quartzitic sandstone is represented and shows apparent near vertical bedding. Micro folding, joints and micro-shears within the drainage indicate extensive shearing parallel to the bedding and joints and fractures perpendicular to the bedding show evidence of remobilisation. The remobilisation is represented by deformation of quartz veins to form vein breccias and opening of the annealed quartz filled joints to show gaps and voids. This target area also occurs on municipal land and no access problems exist as a dirt track runs through the area.
- **DK3:** This target area occurs 610 m to the east of DK1 and DK2 and just north east of the Kareedouw main water storage dam. This target is a 60 m wide zone of north-south oriented fractures and joints perpendicular to the east-west striking bedding. The geology here is also represented by the buff to cream coloured, medium to coarse grained quartzitic sandstone of the Goudini Formation. Two potential drill targets occur along this wide fracture zone and are represented by quartz vein micro-breccia and closely-spaced annealed quartz veining. No direct dirt tracks run to this targets area but it is easily accessible and occurs on municipal land.
- **KAREE4:** This target area occur close to the existing well field along a structural feature running from the water treatment plant past the low cost housing and down toward the gully between Kareedouw and the Uitkyk suburb to the east of Kareedouw. Quartz vein breccia and micro-shearing is evident within Goudini Formation quartzitic sandstone. The quartz veins and breccia are oriented in an east-north east direction perpendicular to the strike of the near vertical bedding. This target contains underground pipes, electrical cabling and is close to several houses and because of all this interference it will not be possible to perform

geophysics over this target. This target area occurs on municipal land and next to a dirt track in the town.

- **AIRF5:** This target occurs to the east of Kareedouw near the disused airfield and further up slope towards the Kareedouw Mountains. A narrow highly jointed breccia zone area occurs perpendicular to the east-west strike of the bedding of the white-grey hard competent quartzitic sandstone. These sandstones represent Peninsula Formation and contain small quartz-vein filled joint sets perpendicular to the near vertical bedding and shows minor shearing along bedding planes. The joint sets and quartz veins become more prominent and outcrop decreases towards the breccia zone represented by north-south oriented area of increased weathering. This target area appears to be on municipal land but ownership needs to be verified and occurs close to a dirt track so no access problems are envisioned.

The targets areas described above represent 4 target areas for further work i.e. geophysical delineation to pin-point potential drill targets for water exploration in and around the town of Kareedouw and are shown in old satellite imagery represented by Figure 14.

Figure 14: Satellite image of the target areas in and around the town of Kareedouw

Four target areas comprising 5 potential drill targets were located for further investigation in Joubertina. These targets comprise the Water Reservoir (Joub1A and B) site on the northern ridge above the town, an area along the R62 close to a road works camp (Joub2), the Kraaltjie River Valley (Joub3) to the north of the Kraaltjie guesthouse and along the Wabooms River and at Twee Reviere (Joub4) through the north-south valley created by the Twee Reviere river cutting the ridge to the north of the town. All of these targets with the location of potential drill sites are shown on the

satellite images in Appendix B. Details of the targets investigated further, at Joubertina, are as follows:

- **JOUB1:** This target area occurs just to the west of the water storage dams in Joubertina. The water storage dams occur on the ridge to the north of the town and occur in Skurweberg Formation a whitish-grey medium to coarse grained hard, competent feldspathic sandstone. The bedding in this are dips south at 70-80°, strikes east-west and occurs on the northern limb of the syncline which forms the Langkloof valley. This target zone comprises parallel sets of fractures or joints running north-south and perpendicular to the bedding. Two areas relatively close together were identified as zones of increased fracturing which needed to be investigated further by geophysical traverses. This target area is on municipal land and several dirt tracks cut the area.
- **JOUB2:** This target area occurs to the west of JOUB1 along the R62 and close to a road works camp. The slope would make access difficult but not impossible as a gate and fence occur within the target area for easier access. This target area occurs on municipal land and partially on land owned by the Kraaltjie guest house and farm. Permission for exploration and drilling has been obtained verbally from the owner if potential targets are identified. Widely spaced thin quartz veins occurs parallel and perpendicular to bedding within this target area. As with JOUB1 the rocks are represented by white-grey competent and hard Skurweberg Formation feldspathic sandstone.
- **JOUB3:** This target area occurs to the north of the R62 and the Kraaltjie guesthouse in the Wabooms river gorge. This land is owned by Mrs Elize Botha who runs the Kraaltjie guesthouse and is accessible by a dirt track and through a locked gate. This target area comprises a river gorge in which the steeply dipping Skurweberg Formation rocks dip to the south. The rocks dip at 70° to the south and represent upward coarsening grey to buff coloured feldspathic sandstone. A zone of shearing occurs in some warped outcrop along the gorge and severe perpendicular jointing has opened numerous voids in the rock along the joints and bedding planes. Quartz veining is common with micro-veins and thick veins filling joints and occurring parallel to bedding. Two breccia zones of fractured quartz veins were also observed south of the zone of shearing and are also considered potential targets.
- **JOUB4:** This target area occurs in the Twee Riviere river valley north of the R62 and is on the opposite side of the ridge from JOUB3. This zone of shearing along the bedding plane of the Skurweberg sandstone presents a good potential target and an attempt to find this target to the east resulted in this target area being selected for further investigation. Accessibility is just off the road leading north through this valley and this target appears to be on the continuation of municipal land.

The targets areas described above represent 6 potential drill targets and require further work i.e. geophysical, to delineate the structures observed within the geology and to pin-point potential sites. The target area described above around the town of Joubertina is shown by Figure 15.

Figure 15: Satellite image of the target areas in and around the town of Joubertina

4.5 Geophysical Investigation

The magnetic traverses over the identified target areas were done between the 20-22 February 2007. The electromagnetic traverses were attempted at the same time as the magnetic work, but the EM34 geonics used showed little response and little variation in signature in the low conductive Table Mountain Group rocks. The geophysics was complete using the Max-Min method in April 2007, with the use of the borrowed DWAF Max-Min equipment. DWAF is kindly thanked for the use of this equipment. All the data from the magnetic, EM and max-min traverses is provided in Appendix A.

The geophysical data for the Kareedouw target areas is discussed below and the traverse lines are shown in Figures 16-17:

- **DK1 & DK2:** A mag traverse from east to west across DK1 and DK2 (DK1 & DK2 EW) was done over a distance of 400 m (Figure 16). The magnetic data indicates a wide anomaly between 45-110 m along the traverse just before the target area labelled DK1. The traverse indicates where the fence is encountered and another anomaly between 230-310 m at the approximate position of the target labelled DK2. These are both wide well developed anomalies showing both magnetic highs and lows. These two drill targets are therefore confirmed as potential structural zones suitable for hydrogeological exploration. The max-min data does not vary considerably but picks up a faint feature between 55-105 m at DK1 and the fence between 155-185 m but shows nothing near DK2. The max-min does not appear to show any definite anomalies or confirm the mag data. The 200 m wide south to

north traverse across DK1 (DK1 NS, Figure 16) indicates a wide structural zone between 55-155 m from the start of the traverse. This anomaly could possibly indicate shearing along the bedding in an east-west direction. No distinct anomaly is delineated by the max-min data but there appears to be a sudden decrease in conductivity at 60 m at the start of the anomaly and a steady increase across the anomaly.

- **DK3:** A mag traverse from east to west across target DK3 was done over a distance of 400 m (DK3 EW, Figure 16). This traverse indicates a broad anomaly between 40-165 m and another anomaly between 205-260 m. These anomalies coincide with the two potential targets noted during the field mapping and remote sensing target selection phase (DK3A & DK3B). The max-min data shows a definite anomaly between 25-135 m but no anomaly further along the traverse.

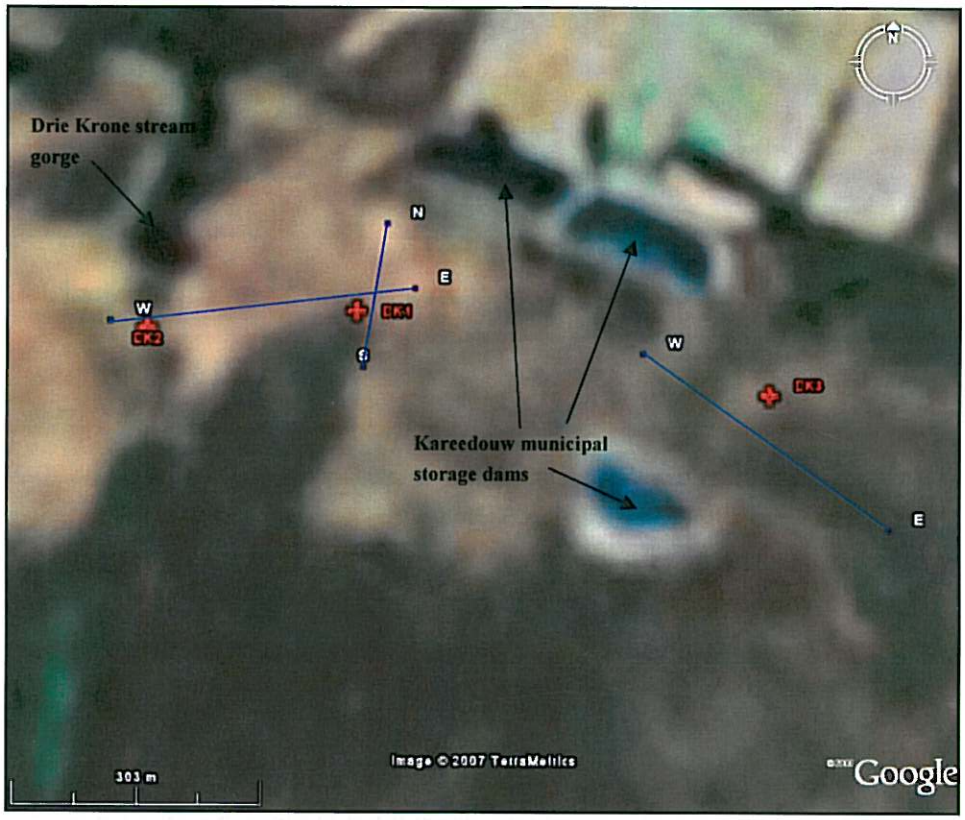

Figure 16: Old satellite imagery (therefore unfocussed) showing the EW and NS geophysical traverses over targets DK1 & DK2 and the EW traverse over target DK3

- **KAREE4:** No geophysical traverses were done over this target due to the interference which would have occurred from the nearby sewer pipe, electrical cables and houses.

- **AIRF5:** A mag traverse from east to west across target area AIRF5 covered a distance of 300 m (Figure 17). No distinct anomalies were observed over this traverse in the mag data. The max-min data indicates an anomaly towards the end of the traverse close to the gorge within which the perennial Kareedouw spring flows. No distinct targets could therefore be discerned to the airfield anomaly.

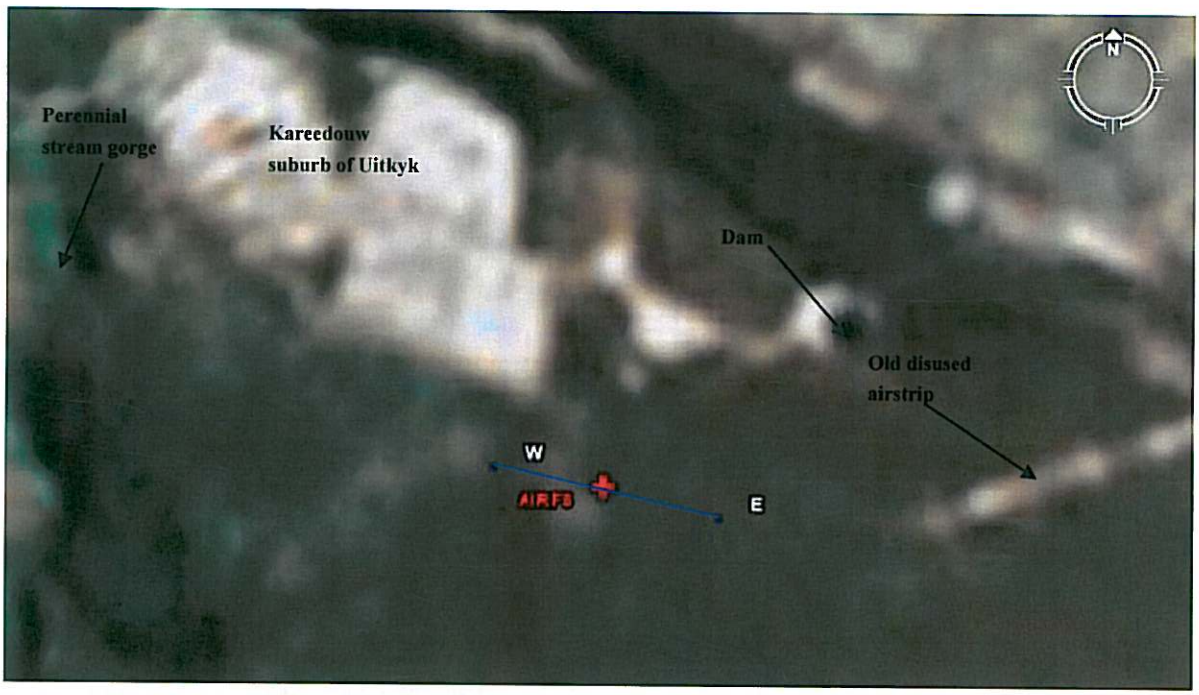

Figure 17: Old satellite imagery (therefore unfocussed) showing the EW geophysical traverse over target AIRF5

The geophysical data for the Joubertina target areas is discussed below and the traverse lines are shown in Figures 18-21:

- **JOUB1:** The mag traverse clearly denotes the water tanks along the east-west traverse 0f 300 m and indicates an anomaly between 140-160 m along the traverse. This anomaly is also indicated on the max-min data as a slight conductive high at 145-165 m and coincides with the JOUB1A target noted during field mapping and remote sensing investigations. The max-min data also picks up the water tanks as a conductive high and of note is an extreme high to low conductive anomaly towards the end of the traverse where the outcrop drops down to a depression and a bowl shaped feature. This anomaly shown by the max-min is not reflected in the mag data. The east-west and north-south traverse lines are shown in Figure 18. The south-north traverse across the target area covers a distance of 100 m and shows a mag high towards the beginning of the traverse at 10-35 m along the traverse which is reflected by a conductive low between 15-35 m along the max-min traverse. This anomaly coincides with target JOUB1B suggested as a potential site of structural complexity during the field mapping phase. The east-west and south-north traverses are shown in Figure 18.

- **JOUB2:** A mag traverse from east to west across target area JOUB2 covered a distance of 300 m (Figure 19). No distinct anomalies were observed over this traverse in the mag data, other than the fence crossed. The max-min data also picks up the fence as a conductive low but no obvious anomalies are indicated.

-

Figure 18: Position of targets JOUB1A and 1B and the east-west and south-north traverses covering target area JOUB1

Figure 19: Position of the east-west traverse covering target area JOUB2

- **JOUB3:** The mag traverse of 400 m over anomaly JOUB3 runs approximately south-north along a dirt track. The mag traverse indicates an anomaly at 150-185 m along the traverse (mag low) with another subtle anomaly showing at the marked linear feature and drainage at 205-225 m. The EM-34 data over the same traverse appear to verify these anomalies with apparent low conductivity features at 180 and 220 m but the data does not vary considerably. The max-min data also shows two distinct anomalies with high conductivities between 145-225 m across the linear feature picked up during field mapping and remote sensing. The mag, EM-34 and max-min data all indicate the fence posts at the beginning of the traverse as well. The traverse across target JOUB3 is shown in Figure 20.

- **JOUB4:** The south-north traverse covering target JOUB4 is 300 m long. The mag data indicates a broad anomaly (mag high) between 145-290 m along the traverse. The max-min data coincides with this anomaly indicating a slightly high conductivity at 155 m along the traverse. The traverse across target JOUB4 is shown in Figure 21.

Figure 20: Position of the south-north traverse covering target area JOUB3

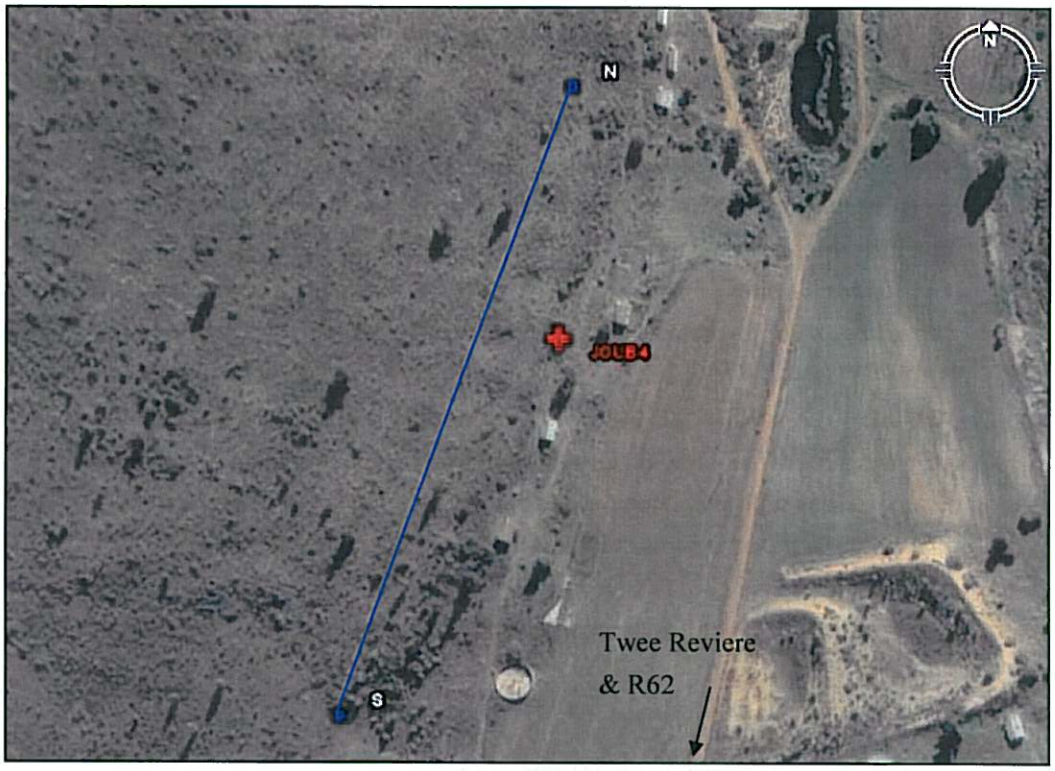

Figure 21: Position of the south-north traverse covering target area JOUB4

The magnetic data appears to have been successful in confirming most of the structural features originally picked up by field mapping and remote sensing. This technique picks up magnetic minerals in the rock, typically developed along shear/fracture/joint planes and within mylonite. Such magnetic minerals such as magnetite (Fe_2O_4) could result from the break down of pyrite in the sandstones during fluid flow but typically occur as fine minerals in structural zones. The max-min and EM34 data showed very few anomalies or changes indicating the material traversed show low electromagnetic conductivities. The max-min and EM34 are therefore deemed unsuccessful and doesn't seem suitable for this study and the hydrogeological exploration in Table Mountain Group quartzitic sandstones.

5 Target Prioritisation

5.1 Kareedouw Targets

From the desk study, target areas and geophysical traverses the following drill targets were selected and prioritised in order of highest water potential. The targets were prioritised with respect to the strength of the geophysical anomalies (mag and EM), intensity of structural deformation (shearing along bedding and cross-cutting joints/fractures), geology, location (private or municipal land), proximity to water storage, access (roads or tracks) and proximity to proven water sources. Priority 1 targets represent high groundwater potential, based on the above factors. Priority 2 represent targets of medium groundwater potential and priority 3 represents targets of low to no groundwater potential. The co-ordinates, expected geology that will be encountered and expected depth of drilling of each of the targets are listed in Table 6.

- **Priority 1 targets:** DK2, DK3A, DK3B and DK1
- **Priority 2 targets:** KAREE4 (no geophysics)
- **Priority 3 target:** AIRF5

Table 6: Co-ordinates, expected geology and depth of drilling required for the Priority 1 and 2 drilling targets identified as potential water sources for Kareedouw

Drill Target	Lat	Long	Expected Geology	Drill depth
DK2	-33.946684	24.255350	Quartzitic sandstone, near vertical beds of Goudini Fm	100-150 m
	-33.946807	24.254221		
DK3A	-33.948626	24.264354	Quartzitic sandstone, near vertical beds of Goudini Fm	100-150 m
	-33.948448	24.264050		
DK3B	-33.947843	24.263114	Quartzitic sandstone, near vertical beds of Goudini Fm	100-150 m
DK1	-33.946498	24.257938	Quartzitic sandstone, near vertical beds of Goudini Fm	100-150 m
KAREE4	-33.955495	24.246933	Quartzitic sandstone, near vertical beds of Goudini Fm	>150 m

5.2 Joubertina Targets

From the desk study, target areas and geophysical traverses the following drill targets were selected and prioritised in order of highest water potential. The targets were prioritised with respect to the strength of the geophysical anomalies (mag and EM), intensity of structural deformation (shearing along bedding and cross-cutting joints/fractures), geology, location (private or municipal land), proximity to water storage, access (roads or tracks) and proximity to proven water sources. The co-ordinates, expected geology that will be encountered and expected depth of drilling of each of the targets are listed in Table 7.

- **Priority 1 targets:** JOUB3A, JOUB3B, JOUB1A & JOUB1B
- **Priority 2 targets:** JOUB4
- **Priority 3 targets:** JOUB2

Table 7: Co-ordinates, expected geology and depth of drilling required for the drilling targets identified as potential water resources for Joubertina

Drill Target	Lat	Long	Expected Geology	Drill depth
JOUB1A	-33.823553	23.866110	Feldspathic sandstone, 60° south dipping Skurweberg Fm	100-150 m
JOUB1B	-33.823860	23.865924	Feldspathic sandstone, 60° south dipping Skurweberg Fm	100-150 m
JOUB3A	-33.816216	23.844609	Feldspathic sandstone, 70° south dipping Skurweberg Fm	200 m
JOUB3B	-33.815884	23.844939	Feldspathic sandstone, 70° south dipping Skurweberg Fm	200 m
JOUB4	-33.827047	23.893262	Feldspathic sandstone, 70° south dipping Skurweberg Fm	100-150 m

6 Conclusions and Recommendations

From the 1st phase of the hydrogeological study and geophysical work done at Kareedouw and Joubertina, the following conclusions and recommendations are made:

- A hydrogeological investigation was carried out to augment the water supply to the towns of Kareedouw and Joubertina. This comprised a desk study component, followed by remote sensing, hydrocensus, geological field mapping and geophysical traverses (Mag, EM and max-min), for determination of suitable hydrogeological drilling sites.
- Six groundwater exploration drill sites have been identified at both Kareedouw and Joubertina.
- The expected geology, estimated depth of drilling and co-ordinates for all twelve drill sites are listed.
- From the hydrocensus, it was determined a supply problem or shortage of water definitely exists in both towns with shortfall often experienced for several days during the weeks. Many community members have drilled their own supply boreholes in the towns due to this problem.
- The quality of water in the Bokkeveld shales tends to be brackish while that from the Table Mountain Group rocks is fresh, with low salinity but relatively acidic. The iron content of water from the Table Mountain Group rocks tends to be relatively high creating soft and corrosive conditions, therefore all boreholes drilled must be cased with PvC casing and pipes and equipped with stainless steel pumps.
- Investigation of dedicated management team of the existing water resources in both towns should be done along with upgrading of the aging supply pipes.

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LGA Maclear Pr Sci Nat
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SRK Consulting

Appendix A:

Geophysical Targets and Data

1. Targets DK1 & DK2: east to west traverse

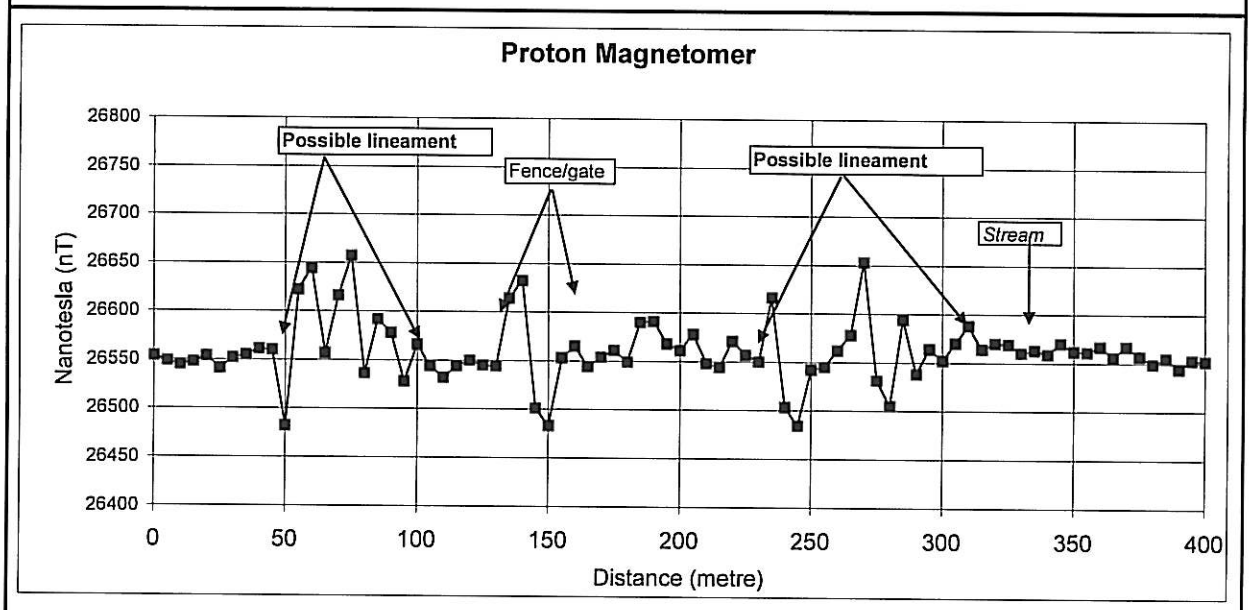
Project Name:	DWAF Hydro Karee	**SRK Technician:**	Jaco Pretorius
Project Number:	374535	**Direction:**	SE258NW
Traverse Number:	374535 - DK1 & DK2 EW	**Date:**	22/2/2007
Village Name:	Kareedouw		
Latitude Start:	33.9463	**Longitude start:**	24.25855
Latitude End:	33.94672	**Longitude End:**	24.25426

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26554	0		
5	26549	10		
10	26545	20		
15	26548	30		
20	26554	40		
25	26541	50		
30	26552	60		
35	26555	70		
40	26561	80		
45	26560	90		
50	26482	100		
55	26622	110		
60	26644	120		
65	26557	130		
70	26616	140		
75	26657	150		
80	26536	160		
85	26592	170		
90	26578	180		
95	26528	190		
100	26566	200		
105	26544	210		
110	26532	220		
115	26544	230		
120	26550	240		
125	26545	250		
130	26544	260		
135	26614	270		
140	26632	280		
145	26501	290		
150	26483	300		
155	26553	310		
160	26565	320		
165	26544	330		
170	26554	340		
175	26561	350		
180	26549	360		
185	26590	370		
190	26591	380		
195	26568	390		
200	26561	400		
205	26578	410		
210	26548	420		
215	26544	430		
220	26571	440		
225	26557	450		
230	26550	460		
235	26616	470		
240	26503	480		
245	26484	490		
250	26542	500		
255	26545	510		
260	26562	520		
265	26578	530		
270	26653	540		
275	26531	550		

280	26505	560		
285	26594	570		
290	26538	580		
295	26564	590		
300	26552	600		
305	26570	610		
310	26588	620		
315	26564	630		
320	26570	640		
325	26569	650		
330	26560	660		
335	26563	670		
340	26559	680		
345	26570	690		
350	26562	700		
355	26561	710		
360	26567	720		
365	26556	730		
370	26567	740		
375	26557	750		
380	26549	760		
385	26555	770		
390	26544	780		
395	26553	790		
400	26552	800		
		810		
		820		

Project Name: **DWAF Hydro Karee** **Project Number:** **374535**

Traversе Number: **374535-DK1 & DK2**



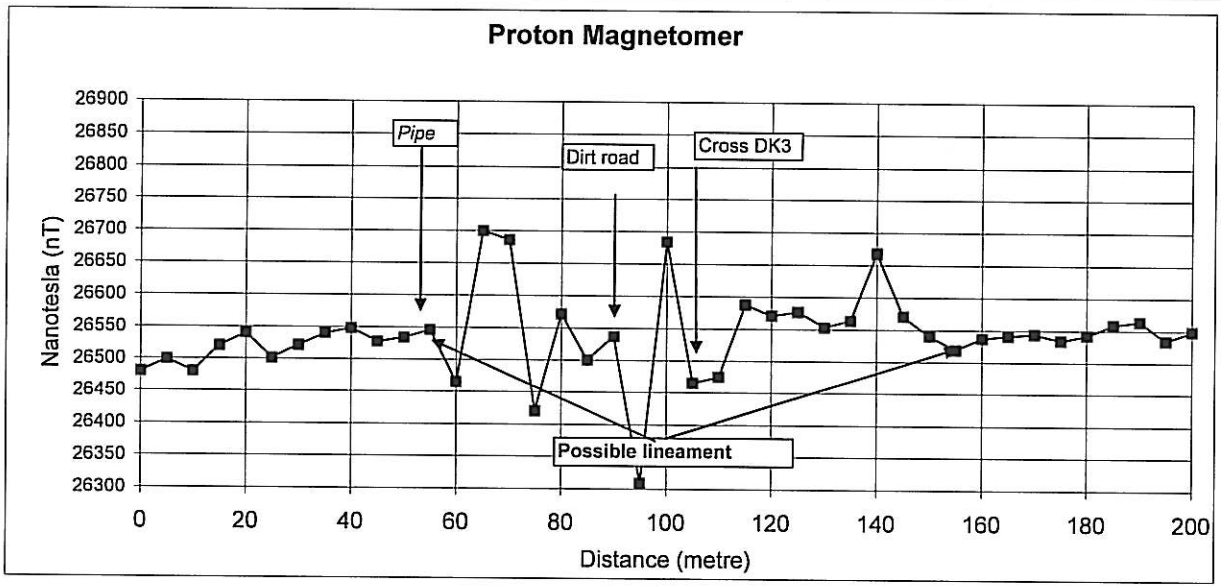
2. Target DK1: south to north traverse

Project Name:	DWAF Hydro Karee	**SRK Technician:**	Jaco Pretorius
Project Number:	37435	**Direction:**	SE258NW
Traverse Number:	374522 - DK1 NS	**Date:**	22/2/2007
Village Name:	Kareedouw		
Latitude Start:	33.9463	**Longitude start:**	24.25855
Latitude End:	33.94672	**Longitude End:**	24.25426

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26480	0		
5	26499	10		
10	26480	20		
15	26520	30		
20	26540	40		
25	26501	50		
30	26521	60		
35	26540	70		
40	26548	80		
45	26527	90		
50	26534	100		
55	26546	110		
60	26465	120		
65	26700	130		
70	26686	140		
75	26420	150		
80	26572	160		
85	26500	170		
90	26537	180		
95	26309	190		
100	26684	200		
105	26465	210		
110	26475	220		
115	26588	230		
120	26571	240		
125	26577	250		
130	26553	260		
135	26564	270		
140	26668	280		
145	26571	290		
150	26540	300		
155	26519	310		
160	26537	320		
165	26541	330		
170	26544	340		
175	26534	350		
180	26542	360		
185	26559	370		
190	26564	380		
195	26534	390		
200	26549	400		

Project Name: DWAF Hydro Karee **Project Number:** 374535

Traverse Number: 374535-DK1



3. Target DK3: east to west traverse

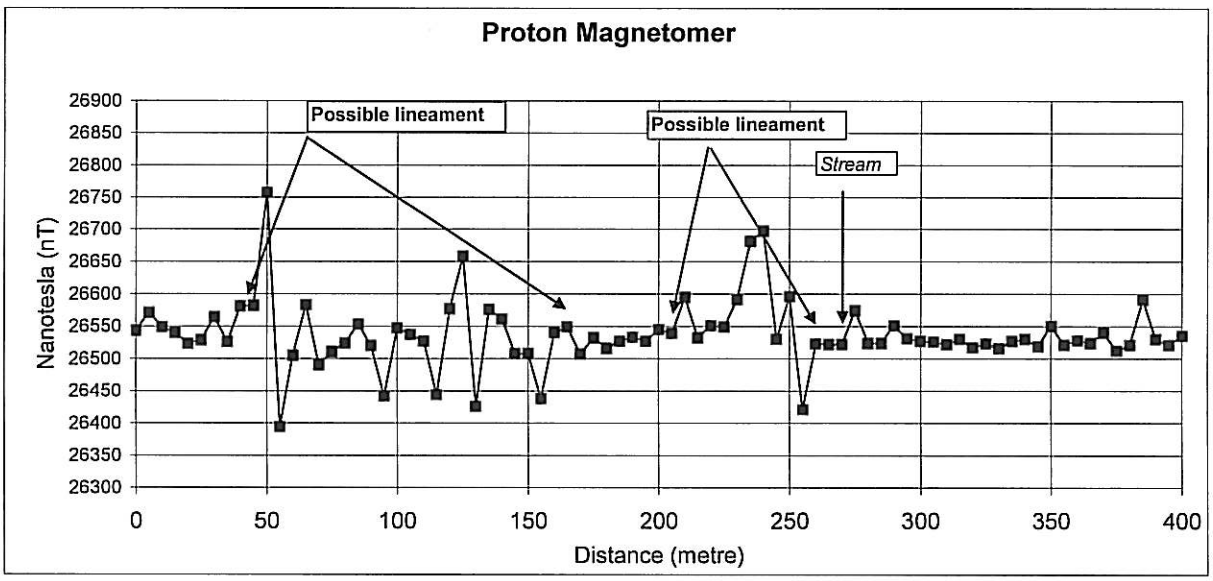
Project Name	DWAF Hydro Karee	**SRK Technician**	Jaco Pretorius
Project Number	374535	**Direction**	SE 303NW
Traverse Number	374535 - DK3 EW	**Date**	22/2/2007
Village Name	Kareedouw		
Latitude Start	33.94916	**Longitude start**	24.26532
Latitude End	33.94707	**Longitude End**	24.26186

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26543	0		
5	26571	10		
10	26549	20		
15	26540	30		
20	26523	40		
25	26529	50		
30	26564	60		
35	26526	70		
40	26581	80		
45	26582	90		
50	26757	100		
55	26394	110		
60	26505	120		
65	26583	130		
70	26490	140		
75	26511	150		
80	26524	160		
85	26553	170		
90	26520	180		
95	26442	190		
100	26547	200		
105	26537	210		
110	26527	220		
115	26444	230		
120	26577	240		
125	26658	250		
130	26426	260		
135	26576	270		
140	26561	280		
145	26508	290		
150	26508	300		
155	26438	310		
160	26540	320		
165	26549	330		
170	26507	340		
175	26532	350		
180	26516	360		
185	26527	370		
190	26533	380		
195	26527	390		
200	26545	400		
205	26539	410		
210	26595	420		
215	26532	430		
220	26551	440		
225	26549	450		
230	26591	460		

235	26681	470		
240	26697	480		
245	26530	490		
250	26596	500		
255	26421	510		
260	26523	520		
265	26522	530		
270	26522	540		
275	26574	550		
280	26524	560		
285	26524	570		
290	26551	580		
295	26531	590		
300	26527	600		
305	26526	610		
310	26522	620		
315	26530	630		
320	26517	640		
325	26523	650		
330	26516	660		
335	26527	670		
340	26530	680		
345	26519	690		
350	26550	700		
355	26521	710		
360	26528	720		
365	26524	730		
370	26540	740		
375	26512	750		
380	26521	760		
385	26591	770		
390	26530	780		
395	26521	790		
400	26535	800		

Project Name: DWAF Hydro Karee **Project Number:** 374535

Traverse Number: 374535 - DK3



4. Target AIRF5: east to west traverse

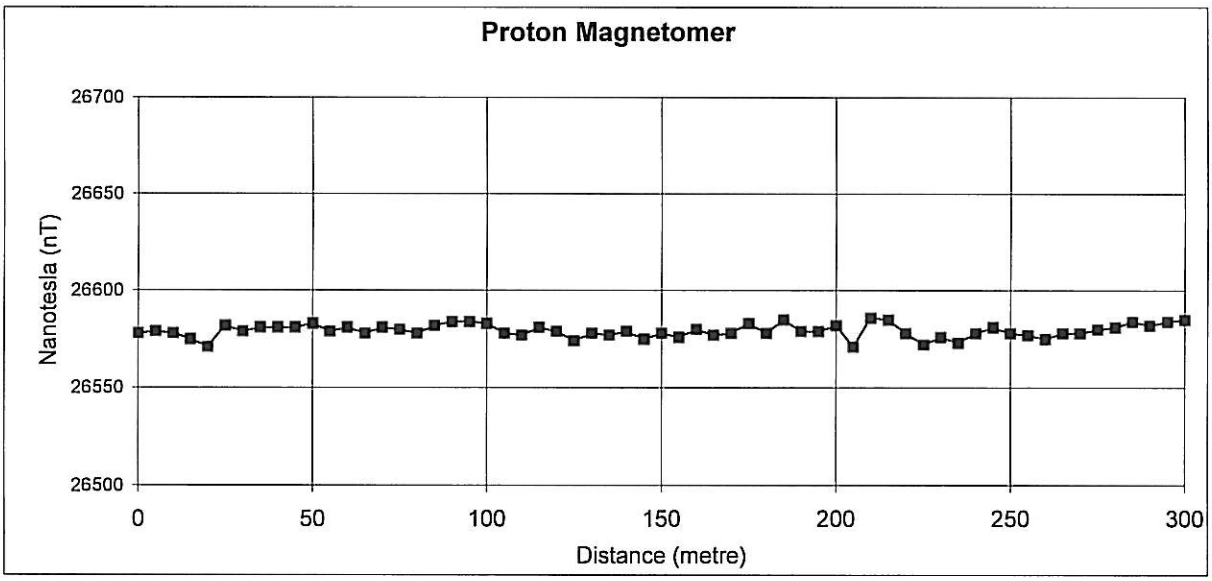
Project Name	DWAF Hydro Karee	**SRK Technician**	Jaco Pretorius
Project Number	374535	**Direction**	SE285NW
Traverse Number	374535 – AIRF5 EW	**Date**	22/2/2007
Village Name	Kareedouw		
Latitude Start	33.96152	**Longitude start**	24.31456
Latitude End	33.96094	**Longitude End**	24.31136

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
0	26578	0		
5	26579	10		
10	26578	20		
15	26575	30		
20	26571	40		
25	26582	50		
30	26579	60		
35	26581	70		
40	26581	80		
45	26581	90		
50	26583	100		
55	26579	110		
60	26581	120		
65	26578	130		
70	26581	140		
75	26580	150		
80	26578	160		
85	26582	170		
90	26584	180		
95	26584	190		
100	26583	200		
105	26578	210		
110	26577	220		
115	26581	230		
120	26579	240		
125	26574	250		
130	26578	260		
135	26577	270		
140	26579	280		
145	26575	290		
150	26578	300		
155	26576	310		
160	26580	320		
165	26577	330		
170	26578	340		
175	26583	350		
180	26578	360		
185	26585	370		
190	26579	380		
195	26579	390		
200	26582	400		
205	26571	410		
210	26586	420		
215	26585	430		
220	26578	440		
225	26572	450		
230	26576	460		
235	26573	470		
240	26578	480		

245	26581	490		
250	26578	500		
255	26577	510		
260	26575	520		
265	26578	530		
270	26578	540		
275	26580	550		
280	26581	560		
285	26584	570		
290	26582	580		
295	26584	590		
300	26585	600		

Project Name: **DWAF Hydro Karee** **Project Number:** **374535**

Traverse Number: **374535-AIRF1**



5. Target JOUB1: east to west traverse

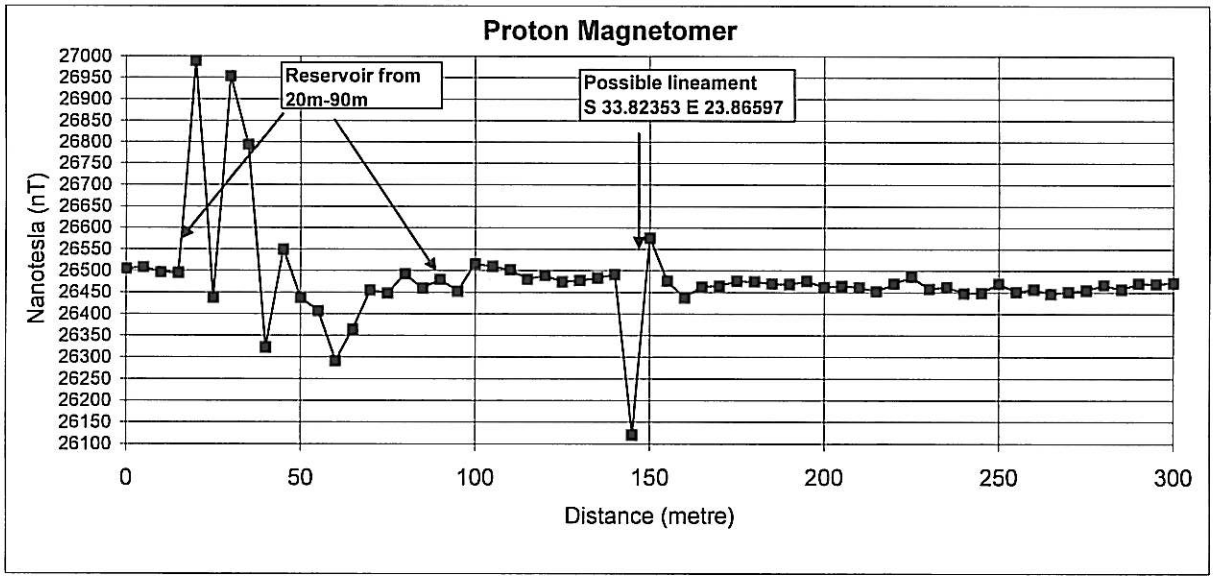
Project Name:	DWAF Hydro Joub	**SRK Technician:**	Jaco Pretorius
Project Number:	374522	**Direction:**	SE281NW
Traverse Number:	374522-JOUB1 EW	**Date:**	21/2/2007
Village Name:	Joubertina		
Latitude Start:	33.82373	**Longitude start:**	23.86749
Latitude End:	33.82332	**Longitude End:**	23.86436

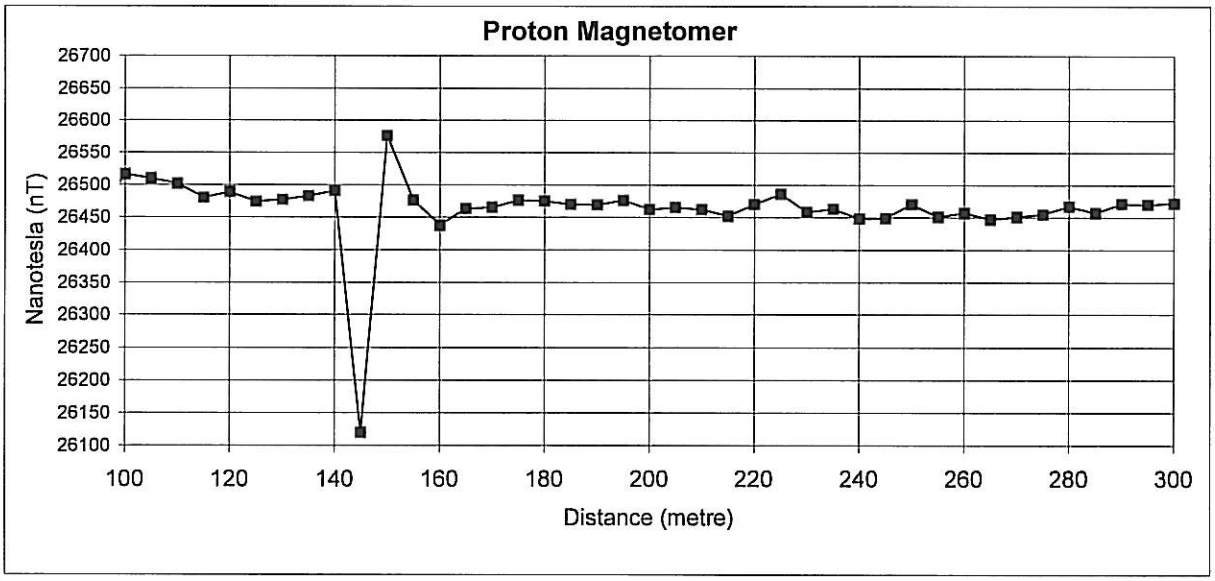
Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26504	0		
5	26508	10		
10	26496	20		
15	26495	30		
20	26989	40		
25	26438	50		
30	26953	60		
35	26794	70		
40	26322	80		
45	26549	90		
50	26438	100		
55	26407	110		
60	26291	120		
65	26364	130		
70	26455	140		
75	26448	150		
80	26492	160		
85	26459	170		
90	26480	180		
95	26452	190		
100	26516	200		
105	26510	210		
110	26502	220		
115	26480	230		
120	26489	240		
125	26474	250		
130	26477	260		
135	26483	270		
140	26491	280		
145	26120	290		
150	26576	300		
155	26476	310		
160	26438	320		
165	26463	330		
170	26465	340		
175	26476	350		
180	26475	360		
185	26470	370		
190	26469	380		
195	26476	390		
200	26462	400		
205	26465	410		
210	26462	420		
215	26452	430		
220	26470	440		
225	26486	450		
230	26458	460		

235	26463	470		
240	26448	480		
245	26449	490		
250	26470	500		
255	26451	510		
260	26457	520		
265	26447	530		
270	26451	540		
275	26455	550		
280	26467	560		
285	26457	570		
290	26471	580		
295	26470	590		
300	26472	600		

Project Name: DWAF Hydro Joub **Project Number:** 374522

Traverse Number: 374522-ReservoirEW





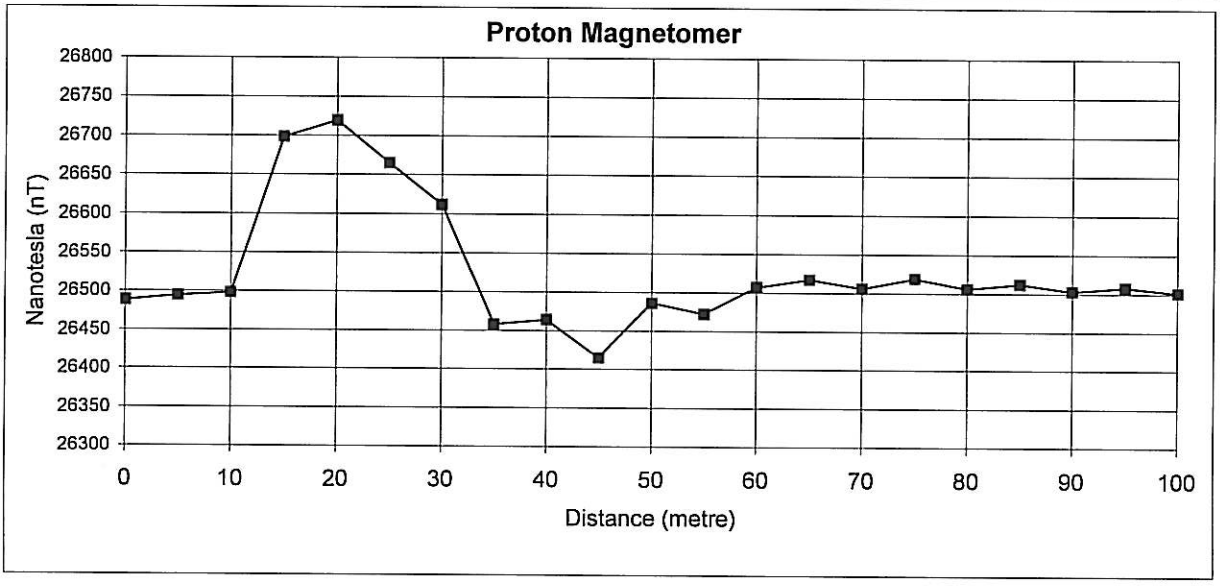
2. Target JOUB1: south to north traverse

Project Name	DWAF Hydro Joub	**SRK Technician**	Jaco Pretorius
Project Number	374522	**Direction**	SW30NE
Traverse Number	374522-JOUB1 NS	**Date**	21/2/2007
Village Name	Joubertina		
Latitude Start	33.82395	**Longitude start**	23.86569
Latitude End	33.82315	**Longitude End**	23.86621

Proton Magnetometer		Geonics EM-34		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26488	0		
5	26494	10		
10	26498	20		
15	26698	30		
20	26719	40		
25	26665	50		
30	26612	60		
35	26458	70		
40	26464	80		
45	26415	90		
50	26486	100		
55	26472	110		
60	26507	120		
65	26517	130		
70	26506	140		
75	26519	150		
80	26506	160		
85	26512	170		
90	26503	180		
95	26508	190		
100	26501	200		

Project Name: DWAF Hydro Joub **Project Number:** 374522

Traverse Number: 374522-Reservoir NS



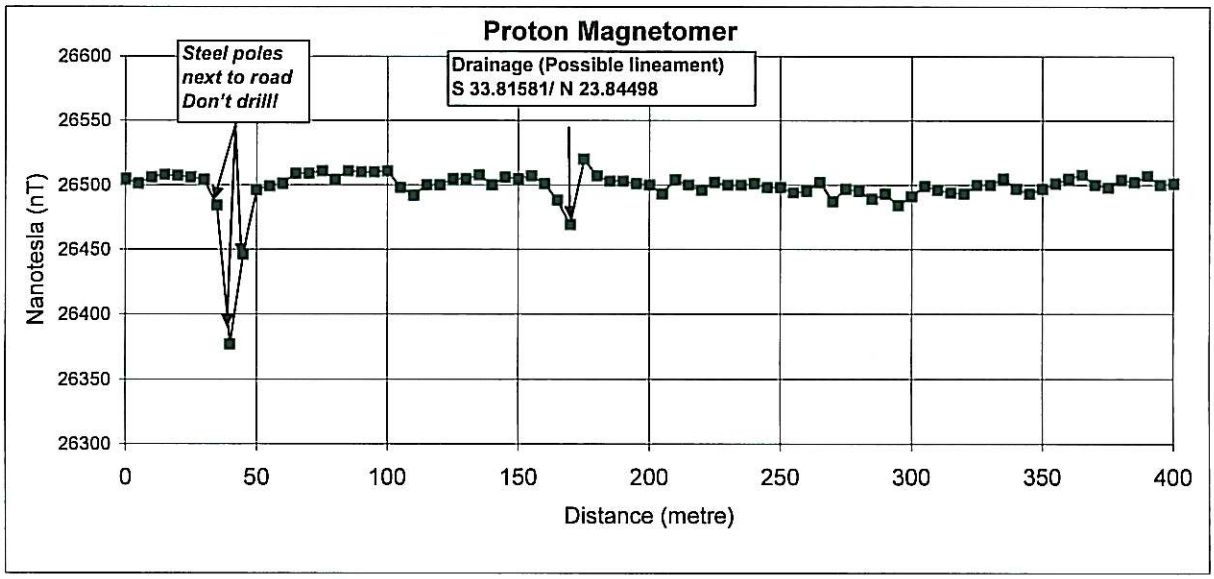
3. Target JOUB3: south to north traverse

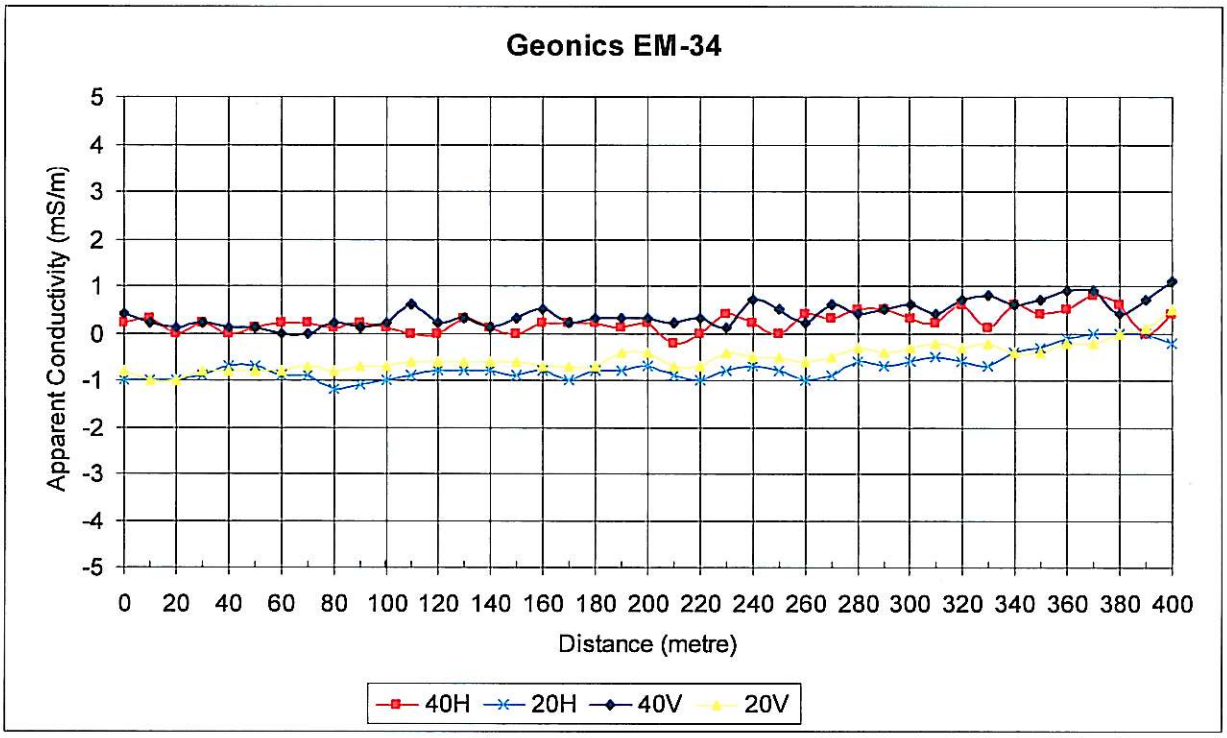
Project Name	DWAF Hydro Joub	**SRK Technician**	Jaco Pretorius
Project Number	374522	**Direction**	SW54NE
Traverse Number	374522-JOUB3 NS	**Date**	20/2/2007
Village Name	Joubertina		
Latitude Start	33.81696	**Longitude start**	23.8439
Latitude End	33.81383	**Longitude End**	23.84558

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26505	0	-0.8	-1
5	26501	10	-1	-1
10	26506	20	-1	-1
15	26508	30	-0.8	-0.9
20	26507	40	-0.8	-0.7
25	26506	50	-0.8	-0.7
30	26504	60	-0.8	-0.9
35	26484	70	-0.7	-0.9
40	26377	80	-0.8	-1.2
45	26446	90	-0.7	-1.1
50	26496	100	-0.7	-1
55	26499	110	-0.6	-0.9
60	26501	120	-0.6	-0.8
65	26509	130	-0.6	-0.8
70	26509	140	-0.6	-0.8
75	26511	150	-0.6	-0.9
80	26504	160	-0.7	-0.8
85	26511	170	-0.7	-1
90	26510	180	-0.7	-0.8
95	26510	190	-0.4	-0.8
100	26511	200	-0.4	-0.7
105	26498	210	-0.7	-0.9
110	26492	220	-0.7	-1
115	26500	230	-0.4	-0.8
120	26500	240	-0.5	-0.7
125	26505	250	-0.5	-0.8
130	26505	260	-0.6	-1
135	26508	270	-0.5	-0.9
140	26500	280	-0.3	-0.6
145	26506	290	-0.4	-0.7
150	26505	300	-0.3	-0.6
155	26507	310	-0.2	-0.5
160	26501	320	-0.3	-0.6
165	26488	330	-0.2	-0.7
170	26469	340	-0.4	-0.4
175	26520	350	-0.4	-0.3
180	26507	360	-0.2	-0.1
185	26503	370	-0.2	0
190	26503	380	0	0
195	26501	390	0.1	0
200	26500	400	0.5	-0.2
205	26493	410		
210	26504	420		
215	26500	430		
220	26496	440		
225	26502	450		
230	26500	460		

235	26500	470		
240	26501	480		
245	26498	490		
250	26498	500		
255	26494	510		
260	26495	520		
265	26502	530		
270	26487	540		
275	26497	550		
280	26495	560		
285	26489	570		
290	26493	580		
295	26484	590		
300	26491	600		
305	26499	610		
310	26496	620		
315	26494	630		
320	26493	640		
325	26500	650		
330	26500	660		
335	26505	670		
340	26497	680		
345	26493	690		
350	26497	700		
355	26501	710		
360	26505	720		
365	26508	730		
370	26500	740		
375	26498	750		
380	26504	760		
385	26502	770		
390	26507	780		
395	26500	790		
400	26501	800		
		810		
		820		

Project Name:	DWAF Hydro Joub	Project Number:	374522
Traverse Number:	374522-Kraaltjie		





3. Target JOUB2: east to west traverse

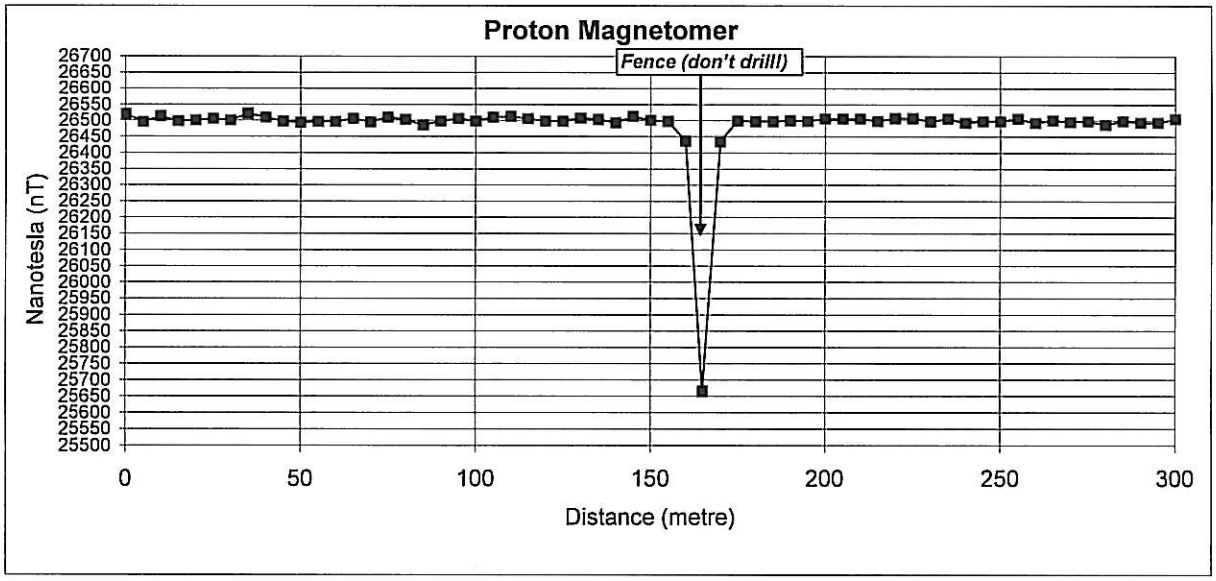
Project Name	DWAF Hydro Joub	**SRK Technician**	Jaco Pretorius
Project Number	374522	**Direction**	SE279NW
Traverse Number	374522-JOUB2 EW	**Date**	21/2/2007
Village Name	Joubertina		
Latitude Start	33.82036	**Longitude start**	23.85343
Latitude End	33.81963	**Longitude End**	23.85035

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26520	0		
5	26495	10		
10	26513	20		
15	26498	30		
20	26501	40		
25	26505	50		
30	26501	60		
35	26522	70		
40	26509	80		
45	26497	90		
50	26493	100		
55	26496	110		
60	26496	120		
65	26505	130		
70	26495	140		
75	26510	150		
80	26502	160		
85	26485	170		
90	26498	180		
95	26506	190		
100	26498	200		
105	26510	210		
110	26513	220		
115	26506	230		
120	26498	240		
125	26497	250		
130	26508	260		
135	26503	270		
140	26493	280		
145	26513	290		
150	26501	300		
155	26497	310		
160	26436	320		
165	25665	330		
170	26434	340		
175	26499	350		
180	26497	360		
185	26497	370		
190	26500	380		
195	26498	390		
200	26505	400		
205	26505	410		
210	26505	420		
215	26498	430		
220	26507	440		
225	26507	450		
230	26497	460		

235	26505	470		
240	26492	480		
245	26498	490		
250	26498	500		
255	26506	510		
260	26492	520		
265	26501	530		
270	26496	540		
275	26498	550		
280	26487	560		
285	26499	570		
290	26494	580		
295	26494	590		
300	26506	600		

Project Name: **DWAF Hydro Joub** **Project Number:** **374522**

Traverse Number: **374522-Roadworks**



4. Target JOUB4: south to north traverse

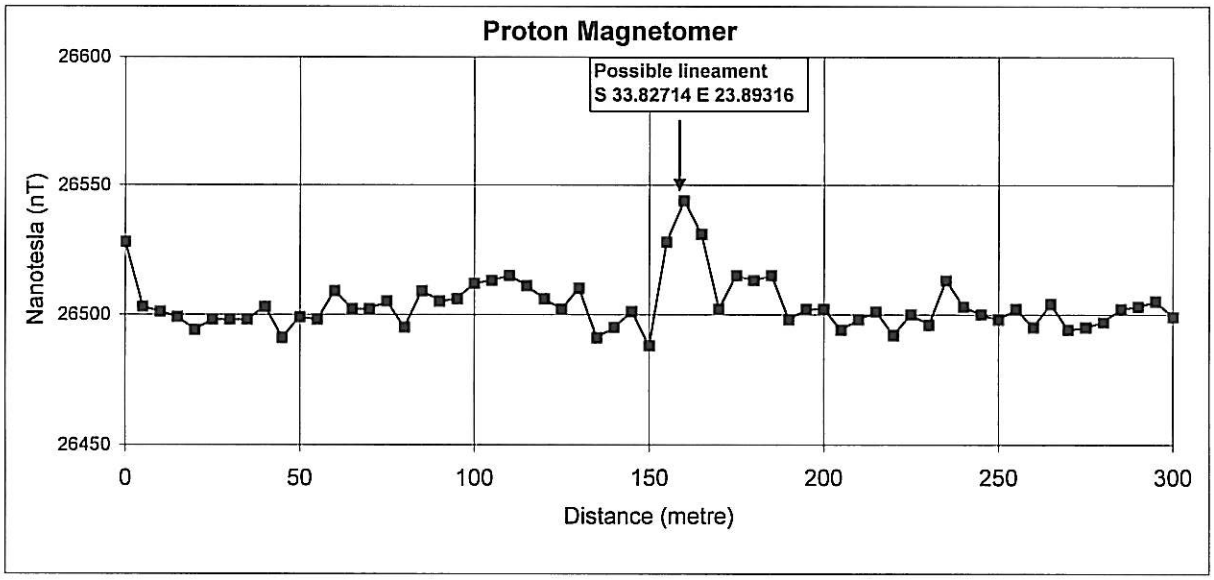
Project Name	DWAF Hydro Joub	**SRK Technician**	Jaco Pretorius
Project Number	374522	**Direction**	SW12NE
Traverse Number	374522-JOUB4 NS	**Date**	21/2/2007
Village Name	Joubertina		
Latitude Start	33.82849	**Longitude start**	23.89256
Latitude End	33.82599	**Longitude End**	23.89366

Proton Magnetometer		**Geonics EM-34**		
			Readings (mS/m)	
Station	Readings (Nano Tesla)	Station	20 Horizontal	40 Horizontal
0	26528	0		
5	26503	10		
10	26501	20		
15	26499	30		
20	26494	40		
25	26498	50		
30	26498	60		
35	26498	70		
40	26503	80		
45	26491	90		
50	26499	100		
55	26498	110		
60	26509	120		
65	26502	130		
70	26502	140		
75	26505	150		
80	26495	160		
85	26509	170		
90	26505	180		
95	26506	190		
100	26512	200		
105	26513	210		
110	26515	220		
115	26511	230		
120	26506	240		
125	26502	250		
130	26510	260		
135	26491	270		
140	26495	280		
145	26501	290		
150	26488	300		
155	26528	310		
160	26544	320		
165	26531	330		
170	26502	340		
175	26515	350		
180	26513	360		
185	26515	370		
190	26498	380		
195	26502	390		
200	26502	400		
205	26494	410		
210	26498	420		
215	26501	430		
220	26492	440		
225	26500	450		
230	26496	460		

235	26513	470		
240	26503	480		
245	26500	490		
250	26498	500		
255	26502	510		
260	26495	520		
265	26504	530		
270	26494	540		
275	26495	550		
280	26497	560		
285	26502	570		
290	26503	580		
295	26505	590		
300	26499	600		

Project Name: **DWAF Hydro Joub** **Project Number:** **374522**

Traverse Number: **374522-TweeRivier**



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