GENERAAL COAL PROJECT

GROUNDWATER FLOW IMPACT ASSESSMENT REPORT

Final

11 December 2013

WSM LESHIKA CONSULTING (PTY) LTD

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Generaal Coal Project

Groundwater Flow Impact Assessment Report

REPORT: WH13078 11 December 2013 Final

Job WH13078–Generaal Coal Project

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LIST OF ACRONYMS

C	Celsius
CoAL	Coal of Africa Limited
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
GRA II	Groundwater Resources Assessment Study II
GRIP	Groundwater Resources Information Project
GSP	Greater Soutpansberg Projects
Ha	Hectare or 10 000 m^2
LMB	Limpopo Mobile Belt
Ma	Million years ago
Mbgl	metres below ground level
mamsl	metres above mean sea level
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MIA	Mining infrastructure area
MODFLOW	Numerical groundwater modeling programme
MPRDA	Mineral and Petroleum Resources Development Act (Act 28 of 2002)
MRA	Mining right application
Mtpa	Million tonnes per annum
NGDB	National Groundwater Data Base
NOMR	New Order Mining Right
RLT	Railway Load-out Terminal
RoM	Run of Mine
RMF	Regional Maximum Flood
RoM	Run of Mine
TIN	Triangular Irregular Network
WR2005	Water Resources 2005 study
WQT	Water Quality Threshold

UNITS OF MEASUREMENT

1 Ml = 1 000 Kl = 1 000 m^3 = 1 000 000 l

GENERAAL COAL PROJECT

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1. INTRODUCTION

An application for a New Order Mining Right (NOMR) in terms of Section 22 of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) for the Generaal Project has been lodged by Coal of Africa Limited (CoAL) to the Department of Mineral Resources (DMR). The Generaal Project forms part of an asset of proposed mining projects collectively known as the Greater Soutpansberg Project (GSP) situated to the north of the Soutpansberg in the Limpopo Province. Similar applications for NOMR's have already been submitted by CoAL and/or subsidiary companies held by them in the Greater Soutpansberg area. The locality of the project relative to some of the main towns in the Limpopo Province is indicated in Figure 1.

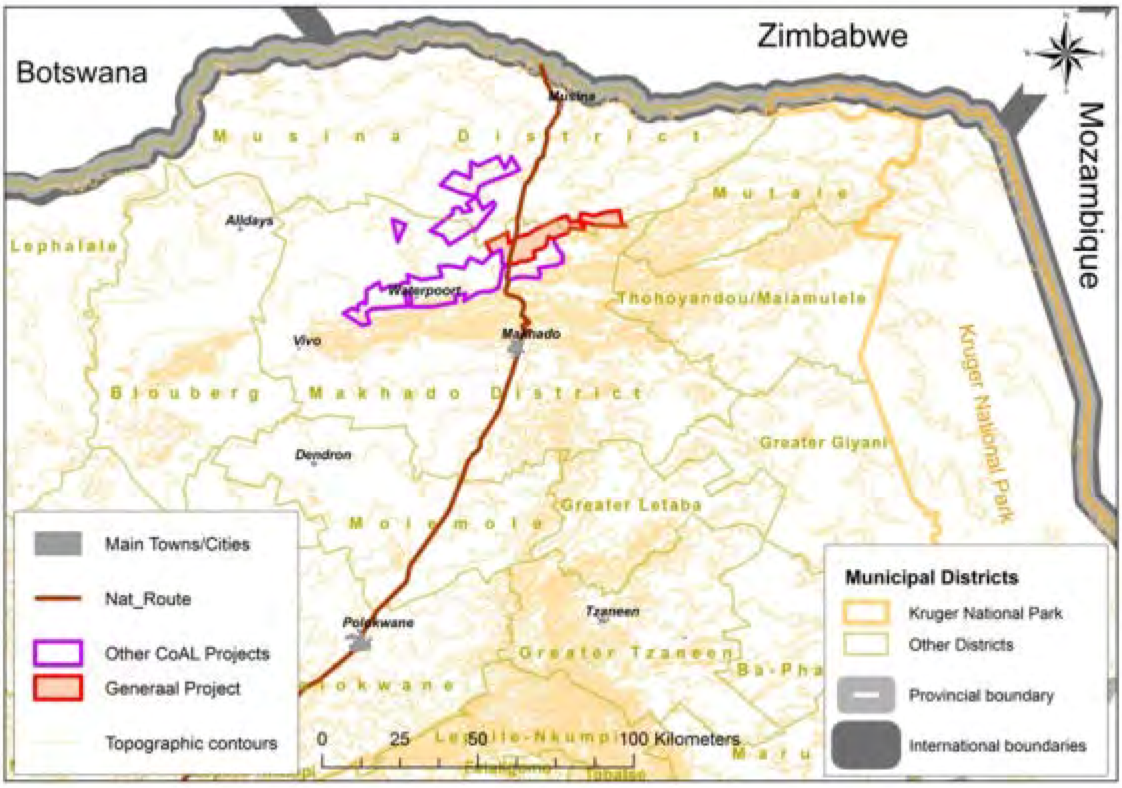

FIGURE 1: COAL GSP PROJECTS IN THE LIMPOPO PROVINCE

As evident from the locality map, the various projects are close to each other, permitting rationalisation of infrastructure. The objective is to have a consolidated project with economically minable blocks which are contiguous.

WSM Leshika Consulting was appointed to conduct the groundwater flow study for the Environmental Impact Assessment (EIA) for the proposed Generaal Colliery Project. See

Appendix A for WSM Leshika's statement of independency, the details of the project team and their curriculum vitae

The EIA report describes the current groundwater status and the potential impact on the groundwater flow, of the Generaal Colliery Project. The other surrounding CoAL Projects were taken into account and cumulative impacts evaluated.

2. PROJECT DESCRIPTION

The Generaal Project is split into two sections, the Generaal and Mount Stuart Sections. The Generaal Section footprint covers an area of 1 554 ha and the Mount Stuart Section footprint covers an area of 118 ha for mining and infrastructure development.

The Generaal Project has the potential to produce good quality hard coking coal and a domestic thermal coal product. The Mount Stuart Section will be mined at 1.4 Mtpa (for 25 years), whilst the Generaal Section will be mined at 1.7 Mtpa, therefore the life of mine is expected to exceed 30 years. The current planning is that construction and mining will commence at the Mount Stuart Section first where the coking coal yields are the highest. It is expected that mining operations at the Generaal Section will only commence much later as capacity in infrastructure is developed.

The Mount Stuart Section resource allows for an underground mining method to a depth of 900m and is planned to be a mechanised mine laid out on a bord-and-pillar design using continuous miners and shuttle cars. It is envisaged that the coal will be treated though its own dedicated processing plant, but dispatched through the Makhado Rapid Load-out Terminal (RLT) situated on the farm Boas 642 MS. The product will be transported from the Mount Stuart Section to the RLT via conveyor.

The Generaal Section will be mined by the total extraction open pit mining method, up to a depth of approximately 200 m. The open pit will be mined through conventional truck and shovel. The Generaal Section will make extensive use of infrastructure at the Makhado Colliery Project, including its processing plant and rail loading facility.

The major infrastructure items were designed and positioned to accommodate mining layouts at both Sections, access to stockpiles, location of the processing plants, and environmental requirements.

Other mine infrastructure includes:

i) Access and on-site haul roads;

ii) Topsoil stockpiles and berms;

iii) Overburden (carbonaceous and non-carbonaceous) stockpiles;

iv) ROM coal storage area;

v) Associated conveyors from the ROM storage areas to the processing plant

vi) Associated conveyors from the processing plant(s) to the product storage areas;

vii) Product stockpile areas;

viii) Carbonaceous discards stockpile at Mount Stuart Section;

ix) Storm water management infrastructure (i.e. clean & dirty water run-off);

x) On-site water management and reticulation systems;

xi) Wastewater (sewage) treatment plant;

xii) Bulk electricity supply infrastructure;

xiii) Bulk water supply infrastructure;

xiv) Offices, vehicle support structures and stores.

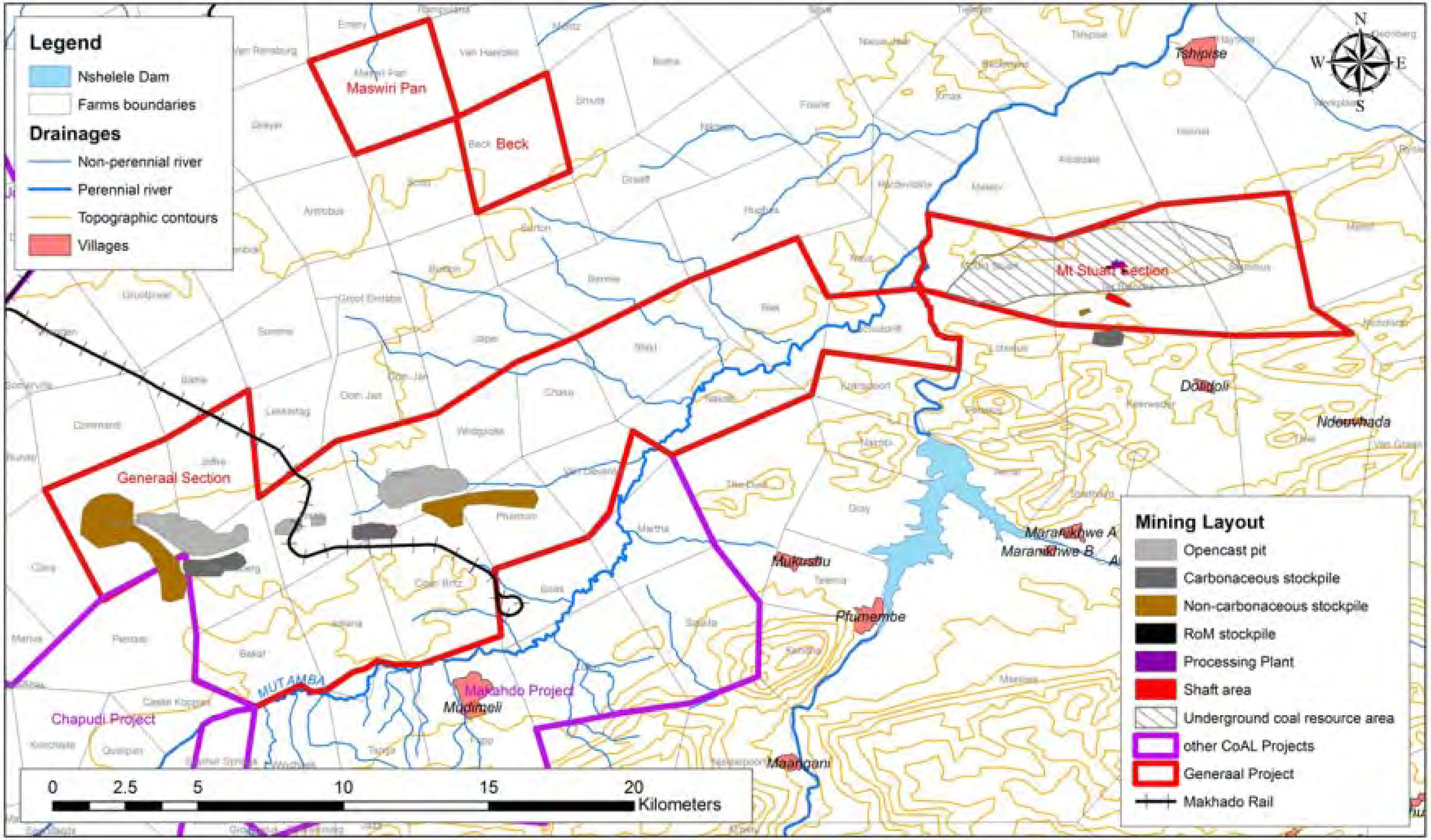

FIGURE 2: PROPOSED MINING LAYOUT WITH PITS AND DUMP MATERIAL

3. GENERAL DESCRIPTION OF THE STUDY AREA

3.1 LOCALITY

The Generaal Project is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 30 km (direct) north of the town of Makhado and 47 km south of Musina in the Musina and Makhado Local Municipal areas. Musina and Makhado are connected by well developed road infrastructure. The Generaal Project area is located north of the Mutamba River and reaches from west of the N1 approximately 11km south of Mopane station, eastwards to 5 km south of Tshipise. The project is divided into two (2) sections, namely the Generaal Section and the Mount Stuart Section – refer to Figure 3.

A single farm (Solitude 111 MS) is located further north with its southern border at the end of the Nzhelele Scheme canal. Two other farms (Maseri Pan 520 MS and Beck 568 MS) are located across the N1 at the Baobab Toll Plaza. Although the 3 farms are grouped as part of the Generaal Coal project, no mining is planned on these properties at this stage and therefore are not included as part of this impact study.

The Generaal Project is well situated with respect to major infrastructure, including rail, road and power. The N1 national road passes through the mining right application (MRA) area (Generaal Section) with the R525 running to the north of the project area in a west-east direction. The Makhado-Musina railway line runs in a north-south direction to the west of the Generaal Project area. Eskom grid power lines are located parallel to the N1 and are situated 6 km east of the farm Cavan 508MS at their closest point.

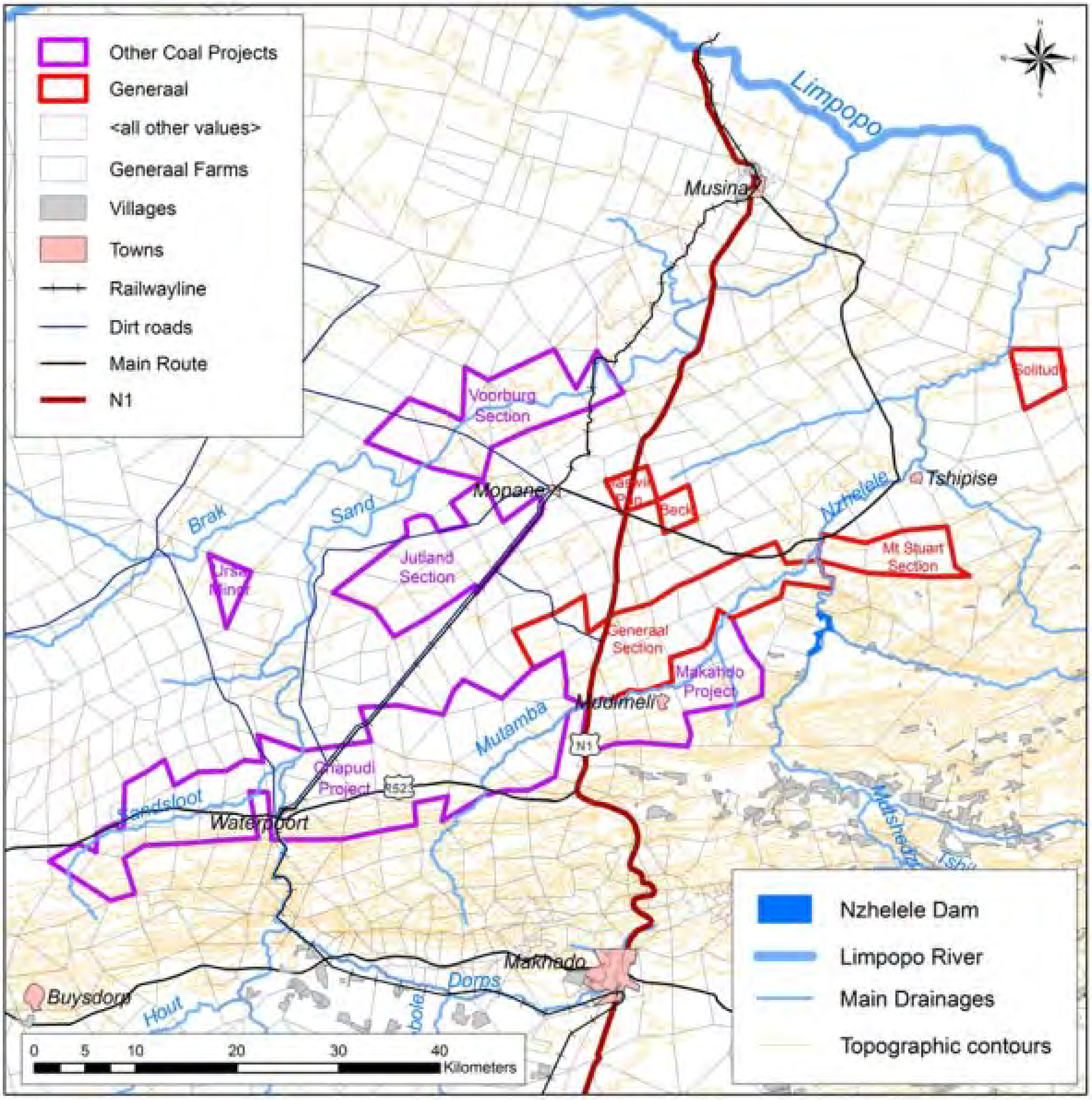

FIGURE 3: GENERAAL PROJECT LOCALITY

3.2 CLIMATE

3.2.1 REGIONAL CLIMATE

The regional climate is strongly influenced by the east-west orientated mountain range which represents an effective barrier between the south-easterly maritime climate influences from the Indian Ocean and the continental climate influences (predominantly the Inter-Tropical Convergence Zone and the Congo Air Mass) coming from the north.

The Generaal Project is located in the hot-arid zone to the north of the Soutpansberg where the rainfall decreases to less than 400mm. The area is situated in the summer rainfall region and rainfall occurs in the form of heavy thunderstorms or soft rain. The area is characterised as being hot and dry resulting in high evaporation rates and low rainfall. The area is characterized by cool, dry winters (May to August) and warm, wet summers (October to March), with April and September being transition months. Temperature range from 0.9°C to 39.9°C and the area is generally frost free.

The mountains give rise to wind patterns that play an important role in determining local climates. These wind effects include wind erosion, aridification and air warming.

3.2.2 PRECIPITATION

The Generaal Project is located in the Nzhelele River Basin which consists of 7 quaternary catchments as defined in the WR90 Study (Midgley et al, 1994) (see Figure 4).

The Generaal project spans the lower two catchments i.e. A80F and A80G. Quaternaries upstream of the project are A80A, A80B, A80C, A80D and A80E. The region is within the impact zone of tropical cyclones occurring in the Indian Ocean which may cause high-intensity rainfalls leading to peak run-off events. These events occurred here for example in 1958 (Astrid), 1976 (Danae), 1977 (Emily) and 2000 (Eline) (Van Bladeren and Van der Spuy, 2000).

The basin's mean annual precipitation (MAP) distribution is shown in Figure 5 below and varies between 900mm in the south and 300mm to the north. The Generaal Project is situated within the hot-arid zone to the north of the Soutpansberg that has a MAP in the 300 – 400 mm range.

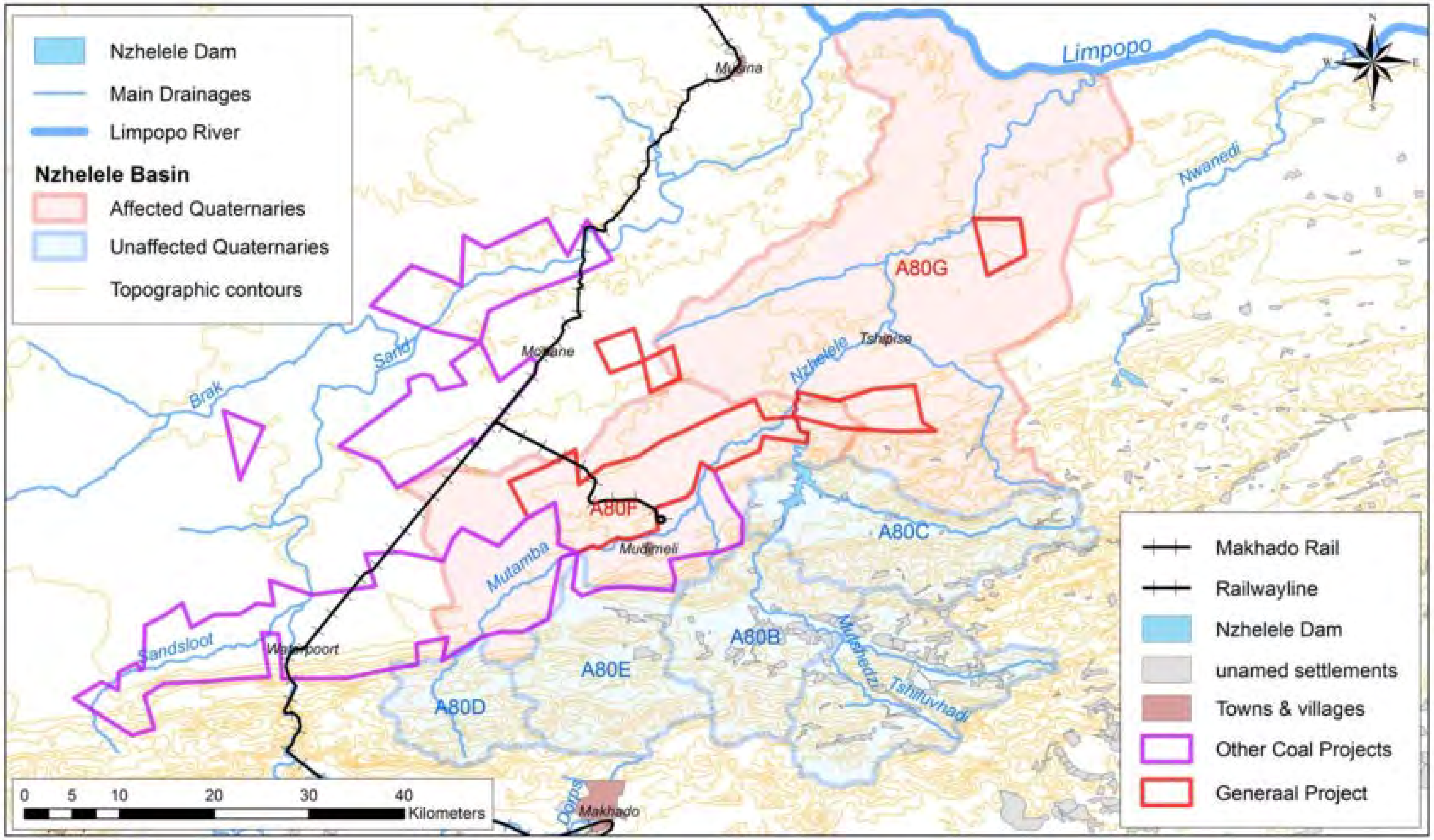

FIGURE 4: THE GENERAAL PROJECT IN RELATION TO THE NZHELELE BASIN

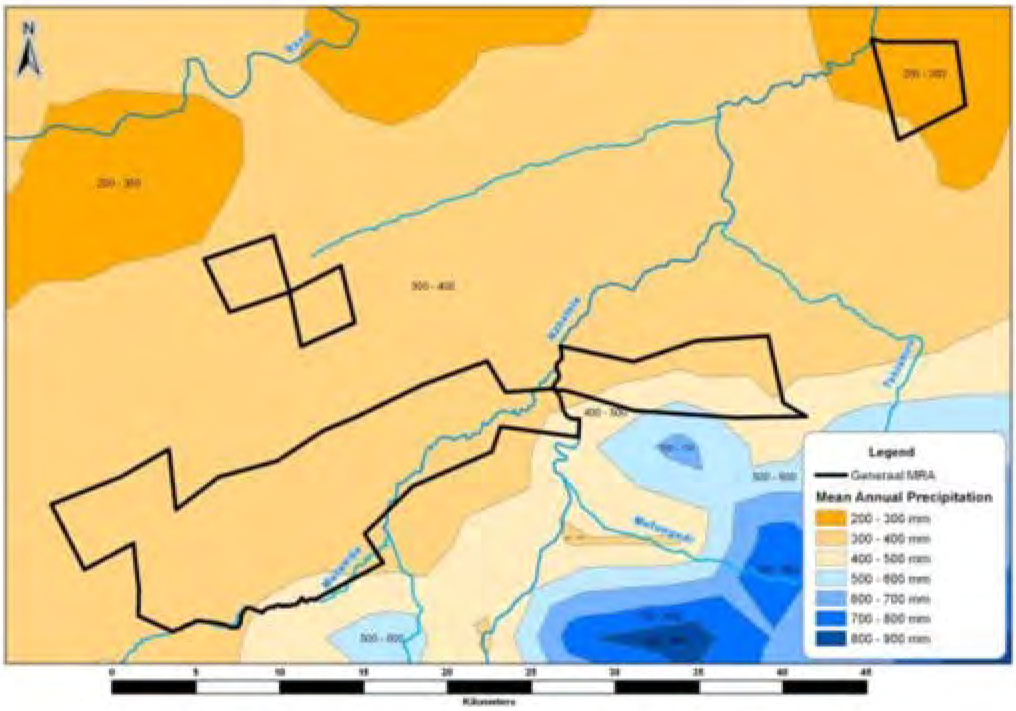

FIGURE 5: GENERAAL PROJECT MEAN ANNUAL PRECIPITATION

The absolute average monthly rainfall in the Nzhelele River Basin for the site per quaternary catchment is shown in Table 1 below. The average rainfall for each catchment has been determined. The maximum rainfall in the basin occurs in January and the lowest is in August. The data in the table is shown in the bar chart below (Figure 6).

TABLE 1: MEAN MONTHLY QUATERNARY RAINFALL (MM) IN THE NZHELE RIVER BASIN

Quaternary catchment	Mean Annual Precipitation (mm)	Rainfall zone	Mean Monthly Precipitation (mm)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
A80A	938	A8A	61	111	142	189	175	123	51	22	15	16	11	23
A80B	659	A8A	43	78	100	133	123	87	36	15	11	11	8	16
A80C	576	A8A	37	68	87	116	107	76	31	13	9	10	7	14
A80D	622	A8A	40	73	94	125	116	82	34	14	10	10	7	15
A80E	622	A8A	40	73	94	125	116	82	34	14	10	10	7	15
A80F	388	A8A	25	46	59	78	72	51	21	9	6	6	4	9
A80G	333	A8B	21	43	51	68	63	42	17	7	4	3	2	8

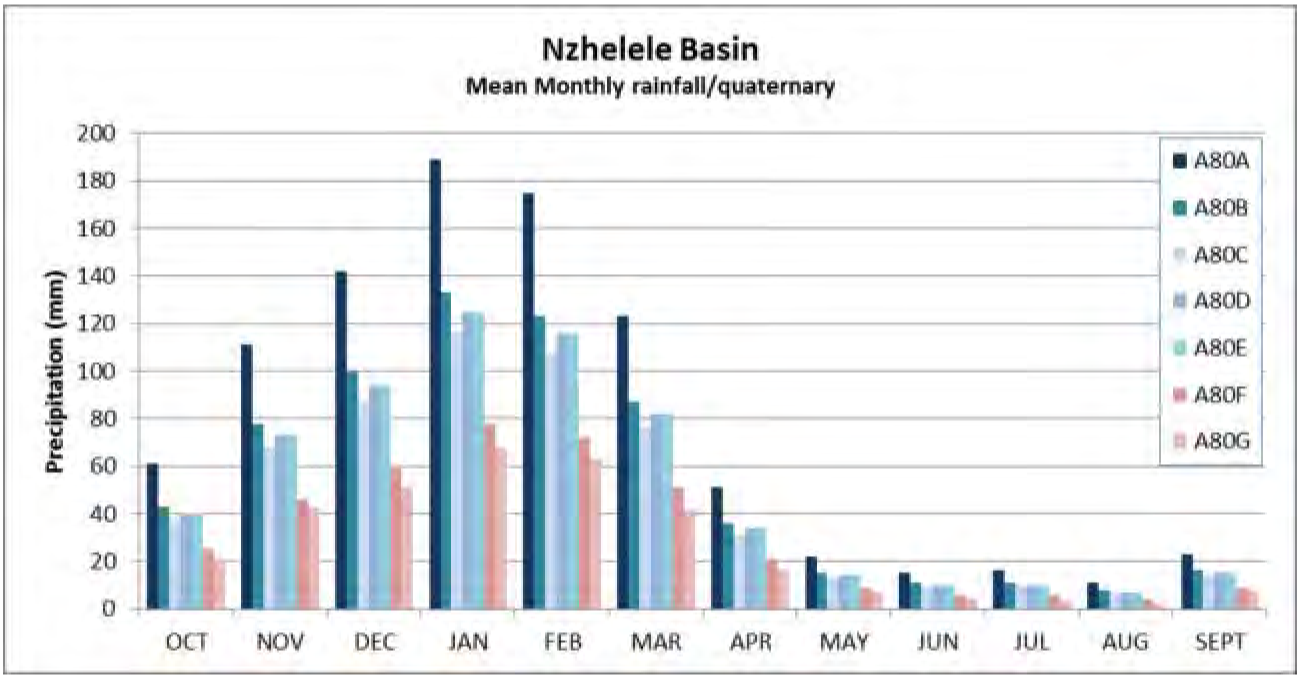

FIGURE 6: ANNUAL DISTRIBUTION OF MEAN MONTHLY PRECIPITATION (MM) IN THE NZHELELE RIVER BASIN

Quaternary catchments A80D, A80E and A80F form part of the Mutamba River basin while quaternary catchments A80A, A80B and A80C form part of the Nzhelele River basin. A80G is the quaternary below the confluence of the two rivers. It is evident from Table 1 and Figure 6 that the MAP for the two lower quaternaries, A80 F and A80G is much lower than the upper catchments.

3.2.3 TEMPERATURE

Average monthly minimum and maximum temperatures for the Tshipise weather station (No. 0766277 1) some 5 km north-east of the Generaal Project area is shown in Table 2 below. Note that this station is the closest station with long term available climate data. Average daily maximum and minimum summer temperatures (November to February) at the weather station range between ~33°C and ~20°C, while winter temperatures (May to August) range between ~28°C and ~7°C respectively. The high average temperatures are reflected by the fact that the minimum average daily summer temperature is a high 20°C and the minimum average daily winter temperature does not dip below 7°C.

TABLE 2: TEMPERATURE DATA FOR TSHIPISE FROM 1994 TO 2006

Month	Temperature (° C)			
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded
January	42.2	32.8	21.5	12.6
February	41.4	32.3	21.5	14.9
March	42.9	31.5	20.1	13.0
April	40.9	30.1	16.3	5.7
May	42.3	27.9	11.2	1.7
June	34.3	25.6	8.2	-0.4
July	34.1	25.0	7.3	-1.2
August	37.4	27.8	10.3	1.7
September	41.2	27.7	12.9	3.6
October	41.4	29.1	16.5	8.0
November	42.5	32.2	20.1	11.1
December	43.4	33.1	21.0	13.8
Year	43.4	29.6	15.6	-1.2

Source: Weather SA (Station No 0766277 1)

The Department of Agriculture's Agricultural Geo-referenced Information System (AGIS) hosts a wide spectrum of spatial information maps for public use. The two figures below, Figure 7 and Figure 8, indicate the maximum and minimum annual temperature for the region that was obtained from their natural resources atlas on climate.

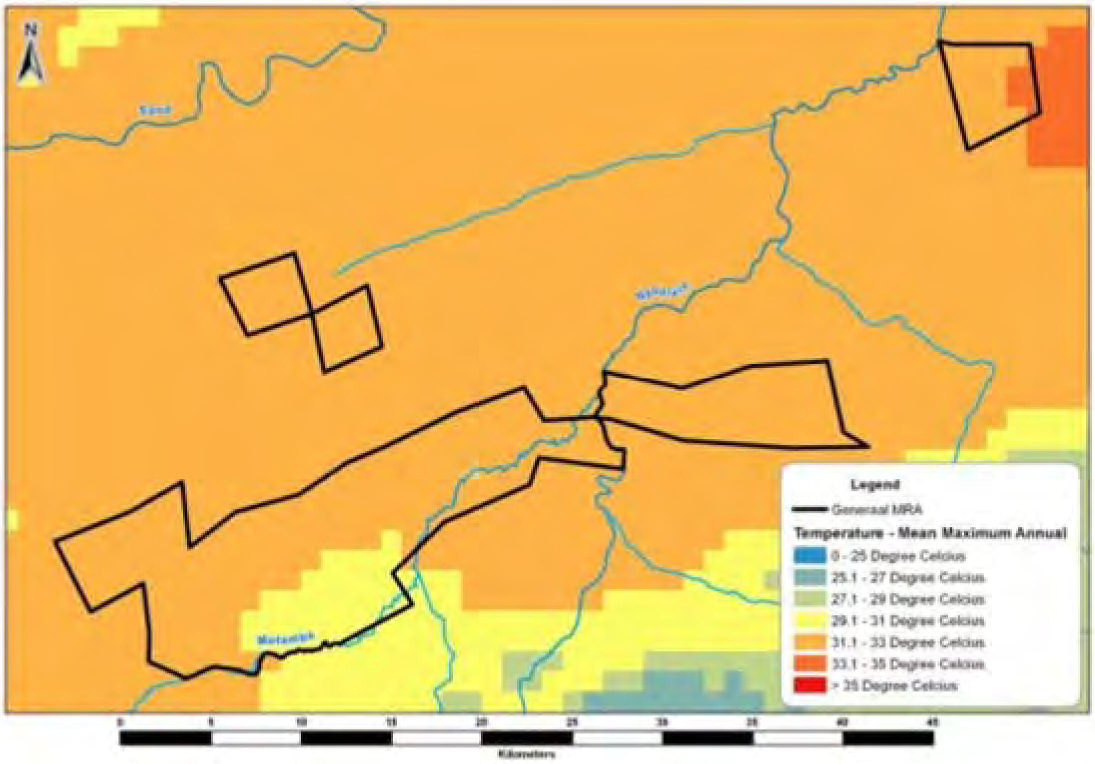

FIGURE 7: MEAN ANNUAL MAXIMUM TEMPERATURE

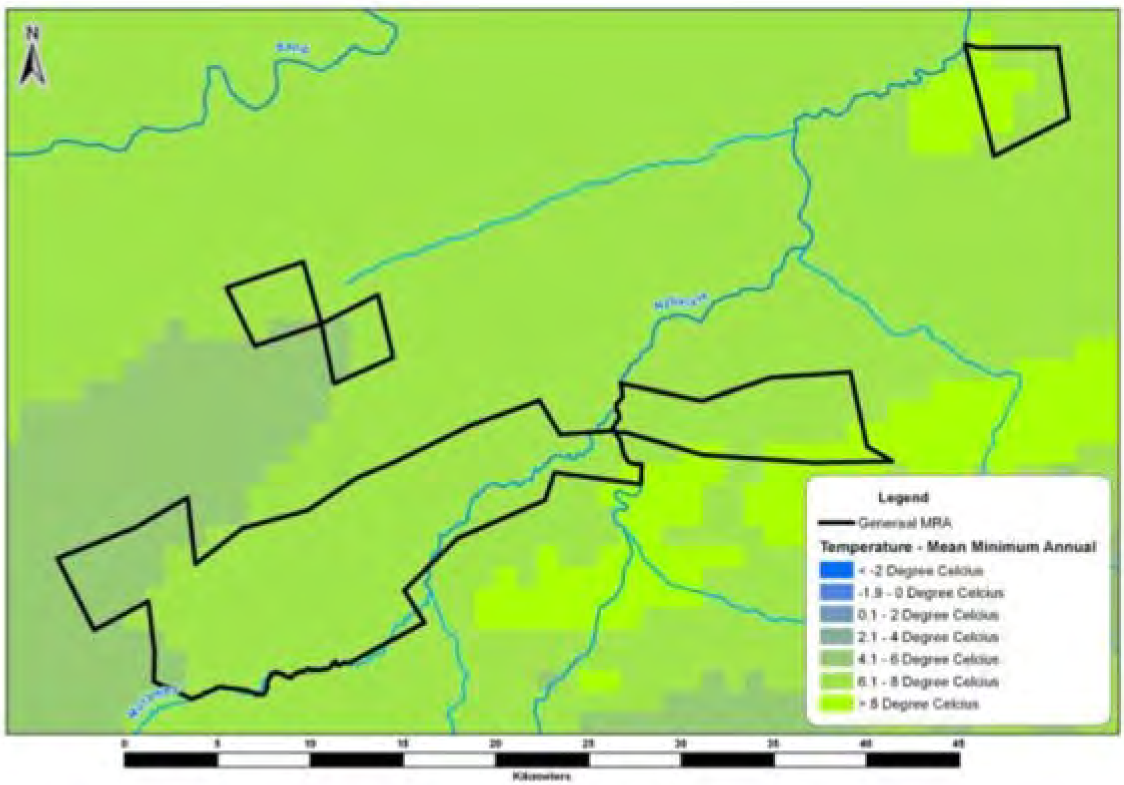

FIGURE 8: MEAN ANNUAL MINIMUM TEMPERATURE

3.2.4 EVAPORATION

Mean Annual Evaporation data per quaternary for the Nzhelele basin is given in Table 3 below, while the monthly evaporation pattern (as percentages of the total) is given in Table 4 below.

TABLE 3: MEAN ANNUAL EVAPORATION DATA

Quaternary catchment	Mean Annual (gross) Evaporation (mm) MAE (Zone 1B)
A80A	1400
A80B	1450
A80C	1600
A80D	1450
A80E	1450
A80F	1750
A80G	1900

TABLE 4: MONTHLY EVAPORATION DISTRIBUTION

Month	Evaporation (%)
October	10.46
November	10.03
December	10.68
January	10.43
February	8.49
March	8.49
April	6.94
May	6.55
June	5.40
July	6.08
August	7.42
September	9.03

Source: WR90, evaporation zone 1B, based on data from Albasini Dam

3.3 TOPOGRAPHY

Topography is formed as a consequence of the landscaping effect of erosional forces (wind and water) on rocks of variable susceptibility to weathering. The topography is described in the Terrain Morphological Map of Southern Africa consists of 3 morphological classes.

(i) Irregular plains with moderate relief (almost hilly)-Generaal Section
(ii) Lowlands with hills-Mt Stuart Section
(iii) Low Mountains-Soutpansberg Mountains

The project area is underlain by Karoo rocks consisting of weather resistant sandstones which form “kopjes” or topographic highs, surrounded by plains and valleys consisting of shale and basalt.

North of the Tshipise fault, conical and rounded boulder “kopjes” are formed on the gneissic basement by quartz vein and pegmatite intruded shear zones and the younger granite intrusives.

The quartzitic Soutpansberg strata form the mountain range to the south.

3.4 CATCHMENTS AND DRAINAGES

The Generaal MRA area spans quaternary catchments A80F and A80G of the Nzhelele River Basin. The two major rivers flowing through the project area are the Mutamba and Nzhelele Rivers which have their source areas within the Soutpansberg Mountains at about 1670 metres above mean sea level (mamsl). Beyond the confluence with the Mutamba (at about 555 mamsl), the Nzhelele river flows in a north easterly direction to the Limpopo River (at about 220 mamsl), refer to Figure 4. The Nzhelele basin covers an area of approximately 425 km2, which is 1% of the entire Limpopo basin.

3.5 GEOLOGY

3.5.1 REGIONAL GEOLOGY

The regional geology is shown in figure 9 and consists of 3 main lithological groups i.e. the Limpopo Mobile Belt, the Soutpansberg Group and the Karoo Sequence rocks:

i) The Limpopo Mobile Belt (LMB); forms the gneissic basement on which the overlying strata (Soutpansberg Group and the Karoo Sequence) was deposited. The LMB rocks are the metamorphic expression of the collision and welding together of the Kaapvaal craton and the Zimbabwe craton. The LMB has a long and complex history of deformation occurring from 3200 Ma (million years ago) to 2000 Ma. The LMB gneisses are made up of inter-cratonic sediments and volcanics, deformed and metamorphosed to granulite facies and intruded by granite bodies which have themselves been metamorphosed to varying degrees. The rift fault systems controlling the various basins, in which the Soutpansberg and Karoo strata have been preserved, are major zones of crustal weakness preferentially re-activated during periods of tectonic instability over time.

ii) The Soutpansberg Group strata were deposited into rift basins controlled by these major fault systems between 1900 Ma and 1600 Ma. The strata consist of basaltic lavas, arenites and shales attaining a maximum preserved thickness of 5000m. Dips can vary from 20° to 80° to the north.

iii) The Karoo Sequence strata were deposited on LMB basement and/or Soutpansberg Group strata between 300 – 180 Ma. Karoo deposits are preserved in rift basins and are often terminated against major east-west trending faults on their northern margins. The dips are between 3° and 20° to the north with coal located at the base of the sequence. The nature of the coal deposits changes from a multi-seam coal-mudstone association (7 seams) approximately 40m thick in the west (Mopane Coalfield), to two thick seams in the east (Pafuri Coalfield in the Tshikondeni area).

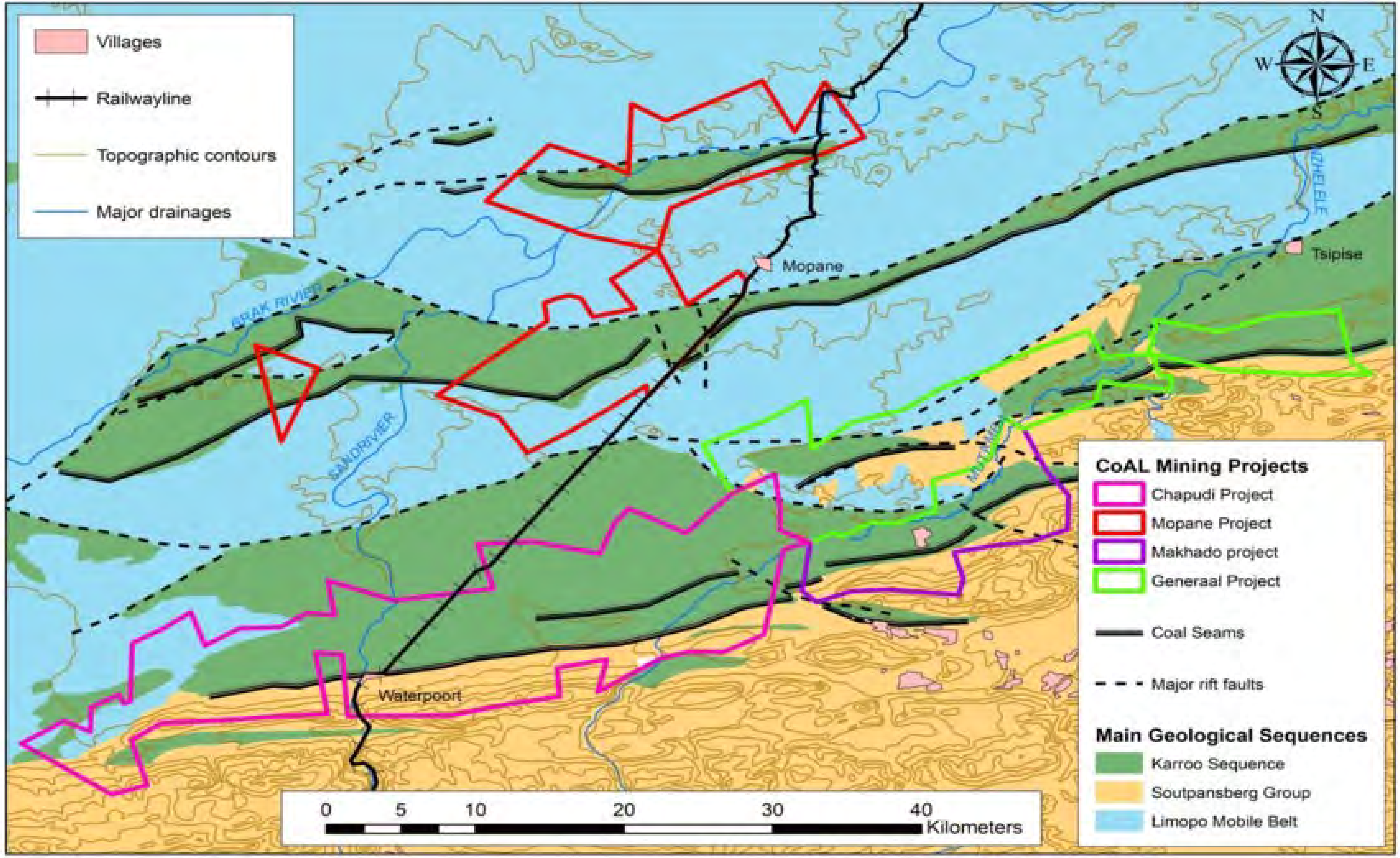

FIGURE 9: REGIONAL GEOLOGY OF COAL MINING PROJECTS WITHIN THE SOUTPANSBERG COALFIELD

3.5.2 *COAL DISTRIBUTION OF THE SOUTPANSBERG COAL FIELD*

The Generaal Colliery Project lies within the Soutpansberg Coalfield which stretches for ± 190km from Waterpoort in the west to the Kruger National Park in the east. The Soutpansberg Coalfield has been divided into 3 separate coal fields i.e. the Mopane Coalfield, the Tshipise Coalfield and the Pafuri Coalfield.

The Pafuri Coalfield terminates at the northern limit of the Kruger National Park in the east and is not part of this study.

The Mopane and Tshipise Coal fields are host to several CoAL mining projects at an advanced stage of development (Figure 9).

- The Mopane Coalfield, lies between the towns of Mopane and Waterpoort in the west and is the target of 2 mining projects;
  - The Chapudi Project
  - The Mopane Project

- The Tshipise Coalfield, stretching east of the town of Mopane to Tshipise and is the target of 2 mining projects;
  - The Makhado Project
  - The Generaal Project

3.5.3 *GENERAAL PROJECT GEOLOGY*

The Generaal Project; consists of the opencast Generaal Section and the underground Mount Stuart Section where Karoo sediments have been deposited directly onto gneissic basement and preserved in a fault bounded basin. The Tshipise Fault forms the northern boundary. For purposes of representation the Karoo Sequence is divided into Lower Karoo, Middle Karoo, the Clarens Formation and the Letaba basalts. See Figure 10 and 11 for local geological map and cross-section.

The Lower Karoo consists of a basal glacial deposit overlain by carbonaceous and coaliferous mudstones. From oldest to youngest the stratigraphy is as follows;

(i) Tshidzi Formation; a 10m thick basal conglomerate/diamictite and can be correlated to glacial Dwyka Tillite in the main Karoo basin.

(ii) The Madzoringwe Formation; a succession of alternating black shale, micaceous sandstone, siltstones and inter-bedded coal seams attaining a thickness of 190m. The coals seams are of economic potential.

(iii) The Mikambeni Formation overlying the above consists of dark grey mudstone and shale with subordinate sandstone attaining an approximate thickness of 140m. The Madzoringwe and Mikambeni Formations can be correlated with the Ecca Group of the main Karoo basin.

The Middle Karoo consists of overlying fluvial deposits made up of sandstones and grey, purple and red mudstones. The stratigraphy is as follows;

i) The Fripp Sandstone Formation consists (10 – 20 m) of coarse feldspathic sandstone or "grit" and often forms a ridge on outcrop and marks a change from a mature meandering river depositional environment to a braided stream environment.

ii) The Solitude Formation; is a 110m thick inter-layered grey and purple shale with minor sandstone and grit intercalations.

iii) The Klopperfontein Formation (10 – 20 m) resembles the Fripp Sandstone Formation as coarse, feldspathic "gritty" sandstone.

iv) The overlying Bosbokpoort consists of red very fine sandstone and dark red silty mudstone.

v) The fluviatile Red Rocks Member (150 m) of the overlying Clarens fm. is also placed in the Middle Karoo strata.

The upper Karoo comprises the *Tshipise Member* (150 m) of the Clarens Formation caps the underlying fluvial sediments with aeolian sands as the final expression of sedimentary deposition in an ever increasingly arid environment.

The Letaba basalt ends Karoo Sequence deposition with widespread outpouring of continental lavas, heralding a period of tectonic instability and the start of the break-up of Gondwanaland. Dolerite sills and dykes served as feeders to the basalt lava and are the hyperbyssal component of this event.

3.5.4 STRUCTURE

The main structural feature of the Generaal basin is the east – west trending Tshipise Fault which also forms the faulted northern contact between the Karoo strata and the LMB gneisses. The Tshipise Fault is a regional tectonic feature which forms the structural partition between the central zone of the LMB and the southern marginal zone. Associated with the Tshipise fault are numerous E-W trending structures that have been reactivated over time. These structures coupled with the brecciation of brittle horizons are the main water bearing features in the study area. The westerly extension of the Little Tshipise fault on the Mt Stuart Section strikes along the base of the mountain and forms a faulted contact between the Karoo strata and the Soutpansberg quartzites.

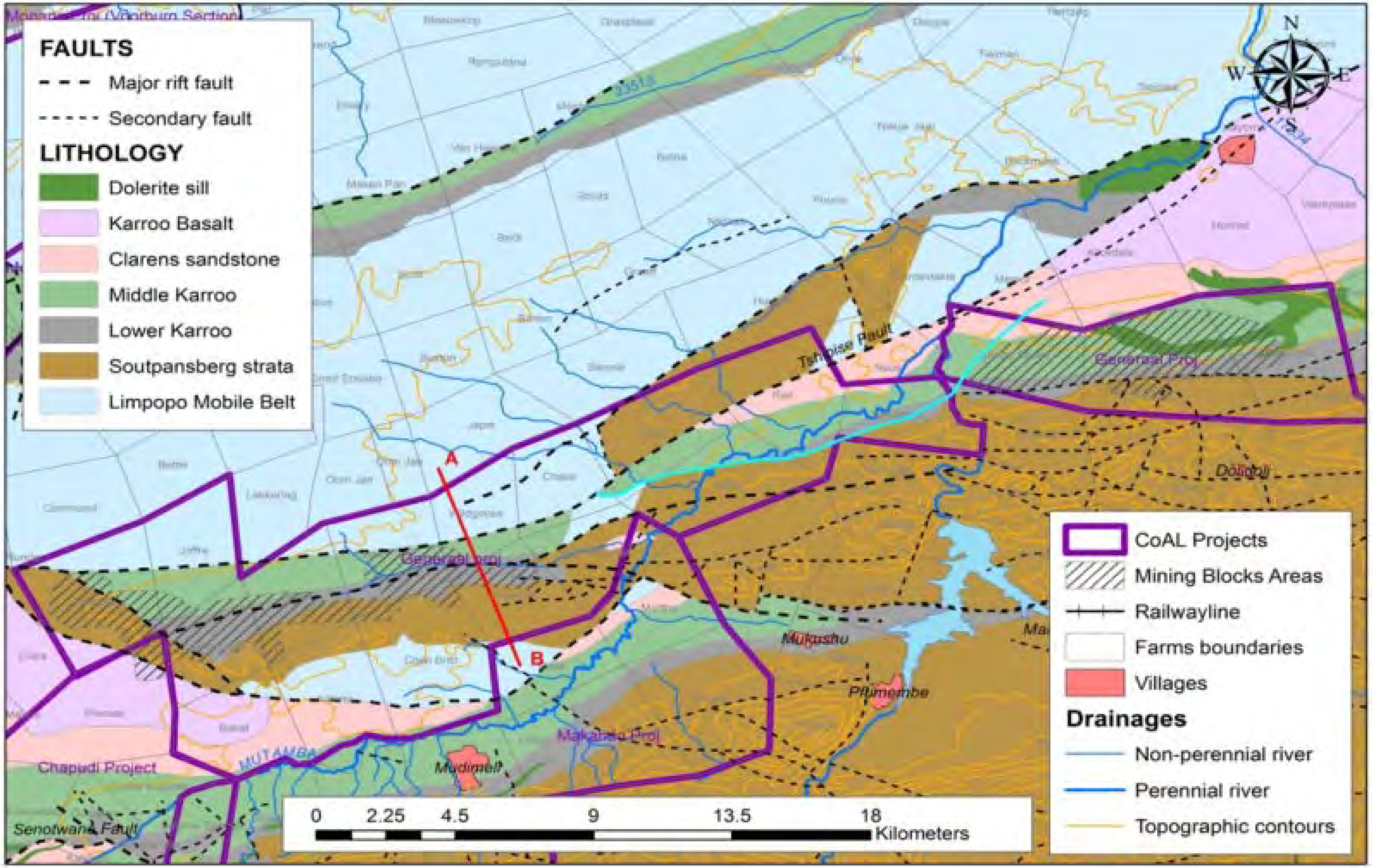

FIGURE 10: GENERAAL MINING PROJECT GEOLOGY

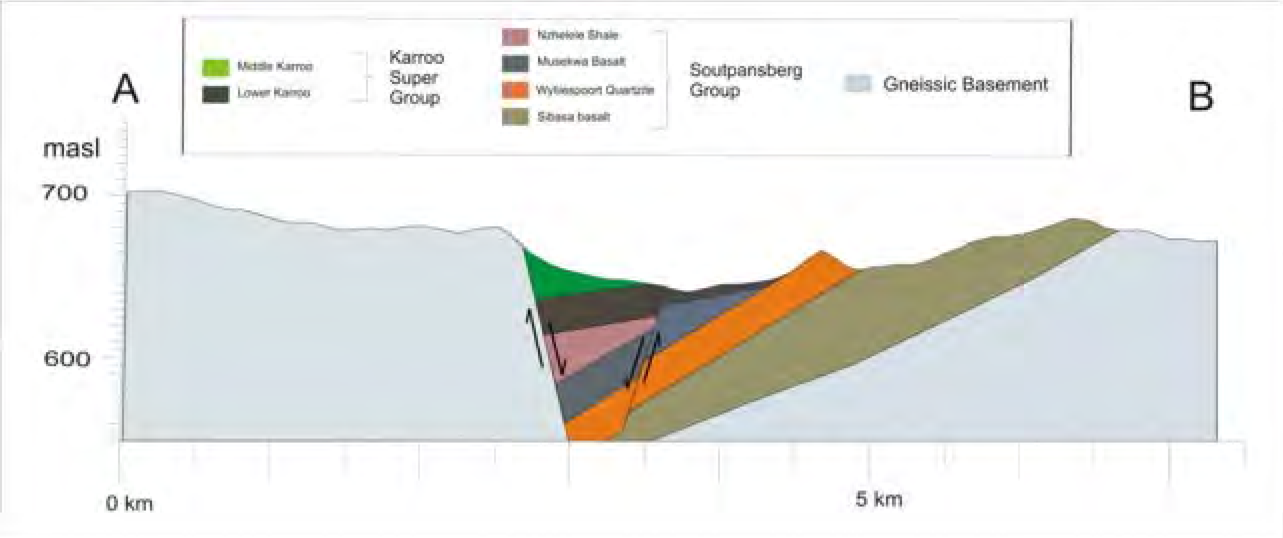

FIGURE 11: GENERAAL MINING PROJECT GEOLOGICAL CROSS-SECTION

3.5.5 IMPACT ON HYDROGEOLOGY

Groundwater flow in study area is towards the Mutamba and Nzhelele Rivers. Groundwater derived from recharge in the mountains is generally of better quality than that derived from direct recharge onto Karoo and basement rocks. Elevated salt content is indicative of the arid climate and contact with upper Karoo strata.

The Generaal Section can be regarded as having a low to moderate groundwater potential with groundwater occurrences confined to the major structures. The Generaal Section is situated mostly north of the Mutamba where recharge is low.

The Mt Stuart Section has a higher groundwater potential because of the proximity to the mountains (higher recharge) and the presence of E-W trending faults systems at the base of the mountain and within the mountain valleys which can store and transmit groundwater. These fractured systems are recharged by Nzhelele river where high yielding boreholes associated with these fault systems have been developed. In addition the Nzhelele River also has well developed alluvial deposits. Both these aquifer types are utilized by irrigation farmers in the area as a backup water supply to the Nzhelele Scheme during drought periods.

4. DATA COLLECTION

4.1 HYDROCENSUS

A borehole census was conducted on the mining right application area over the following farms; Riet 182 MT, Skuitdrif 179MT, Mount Stuart 153 MT, Terblanche 155 MT, Septimus 156 MT, Stayt 183MT, Chase 576 MS, Nakab 184MT, Wildgoose 577MS, Fanie 578 MS, Van Deventer 641 MS, Rissik 637 MS, Phantom 640 MS, Kleinenberg 636MS, Coen britz 646MS, Juliana 647MS, Bekaf 650MS and Generaal 587MS. Data was collected on some of the farms outside of the application area such as Japie 574MS, Oom Jan 586MS, Keerweerder 169 MT(Doli Doli) and Thiel 168MT(Ndouvhada). Where possible water levels were measured and abstraction information obtained. Water samples were taken for macro and micro chemical analysis. The borehole localities are indicated on Figure 12. The hydrocensus borehole data is summarized in Table 5.

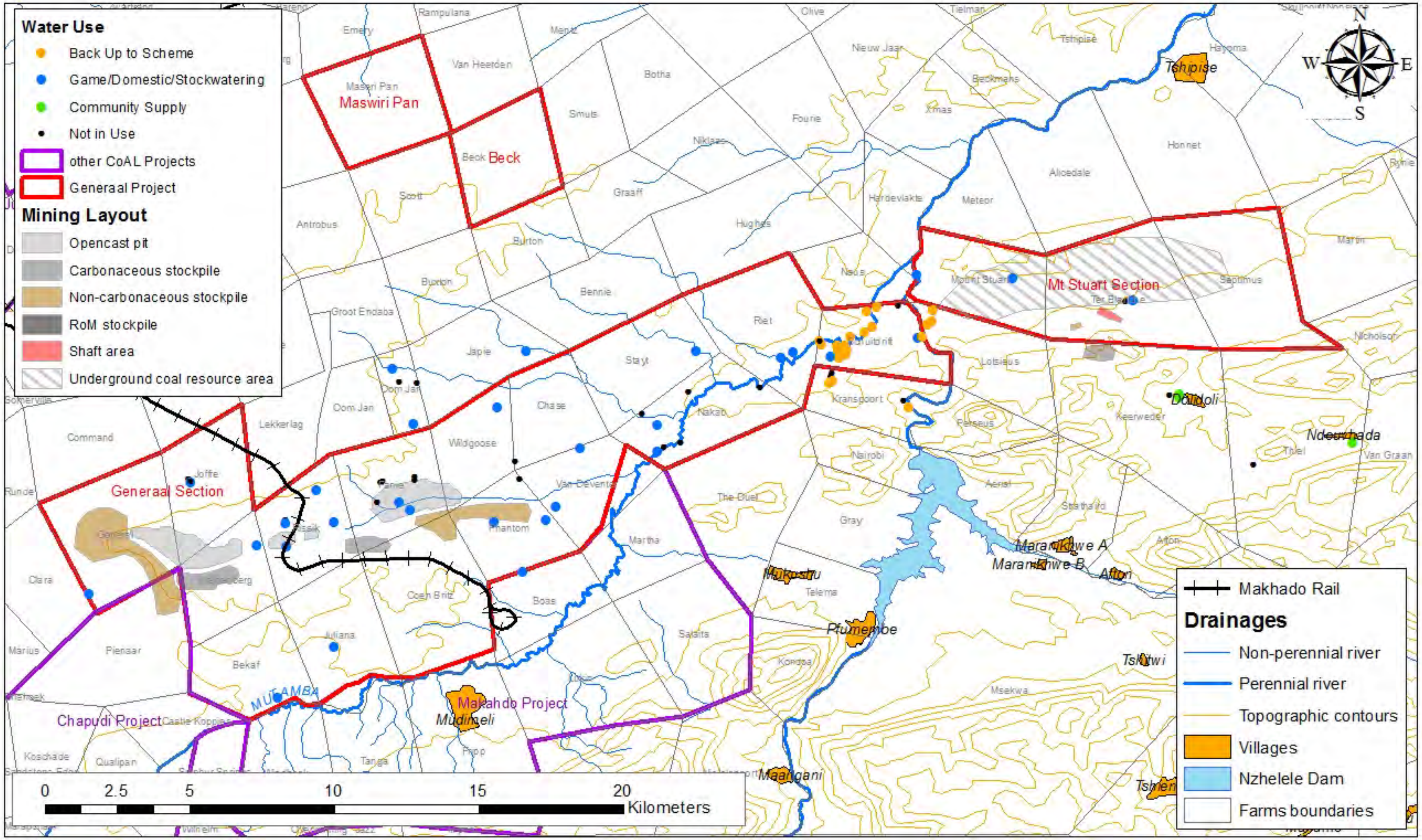

FIGURE 12: MOPANE PROJECT HYDROCENSUS BOREHOLE LOCALITIES

TABLE 5: HYDROCENSUS BOREHOLE DATA

D-Diesel, E-Electric,-W-Wind, Sol-solar

N-None, M-Mono, S-Submersible, W-Windpump

NIU-not in use, G/D/S-Game/Domestic/Stock, BU-Backup to surface water scheme

Farm	Name	Longitude	Latitude	Date	SWL	Power*	Pump**	Daily abstraction (m3/day)	Use***
GENERAAL	GEN-1	29.83764	-22.76818	18/09/13	25.08		S	8	G/D/S
Bekaf	EKL-15	29.89628	-22.80043	2011	7.4	E	M	15	G/D/S
Juliana	EKL-16	29.91364	-22.78453	2011		E	S	1	G/D/S
van DEVENTER	BF-1	29.99015	-22.72278	2011	24.9	N	N	3	G/D/S
van DEVENTER	BF-2	29.97116	-22.73239	2011	18.8	N	N	0	NIU
Chase	BF-3	29.96964	-22.72689	2011	17.8	N	N	0	NIU
van DEVENTER	BF-4	29.98260	-22.74096	2011		Sol	S	3	G/D/S
Fanie	FANI-1	29.92688	-22.73953	2011	24.4	W	W	0	NIU
Fanie	FANI-2	29.93370	-22.73964	2011		D	M	1	G/D/S
Fanie	FANI-3	29.93878	-22.73188	2011		N	N	0	NIU
Fanie	WFAN-1	29.92797	-22.73340	2013		N	N	0	NIU
Fanie	WFAN-2	29.92852	-22.73316	2013	34.9	N	N	0	NIU
Fanie	WFAN-3	29.93861	-22.73275	2013	31.2	N	N	0	NIU
Fanie	WFAN-4	29.93737	-22.74190	2013	5.2	D	S	7	G/D/S
Joffre	Jof-1	29.86848	-22.73258	25/04/12	dry		N		
Joffre	Jof-2	29.86906	-22.73332	25/04/12	41.52		S	1	G/D/S
Joffre	Jof-3	29.86913	-22.73306	25/04/12			S		
Keerweerder	DOLI1	30.17595	-22.70697	5/09/13		E	S	5	IU
Keerweerder	DOLI2	30.17658	-22.70675	5/09/13	7.85	N	N	0	NIU
Keerweerder	DOLI3	30.17293	-22.70655	5/09/13		W	W	0	NIU
Kranspoort	KRAN1	30.06825	-22.69962	6/09/13	Artesian	N	N	0	NIU
Kranspoort	KRAN2	30.06770	-22.70050	6/09/13	0.5	N	N	0	NIU
Kranspoort	KRAN3	30.06858	-22.70200	6/09/13	3.5	E	M	0	BU
Kranspoort	KRAN4	30.06750	-22.70278	6/09/13		E	S	0	BU
Kranspoort	KRAN5	30.09047	-22.70807	6/09/13	6.85	N	N	0	NIU
Perseus	PERS1	30.09193	-22.71027	6/09/13		N	N	0	BU
Schuitsdrift	SDRIF1	30.08202	-22.67900	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF12	30.06770	-22.69430	6/09/13	7.5	E	S	3	G/D/S
Schuitsdrift	SDRIF13	30.07252	-22.69362	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF14	30.07048	-22.69483	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF15	30.07285	-22.69223	6/09/13	Artesian	E	M	0	BU
Schuitsdrift	SDRIF151	30.09500	-22.68852	6/09/13		E	S	30	G/D/S
Schuitsdrift	SDRIF16	30.08852	-22.67868	6/09/13		N	N	0	NIU
Schuitsdrift	SDRIF2	30.07902	-22.68043	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF3	30.08077	-22.68498	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF4	30.07842	-22.68672	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF5	30.07377	-22.68825	6/09/13	2.6	E	N	0	BU
Schuitsdrift	SDRIF6	30.07227	-22.69090	6/09/13	4.5	D	M	0	BU
Schuitsdrift	SDRIF7	30.06419	-22.68954	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF8	30.06508	-22.69072	6/09/13		E	M	0	BU
Schuitsdrift	SDRIF9	30.06995	-22.69085	6/09/13		E	M	0	BU
Schuitsdrift	SDRIFT11	30.07018	-22.69237	6/09/13		E	M	0	BU
Lotsieus	LOTS1	30.09617	-22.68823	6/09/13		E	M	0	BU
Lotsieus	LOTS2	30.09795	-22.68432	6/09/13		E	M	0	BU
Lotsieus	LOTS3	30.09925	-22.68328	6/09/13		E	M	0	BU
Lotsieus	LOTS4	30.09973	-22.67997	6/09/13	11.5	E	S	0	BU
Riet	RIET1	30.05250	-22.69480	6/09/13		E	S	3	G/D/S
Riet	RIET2	30.05610	-22.69300	6/09/13		E	M	3	G/D/S
Riet	RIET7	30.06418	-22.68953	6/09/13		N	N	0	NIU

TABLE 6: CONT

D-Diesel, E-Electric,-W-Wind, Sol-solar
N-None, M-Mono, S-Submersible, W-Windpump
NIU-not in use, G/D/S-Game/Domestic/Stock, BU-Backup to surface water scheme

Farm	Name	Longitude	Latitude	Date	SWL	Power*	Pump**	Daily abstraction (m3/day)	Use***
Mount Stuart	MTS1	29.97010	-22.33377	4/09/13	1.6	N	N	0	NIU
Mount Stuart	MTS2	30.09447	-22.66897	4/09/13		E	M	3	G/D/S
Ter Blanche	TER1	30.12417	-22.66993	4/09/13		D	M	1	G/D/S
Ter Blanche	TER2	30.15932	-22.67712	4/09/13	35.3	N	N	0	NIU
Ter Blanche	TER3	30.16160	-22.67683	4/09/13	35.3	D	S	1	G/D/S
STAYT	WSTAY-1	30.02608	-22.69270	2011	18.91	D	S	1	G/D/S
Nakap	NHOLE-9	30.04590	-22.70397	2011	2.73	N	N	0	NIU
Nakap	NAK-1	30.02105	-22.72100	2011	5.65	N	N	0	NIU
Nakap	NAK-2	30.01414	-22.71575	2011	15.9	E	S	1	G/D/S
Nakap	NAK-3	30.01604	-22.72240	2011	6	N	N	0	NIU
Nakap	NAK-4	30.01402	-22.72389	2011		D	S	1	G/D/S
Nakap	NAK-5	30.00934	-22.71211	2011	16.3	N	N	0	NIU
Nakap	NAK-6	30.02349	-22.70520	2011	16.6	N	N	0	NIU
Japie	JAPI1	29.97318	-22.69263	4/09/13	8m	D	M	2	G/D/S
Oom Jan	OJAN1	29.93187	-22.69823	4/09/13	21.9	E	S	2	G/D/S
Oom Jan	OJAN2	29.93832	-22.71513	4/09/13		D	M	1	G/D/S
Oom Jan	OJAN3	29.93378	-22.70232	4/09/13	23m	N	N	0	NIU
Oom Jan	OJAN4	29.93917	-22.70260	4/09/13	28m	N	N	0	NIU
Phantom	PHAN-1	29.97235	-22.76112	2011	35.8	Sol	S	1	G/D/S
Phantom	PHAN-2	29.96329	-22.74594	2011	13.2	Sol	S	1	G/D/S
Phantom	PHAN-3	29.97952	-22.74504	2011	22.87	D	S	3	G/D/S
WILDGOOSE	WILDG-1	29.96442	-22.71032	2011	22.07	Sol	S	1	G/D/S
Rissik	Ris-1	29.89857	-22.74511	2012	36.82	N	N	0	NIU
Rissik	Ris-2	29.89845	-22.74623	2012	34.45	E	S	3	G/D/S
Rissik	Ris-3	29.90819	-22.73575	2012	31.5	D	M	3	G/D/S
Rissik	Ris-4	29.91376	-22.74595	2012		E	S	1	G/D/S
Rissik	Ris-5	29.89881	-22.75325	2012	25.18	E	S	3	G/D/S
Rissik	Ris-6	29.88948	-22.75306	2012	26.78	E	S	3	G/D/S
Thiel	H250010	30.17602	-22.70605	5/09/13		D	M	10	IU
Thiel	H250184	30.19892	-22.72783	5/09/13		N	N	0	NIU
Thiel	H290011	30.22987	-22.72108	5/09/13	pumping	D	M	43	IU
Thiel	H25-5180	29.82390	-22.68773			N	N	0	NIU

4.2 PIEZOMETRY AND GROUNDWATER FLOW

If the water table is undisturbed, the groundwater surface tends to mimic a subdued form of the topography. Water levels measured during the hydrocensus exhibited water levels ranging from artesian to 35 meters below ground level (mbgl).

The water level data was colour coded according to set piezometric height ranges from which a piezometric contour map was drawn (see Figure 13). Groundwater flow direction is perpendicular to the piezometric contours and towards the drainages.

Groundwater is used on a small scale within the mine application area and as a result water levels are probably close to the natural state. Some weakly artesian boreholes occur on the Mt Stuart Section where the elevated hydrostatic head of the mountain has an influence.

Springs occur where the water table intersects the surface, usually along some structure. The well-known hot spring at Tshipise is associated with a large dolerite sill and two secondary fault systems in conjunction with the Tshipise Fault.

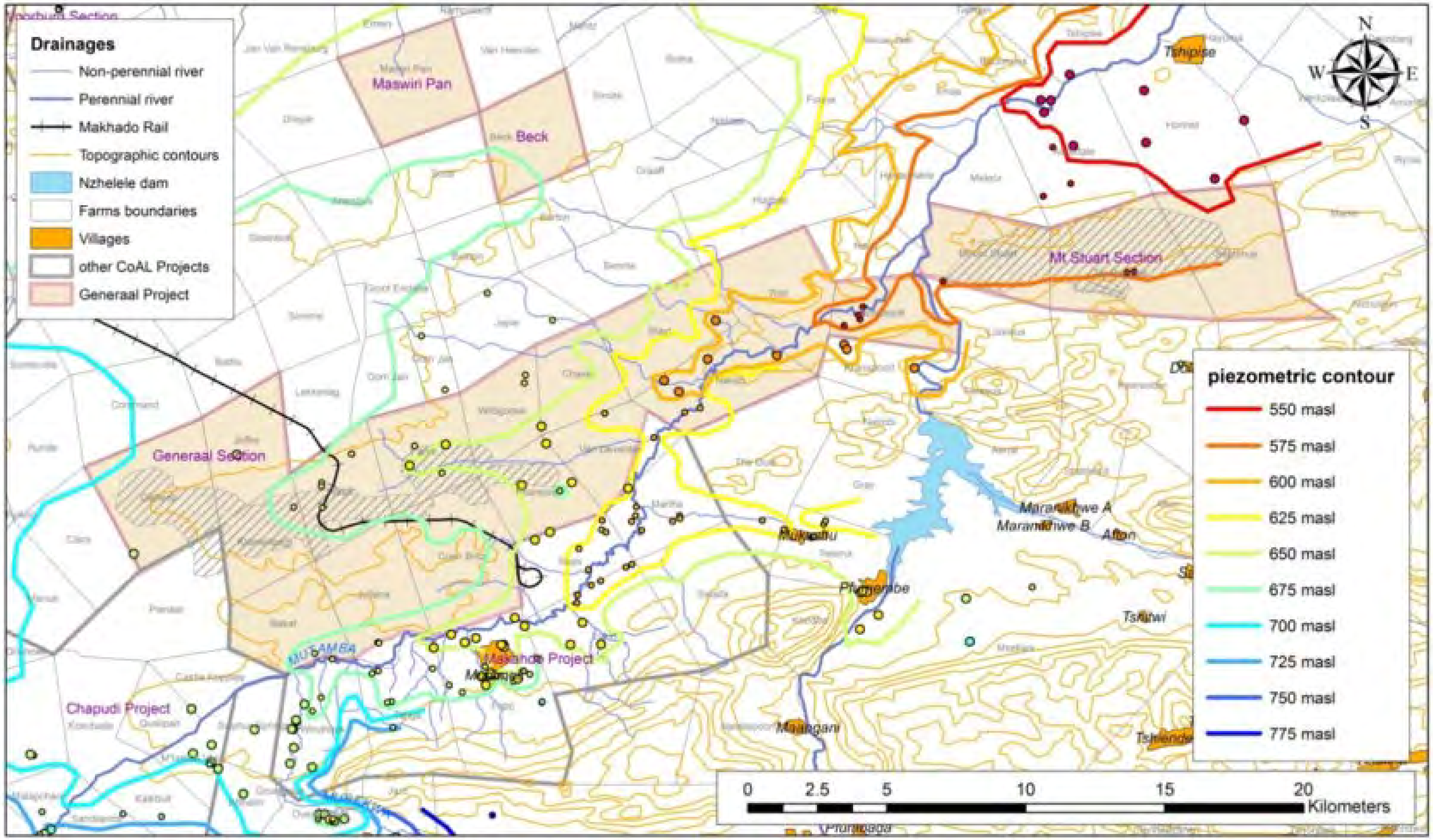

FIGURE 13: PIEZOMETRIC CONTOUR MAP

4.3 GROUNDWATER QUALITY

Groundwater quality is dependent on the concentrations of soluble salts and the residence time of water within the host rock. Most of the water derived from secondary aquifers reflects the aridity of the study area with elevated salt content.

The data is presented with reference to the Water Quality Threshold (WQT) according to the Department of Water Affairs Water Quality Guidelines for Rivers and Streams as summarized in the table below, for the following water uses;

i Drinking water

ii Agriculture-irrigation

iii Agriculture-livestock

4.3.1 MACRO CHEMISTRY

TABLE 7: DWAF WATER QUALITY THRESHOLD CLASSIFICATION – MACRO CHEMISTRY

Species			E.C	TDS	NO_3	F	SO_4	Cl	Ca	Mg	Na
Unit	date	pH	mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Drinking		6.0 - 9.0	150	1000	6.0	1.0	400	200	150	100	200
Agriculture (irrigation)		6.5 - 8.4	40		5.0	2.0		100			70
Agriculture (livestock)				1000	100.0	2.0	1000	1500	1000	500	2000

A total of 41 hydrocensus samples were analysed for pH and major and micro elements. The chemistry results are listed in the table below. Concentrations exceeding the WQT for any of the above uses are marked in red.

TABLE 8: MACRO CHEMISTRY WITH DWAF CLASSIFICATION

Species			E.C	TDS	NO_3	F	SO_4	Cl	Ca	Mg	Na
Unit	date	pH	mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BF-1	15/07/2011	7.5	139	898	0.7	3.1	157	181	56	53	159
BF-2	15/07/2011	6.9	773	4960	0.8	0.8	185	0	237	372	778
BF-4	15/07/2011	7.3	72	461	0.5	0.4	28	62	42	43	44
BOAS -1	3/04/2008	6.7	135	984	0.0	0.5	62	186	165	107	110
EKL-15	23/05/2011	7.8	142	832	3.0	0.5	11	151	33	46	143
EKL-16	5/09/2011	7.4	85	524	0.6	0.2	27	121	36	22	74
FANI-1	14/11/2011	7.7	201	1290	0.2	3.7	5	380	8	9	390
FANI-2	14/11/2011	7.2	525	3360	3.0	0.5	157	0	122	235	614
H18-0006	15/07/2011	7.9	294	1718	0.2	0.4	110	552	34	16	511
H25-0010	8/09/2013	7.3	246	1601	64.0	0.3	127	333	161	144	150
H29-0011	8/09/2013	7.2	179	1165	29.8	0.2	50	224	141	70	154
Jap-1	8/09/2013	7.1	143	929	9.2	1.8	46	63	77	100	121
Kran-1	8/09/2013	7.9	104	676	1.6	2.8	105	111	25	12	194
Mon-13	27/06/2011	7.8	108	612	0.5	1.8	49	141	65	63	115
Mon-13	15/07/2011	8.6	99.7	580	0.5	1.6	45	98	58	61	109
Mon-18	8/02/2011	8.6	150	932	5.6	0.6	41	196	26	40	174
Mon-18	15/07/2011	8.7	140	862	0.2	0.6	39	184	54	59	212
Mon-24	23/04/2012	7.4	150	932	8.1	1.0	57	120	95	98	109
MTS-1	8/09/2013	7.9	154	998	1.4	2.8	18	241	28	37	256
Nak-2	21/06/2011	7.2	242	1452	7.7	2.3	138	346	91	108	274
Nak-3	21/06/2011	7.4	331	1986	0.2	3.0	170	519	83	124	529
Nak-4	21/06/2011	7.5	276	1662	3.4	3.7	159	442	61	95	421
Ojan-1	8/09/2013	7.6	232	1507	18.5	2.4	98	236	75	110	301
PHAN-1	12/09/2011	7.6	93	612	13.0	0.5	48	53	117	61	31
PHAN-2	12/09/2011	7.6	79.9	444	4.3	0.2	6	35	66	49	43
PHAN-3	12/09/2011	7.4	80.9	490	5.8	0.2	10	36	57	54	42
PHAN-3	23/04/2012	7.2	89.5	548	5.3	0.2	10	40	62	62	53
Riet-2	8/09/2013	7.5	298	1936	3.2	1.7	317	525	68	98	440
RIS-1	19/11/2012	7.4	782	4720	0.0	0.5	76	2282	190	370	988
RIS-2	19/11/2012	7.8	441	2802	2.9	0.6	240	1036	103	198	632
RIS-3	19/11/2012	7.4	312	2022	2.2	1.2	176	630	123	185	334
RIS-4	19/11/2012	7.7	369	2288	4.6	0.6	130	748	58	146	591
RIS-5	19/11/2012	8	498	3072	1.7	0.5	130	1236	143	200	677
RIS-6	19/11/2012	7.7	415	2562	1.2	0.7	103	1083	128	189	501
Sdrif-15	8/09/2013	7.7	124	804	3.4	4.2	147	146	53	30	175
Ter-1	8/09/2013	7.7	191	1243	8.2	1.4	79	218	60	75	273
Ter-3	8/09/2013	7.9	116	757	1.4	0.6	45	90	73	71	90
WILDG-1	12/09/2011	7.4	198	1270	10.0	1.3	113	195	118	111	167

A histogram depicting the distribution of the TDS range within the application area is shown in Figure 14 below.

TDS is a general indicator of water quality. The histogram indicates that 45% of the samples were below 1000 mg/l and of potable quality. The remaining 55% are above 1000 mg/l but no sample was found to exceed 5000 mg/l within the project area. Water quality in the application area can be described as being of good to moderate quality. The TDS data was plotted and contoured to depict the spatial distribution of TDS concentrations in groundwater for the Generaal Project area and surrounds (See Figure 15).

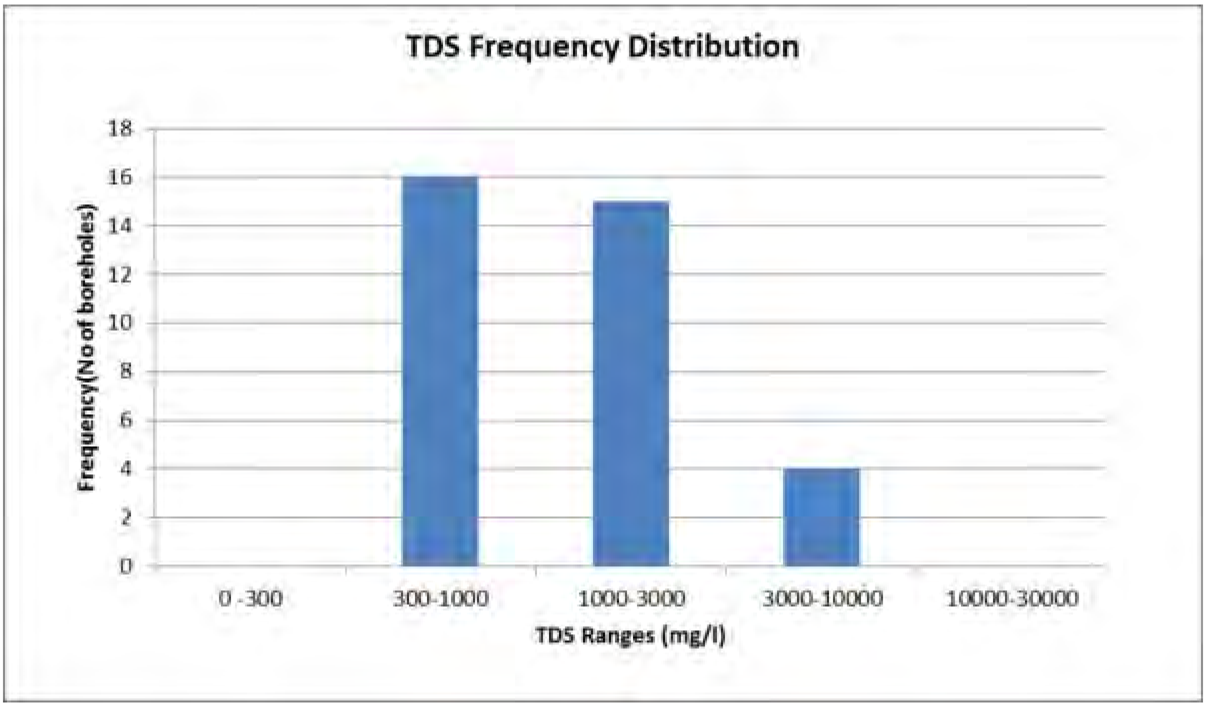

FIGURE 14: % FREQUENCY DISTRIBUTION OF TDS WITHIN THE GENERAAL PROJECT AREA

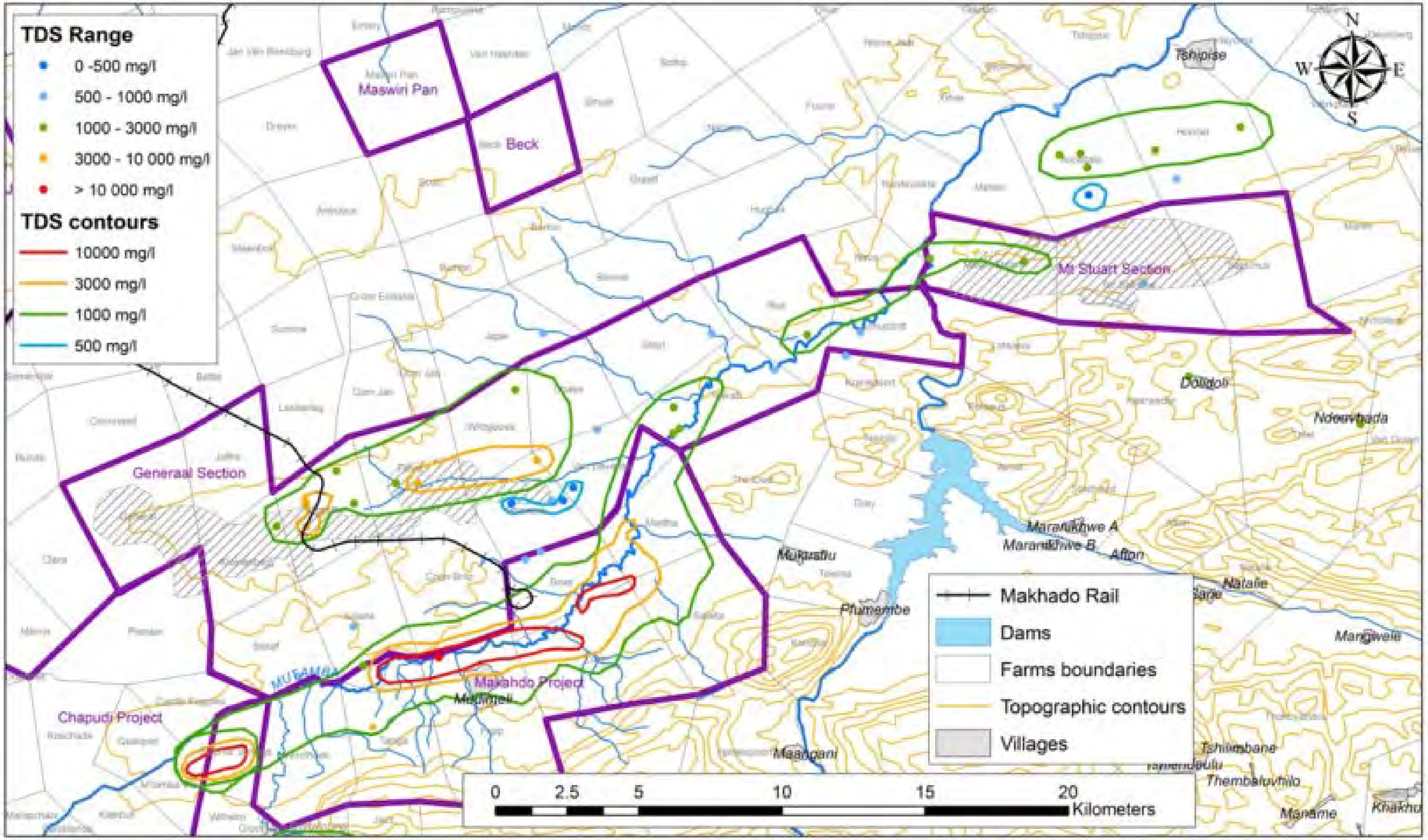

FIGURE 15: CONTOURED TDS DATA

4.3.2 Microchemistry

TABLE 9: MICRO-CHEMISTRY DWAF-WQT CLASSIFICATION

Specie	Al	As	B	Cd	Co	Cr	Cu	Hg	Mn	Mo	Ni	Pb	Se	V	Zn
Unit	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Drinking	0.5	0.05		0.005		0.05	1,3	0.001	0.4			0.01	0.05	0.1	5
Agriculture (irrigation)	5	0.1	0.5	0.01	0.05	0.1	0.2		0.02	0.01	0.2	0.2	0.02	0.1	1
Agriculture (livestock)	5	1	5	0.01	1	1	0.5	0.001	10	0.01	1	0.1	0.05	1	20

Concentrations exceeding the WQT for any of the above uses are marked in red. It must be noted that concentrations exceeding the WQT are often below the detection limit for some elements.

TABLE 10: MICRO-CHEMISTRY WITH DWAF-WQT CLASSIFICATION

Element	Al	As	B	Cd	Co	Cr	Cu	Mn	Mo	Ni	Pb	Se	V	Zn
Unit	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BF-1	0.10	0.01	0.35	0.005	0.025	0.025	0.025	0.05	0.025	0.025	0.020	0.020	0.025	0.025
BF-2	1.65	0.01	0.64	0.005	0.025	0.025	0.037	1.54	0.025	0.025	0.020	0.020	0.025	0.319
BF-4	0.10	0.01	0.19	0.005	0.025	0.025	0.025	0.27	0.044	0.025	0.020	0.020	0.025	0.025
EKL-15	0.10	0.13	0.25	0.005	0.025	0.025	0.025	0.14	0.025	0.025	0.020	0.020	0.036	0.025
EKL-16	0.14	0.01	0.16	0.005	0.025	0.025	0.083	0.60	0.025	0.025	0.020	0.020	0.025	0.196
FANI-1	0.20	0.01	0.78	0.005	0.025	0.025	0.025	0.04	0.025	0.025	0.020	0.020	0.025	0.102
FANI-2	0.10	0.01	0.74	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.037	0.025
H18-0006	0.10	0.01	0.96	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.025	0.157
H25-0010	<0,01	<0,03	0.25	<0,01	<0,01	<0,01	<0,01	<0,01	<0,05	<0,01	<0,09	0.02	0.05	0.06
H29-0011	<0,01	<0,03	0.31	<0,01	<0,01	<0,01	<0,01	<0,01	<0,05	<0,01	<0,09	0.03	0.02	0.08
Jap-1	<0,01	<0,03	0.21	<0,01	<0,01	<0,01	<0,01	0.20	<0,05	<0,01	<0,09	<0,02	0.03	1.00
Kran-1	<0,01	<0,03	0.28	<0,01	<0,01	<0,01	<0,01	<0,01	<0,05	<0,01	<0,09	<0,02	<0,01	<0,01
Mon-13	0.59	0.01	0.37	0.005	0.025	0.025	0.025	0.07	0.060	0.025	0.020	0.020	0.025	0.025
Mon-13	0.10	0.01	0.41	0.005	0.025	0.025	0.025	0.34	0.025	0.025	0.020	0.020	0.025	0.025
Mon-18	0.10	0.01	0.22	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.050	0.025
Mon-18	0.13	0.01	0.36	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.030	0.025
Mon-2	0.13	0.01	0.98	0.005	0.025	0.025	0.025	1.40	0.025	0.025	0.020	0.020	0.025	0.025
Mon-24	2.81	0.03	0.29	0.005	0.025	0.025	0.025	0.42	0.025	0.025	0.020	0.020	0.025	2.210
MTS-1	<0,01	<0,03	0.33	<0,01	<0,01	<0,01	<0,01	0.05	<0,05	<0,01	<0,09	0.03	<0,01	0.01
Nak-2	0.10	0.01	0.50	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.025	0.025
Nak-3	0.49	0.01	0.97	0.005	0.025	0.025	0.025	0.91	0.025	0.071	0.047	0.034	0.177	1.550
Nak-4	0.12	0.01	0.69	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.032	0.036
Ojan-1	<0,01	<0,03	0.71	<0,01	<0,01	<0,01	0.02	<0,01	<0,05	<0,01	<0,09	<0,02	0.03	0.02
PHAN-1	0.10	0.01	0.10	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.032	0.025
PHAN-2	0.10	0.01	0.16	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.026	0.025
PHAN-3	0.11	0.02	0.17	0.005	0.025	0.025	0.025	0.03	0.025	0.025	0.020	0.020	0.025	0.027
PHAN-3	0.10	0.01	0.16	0.005	0.025	0.025	0.092	0.03	0.025	0.025	0.020	0.020	0.040	0.096
Riet-2	<0,01	<0,03	0.75	<0,01	<0,01	<0,01	<0,01	0.02	<0,05	<0,01	<0,09	<0,02	0.02	0.03
RIS-1	0.14		0.57	<0.005		<0.025		0.93	<0.025	<0.025	<0.020		<0.025	
RIS-2	0.12		0.58	<0.005		<0.025			<0.025	<0.025	<0.020		<0.025	0.290
RIS-3	0.14		0.86	<0.005		<0.025		0.03	<0.025	<0.025	<0.020		<0.025	1.010
RIS-4	<0.01		0.76	<0.005		<0.025			<0.025	<0.025	<0.020		<0.025	
RIS-5	0.13		0.70	<0.005		<0.025			<0.025	<0.025	<0.020		<0.025	
RIS-6	0.13		0.47	<0.005		<0.025		0.07	<0.025	<0.025	<0.020		<0.025	0.054
Sdrif-15	<0,01	<0,03	0.24	<0,01	<0,01	<0,01	<0,01	<0,01	<0,05	<0,01	<0,09	<0,02	0.01	0.01
Ter-1	<0,01	<0,03	0.39	<0,01	<0,01	<0,01	<0,01	0.30	<0,05	<0,01	<0,09	<0,02	0.03	0.35
Ter-3	<0,01	<0,03	0.22	<0,01	<0,01	<0,01	<0,01	<0,01	<0,05	<0,01	<0,09	0.02	<0,01	0.01
WILDG-1	0.10	0.01	0.35	0.005	0.025	0.025	0.027	0.03	0.035	0.025	0.020	0.020	0.025	0.073

The ICP scan (analysis method) detection limit for Cd, Mo and Pb is below or on the WQT concentration value. Elevated B occurs in the groundwater samples from Rissik, Stayt and Fanie. Sub-economic Cu, Zn mineralization along the Tsipise fault on the farm Stayt is reflected by slightly elevated Zinc and V values in the water (Mon-24).

4.4 GROUNDWATER USE

Groundwater abstraction is on a small scale mainly for farmsteads, hunting/game lodges and game and stock watering. Irrigation occurs (see figure 16) on the farms Mount Stuart (494 ML/annum) and Maswiri (824 ML/annum) but they utilize surface water from the Nzhelele Irrigation Scheme with groundwater as a back-up when surface water is not available. There are numerous high yielding boreholes developed for this purpose, as gauged from pump installations, although mostly in a state of disrepair. These holes have not been used for several years and quantitative data was not available from the owners/managers at the time of census. The boreholes abstract water mostly from the fractured rock aquifers consisting of the E-W fault systems within the Karoo and Soutpansberg strata.

The total estimated existing groundwater abstraction for the Generaal MRA area is estimated at 117 m^3/day or 43 ML/annum (See Table 13). This excludes backup ground water that is utilized during drought periods when the Nzhelele Scheme allocation is inadequate to sustain the citrus orchards.

Generaal MRA area is about 22 800ha or 228 000 000m^2. Average annual recharge over the area is taken as 4.7mm/annum (see chapter 6.4) or 0.0047m/annum. Therefore average annual recharge volume is 228 000 000 X 0.0047 = 1 071 600 m^3/annum or 2 935m^3/day. This is more than 25 times the existing use and it can therefore be concluded that groundwater is underutilized. However during drought periods when the irrigation farmers need the backup groundwater the groundwater resources could be heavily utilised.

TABLE 11: GROUNDWATER USE

Quat	Owner/Business	Farms	Estimated Groundwater Use					Comments
			House hold and Lodges (m3/day)	Game and stock watering (m3/day)	Cleared Land (Ha)	Irrigated Land (Ha)	Total Estimated groundwater use ML /annum	
A80F	Ekland Safaris	Generaal 587 MS	5	3	25	0	11	Water use for Lodges, game and dams
		Kleinenberg 636 MS	0	3	-	-		
		Bekaf 650 MS	12	3	-	-		
		Juliana 647 MS	0	1	-	-		
		Coen Britz 647 MS	0	2	-	-		
	Malumbane Community Trust	Joffre 584 MS	5	3	-	-	3	Water use for domestic cattle and game
	W C Fourie	Rissik 637 MS	5	3	-	-	3	Water use for domestic cattle and game
	S P Matodzi	Rissik 637 MS	0	2	8	0	1	Water use for domestic cattle and game
	L H Traut	Rissik 637 MS	2	1	-	-	1	Water use for domestic cattle and game
	A S van der Merwe	Fanie 578 MS	5	3	-	-	3	Water use for domestic cattle and game
	Tony Zambakides	Wildgoose 577 MS Phantom 640 MS	3	3	-	-	2	Water use for domestic and game
	Born Free Investments	Chase 576 MS Van Deventer 641 MS	3	3	-	-	2	Water use for lodge, domestic and game
	Clint Howes	Stayt 183 MT Nakab 184 MT	1	2	-	-	1	Water use for lodge, domestic and game
	Maswiri Boerdery	Riet 182 MT	3	3	-	-	14	Water use for lodge, domestic and game. Irrigation from Nzhelele scheme 830 Ml/annum
		Skuitdrift 179 MT	30	3	172	105		
		Kranspoort	0	0	-	-		
		Lotsieus	0	0	-	-		
		Perseus	0	0	-	-		
	Mount Stuart Boerdery	Mount Stuart 153 MT	1	2	119	63	2	Water use for domestic and game. Irrigation from Nzhelele scheme 500 Ml/annum
A80G		Terblanche 155 MT	0	2	-	-		
		Septimus 156 MT	0	0	-	-		
		TOTAL	117 m3/day				43 ML/annum	

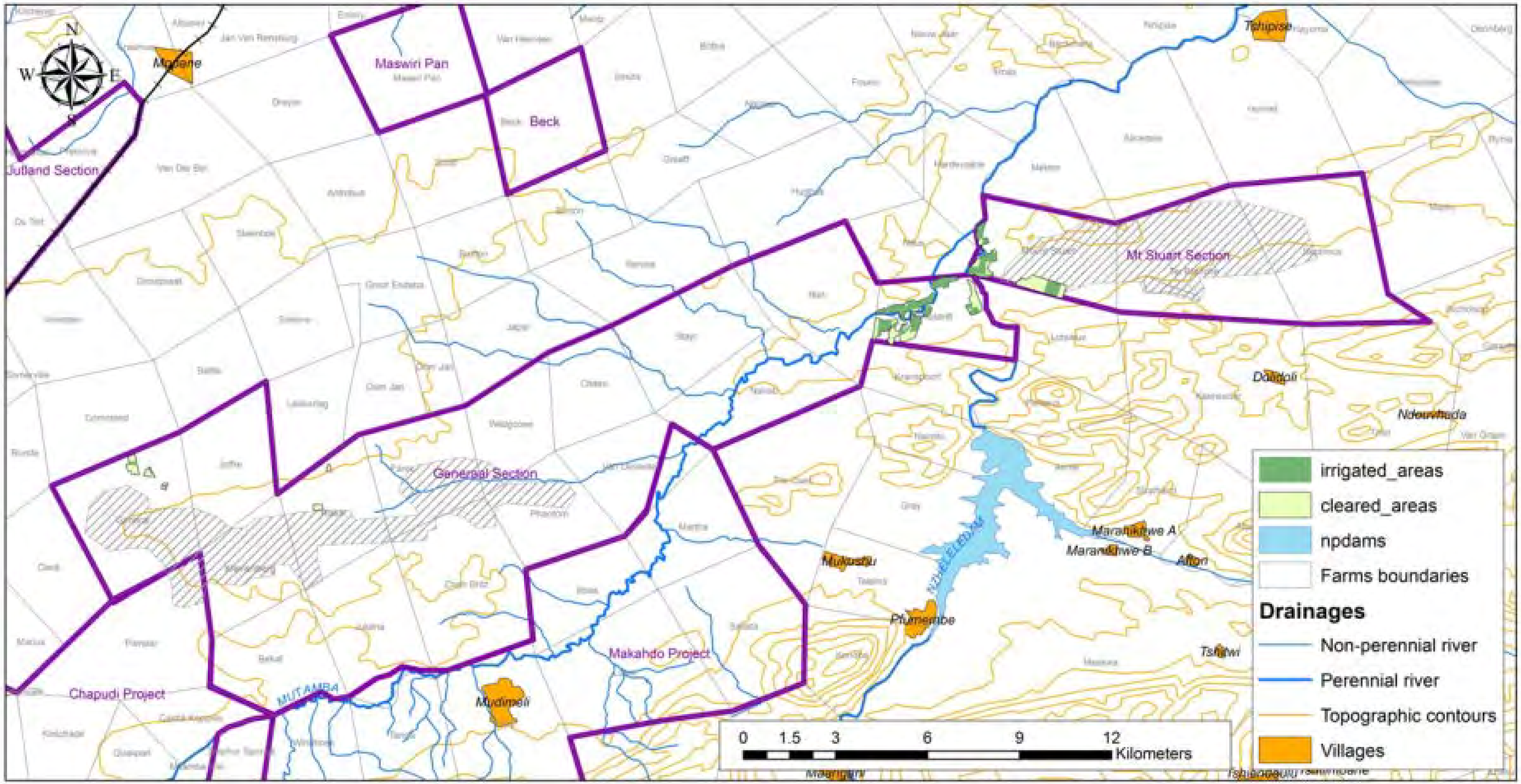

FIGURE 16: CLEARED LANDS AND IRRIGATED AREAS

5. REGIONAL GROUNDWATER FLOW

To determine the orientation of groundwater flow on a regional scale, water levels were available from 965 boreholes. Historic data from 657 boreholes was obtained from the National Groundwater Database (NGDB), and the remainder were collected by hydrocensus during the study for Makhado mine and the present study. These data were converted to absolute water levels by determining borehole elevation from Google Earth. The MODFLOW model (section 6), was utilised to generate current water levels as a piezometric map (Figure 17). The Model was also utilised to generate a map of water level under virgin conditions (Figure 18).

Regional groundwater flow is oriented northeast towards the Limpopo River (Figure 17 and 18). Flow volumes are extremely low due to the low permeabilities and low recharge, especially in the northern half of the catchment underlain by the Limpopo Mobile Belt and overlain by alluvium.

In the south, where the catchment is underlain by Karoo and Soutpansberg rocks and where mining is proposed, a local northward hydraulic gradient is present due to high recharge in the Soutpansberg Mountains. A significant cone of depression exists around the Sand River directly north of the Soutpansberg Mountains due to the large scale irrigation from groundwater. Quantifying abstraction is problematic, since not all the lands are irrigated every year. Irrigation was estimated from lands identified as being irrigated on the most recent Google Earth images, i.e. 2009.

Under natural conditions, groundwater drains via localised springs, as baseflow to the perennial tributaries flowing from the Soutpansberg, and by evapotranspiration by riverine vegetation along the main river channels.

Groundwater is of good quality in the Soutpansberg rocks, which is the main recharge zone; however, increased salinity occurs northwards as groundwater flows through saline Karoo sediments, accumulating salts. Low recharge rates in the drier terrain north of the Soutpansberg also results in low recharge rates to dilute these salts. The movement of groundwater passing through saline deposits of the Karoo rocks, and subsequent evapotranspiration by riverine vegetation, causes a rapid salt accumulation northward, with a peak salt load along the fringes of the channels lying over Karoo rocks, like the Mutamba, the Brak and Sand Rivers, resulting in poor natural water quality.

The Mufungudi entering Nzhelele dam, the Kandanama River a tributary of the Mutamba River, entering the catchment in the south along the N1 highway, and the upper reaches of the Mutamba emerging from the Soutpansberg are perennial, but lose water to groundwater as they flow out of the Soutpansberg, becoming ephemeral. This water is abstracted by boreholes for irrigation on the farms Windhoek, Grootgeluk and Overwinning along the Kandanama, and by irrigation boreholes along the Sand River on Sterkstroom, Sitapo, Sutherland and Waterpoort, or is utilized by riparian vegetation. Very little surface runoff is believed to recharge the regional aquifers north of the Soutpansberg, since high salinity levels in the Karoo aquifers suggest it is not recharged by fresh water from the river. In comparison, groundwater is of good quality in the Karoo aquifer along the southern tributaries such as the Kandanama River, where river losses take place. Isotope studies conducted during the Makhado investigation confirm this.

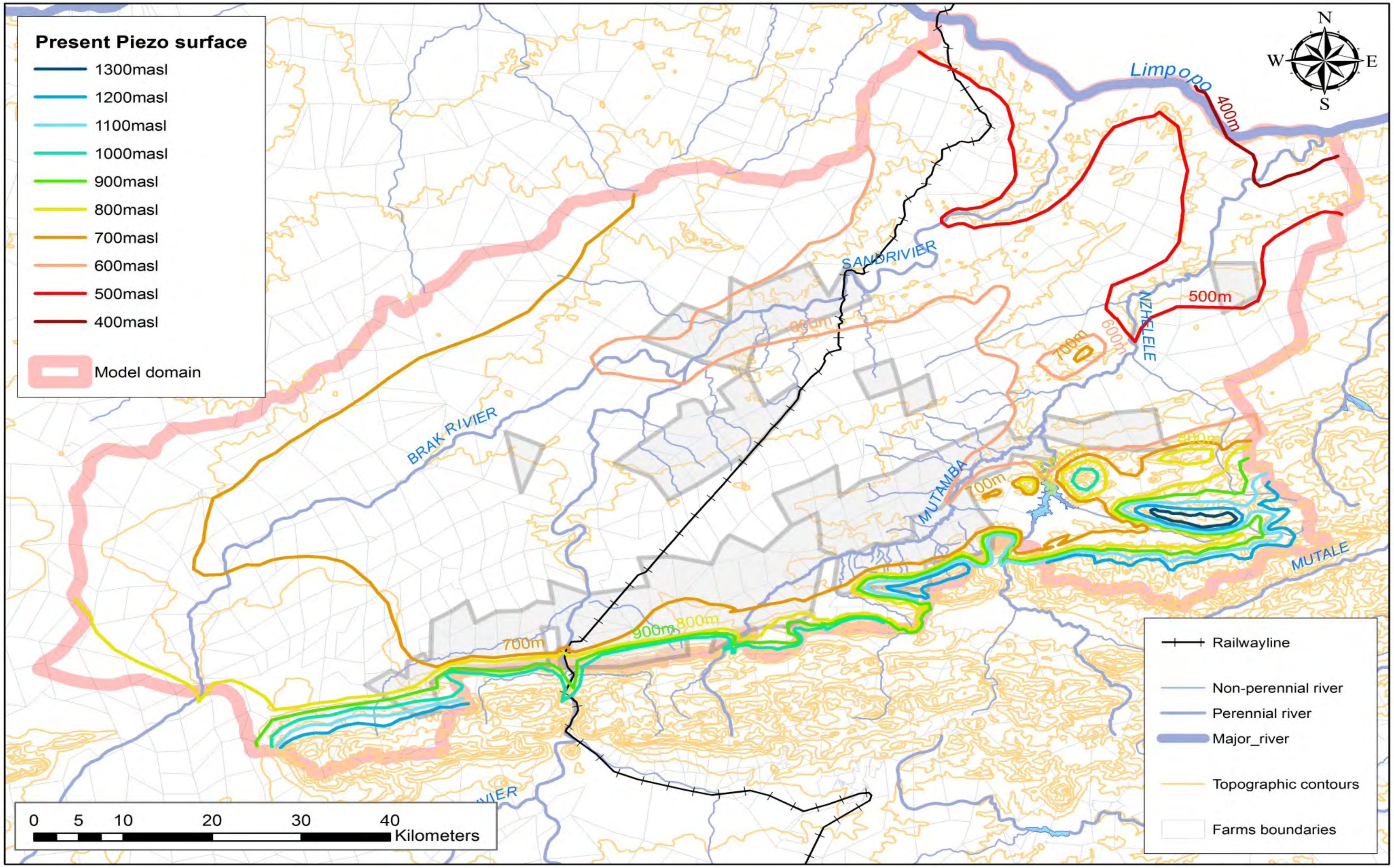

FIGURE 17: STEADY STATE WATER LEVELS UNDER CURRENT CONDITIONS (METRES ABOVE MEAN SEA LEVEL)

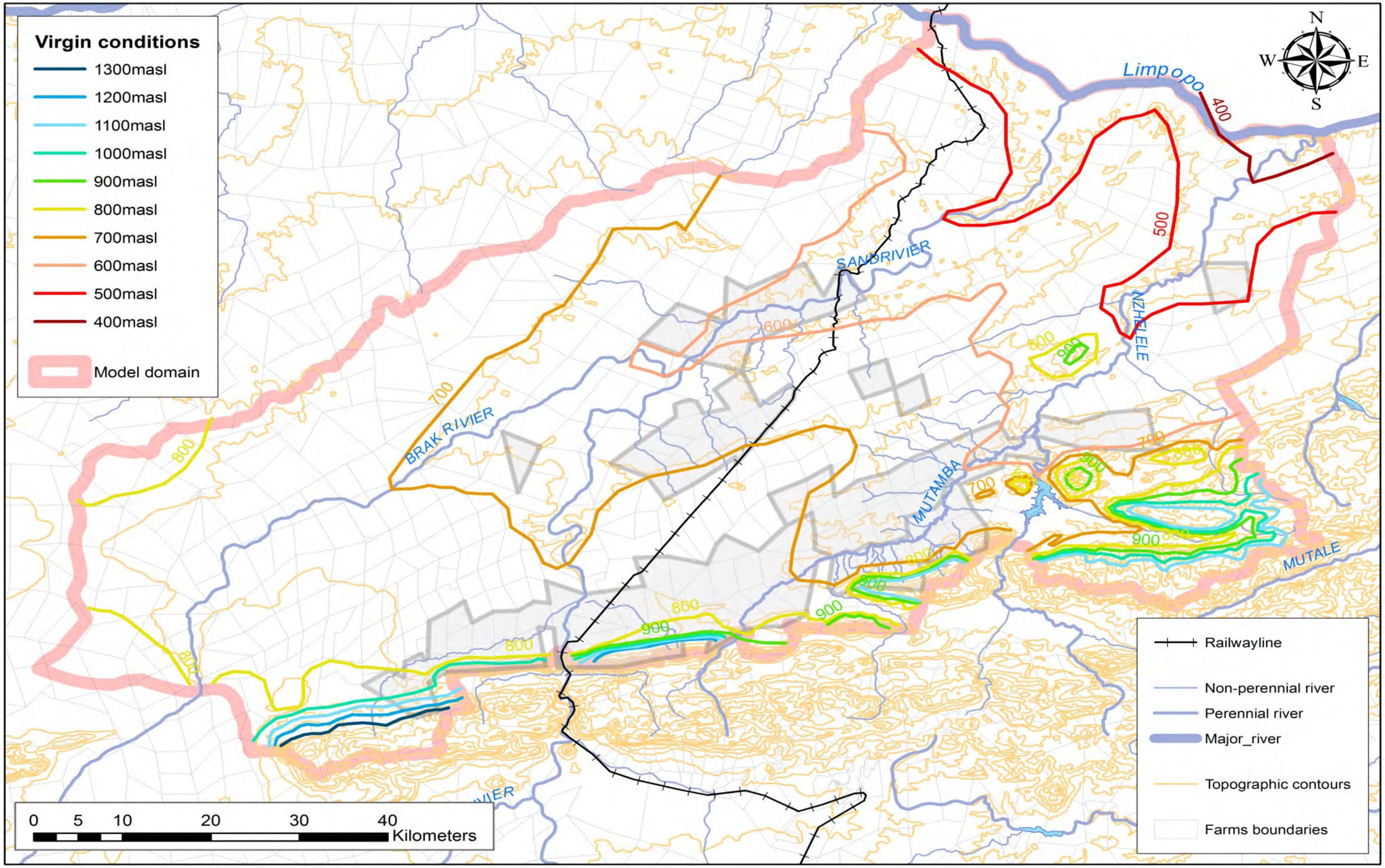

FIGURE 18: STEADY STATE WATER LEVELS UNDER VIRGIN CONDITIONS (METRES ABOVE MEAN SEA LEVEL)

6. GROUNDWATER FLOW MODEL

A numerical model was generated in order to quantify the impact of the proposed mine on the groundwater in the study area, and to determine inflows into the mine workings. Since many mines will be operated in conjunction, it was necessary to model a large area to determine cumulative impacts. The Makhado mine will be in operation before the Generaal project, and will impact on water levels. In addition, the Mopane and Chapudi projects will overlap with Generaal, hence all the projects must be considered in conjunction (see figure 19).

The USGS MODFLOW2000 Finite Difference groundwater model was used in the US Department of Defence GMS 9.0 (Groundwater Modelling System) interface to simulate and plot groundwater flow.

6.1 CONCEPTUAL MODEL

In every modelling study the natural system is represented by a conceptual model representing the best understanding of how the natural system operates. The development of a conceptual model includes identifying hydrogeological layers, boundaries and zones of similar properties that need to be differentiated. Subsequently, a numerical model is designed and constructed with equivalent but simplified conditions of the real world, in sufficient detail to meet the objectives of the modelling study and reproduce observed conditions. Transferring the real world situation into an equivalent conceptual model system, which can then be solved using existing program codes, is a crucial step in groundwater modelling. The following are considered in the development of a conceptual model:

- The known geological and hydrogeological features and characteristics of the area and their vertical and horizontal variations.
- The variations of permeabilities and storativities of the geological formations
- The recharge to the aquifers and its variability
- The static water levels/piezometric heads of the study area.

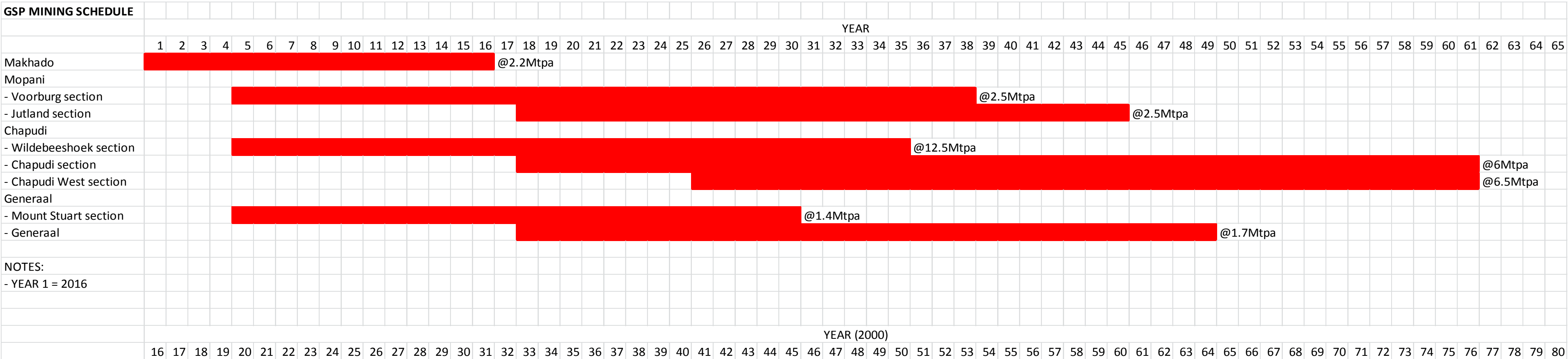

FIGURE 19: GSP MINING SCHEDULE

- The extent to which intended activities will interact with the geology and hydrogeology on the region so that the lateral and vertical boundaries of concern can be identified.
- The identification of the processes and interactions taking place within the study area that will influence the movement of groundwater, such as evapotranspiration from riverine zones, abstraction from boreholes, springs and baseflow to streams and rivers.
- Any simplifying assumptions necessary for the development of a numerical model and the selection of a suitable numerical code.

Due to the depth of mining, approximately 200 m for the open pit mines, 400 m for the underground Mount Stuart operation, and the dip of the strata, the model domain needs to be conceptualised as a 3 dimensional multilayer aquifer system, cut by fault zones. The faults need to be simulated using linear higher permeability zones, with major east north east permeable faults assigned a higher permeability than north south faults due to the tensional nature of ENE trending structures. These faults also need to be able to transmit water across the catchment boundary. However, due to such complexities and the large area covered by the GSP project and the number of mines in operation during the lifespan of the Generaal project, a regional 2 layer model was first developed to determine the cumulative impact of all the mines, from which local multi-layer models for each mine will later be developed once mining plans have been finalised.

Each geological formation was assigned its own permeability and storage parameters, and these were considered to decrease with depth due to reduced weathering and fracturing, hence the use of 2 layers, each 200 m thick, resulting in an aquifer depth of 400 m. Clastic sedimentary structures such as sandstones were assumed to have a more gradual decline in permeability with depth than non-clastic deposits like coal and mudstone. Basalts were given a high permeability due to the high yields of boreholes in basalt and the low hydraulic gradients present. Due to low borehole yields and the resistant nature of the rock, the mountainous region of the Soutpansberg was given a very low permeability.

Recharge was considered to vary, being lowest over the Karoo rocks due to low permeability mudstone layers, and slightly higher in the basalts and in Mobile Belt rocks overlain by Kalahari sands. Higher recharge in these zones was required to fit simulated water levels to observed water levels. The soils in the basalt are more permeable, and it is assumed the sand cover allows more percolation and less runoff, and allows rainwater to percolate below the evaporation zone. Recharge is significantly higher in the Soutpansberg outcrop areas due to higher rainfall and shallow soils.

Based on the observed hydraulic gradient, the aquifer was considered to discharge naturally towards the Nzhelele River, the Mufungudi, Kandanama and Nzhelele dam as baseflow, and via several springs identified on the geological map and in the field, and via evapotranspiration in the vicinity of the Mutamba, the Sand and the Brak Rivers and tributaries with significant alluvium, and in pans located north of the Soutpansberg in the western half of the study area.

In order to simulate interactions between surface and groundwater, perennial rivers were modelled as head dependent boundaries where perennial flow occurs. This implies that when aquifer water levels are above the level of the stream baseflow occurs, and when below, the river can recharge the aquifer. This allows boreholes and mining to increase losses from a river.

Water courses were considered as drains when the channels were ephemeral, and flowed only during major storm events, and considered not to recharge the aquifer. This allows baseflow for periods when aquifer levels are high, but not replenishment of the aquifer. Saline conditions in groundwater near ephemeral channels suggest that rivers do not recharge the aquifer, since dilution by fresher water from the river is not evident in the aquifer.

Rivers like the Sand, the Brak and the Mutamba contain significant alluvium, which is tapped in places by irrigators. These rivers were considered as drains, as river losses to the alluvium remains in the alluvium and is utilised by riverine vegetation and irrigators, and does not recharge the regional aquifer since hydraulic gradients are oriented towards the channels.

Where the rivers are perennial and where the alluvium is of a sandier and gravelly nature, good quality water in boreholes next to the river and the disappearance of flow in the river suggest the rivers recharge the aquifer. These lengths of river were treated as head dependent boundaries where water can flow from the river to the aquifer when groundwater levels are below the level of the river, and from the aquifer to the river when groundwater levels are above the level of the river.

It was considered necessary to include evapotranspiration to drain groundwater and prevent baseflow.

The reasons why these decisions were taken are the following:

- Without evapotranspiration, recharge to the aquifer would constantly induce groundwater discharge as baseflow under natural conditions. Natural recharge must discharge somewhere and the Mutamba, Sand, Brak and Nzhelele Rivers are the only receiving source in the catchment, however, they are ephemeral over much of their length.
- According to baseflow data in the GRAII (Groundwater Resource Assessment Phase II, a study commissioned by DWA), groundwater baseflow to surface water courses only exists along the Kandanama and Mufungudi, hence, natural recharge must be lost through riverine vegetation and spring discharge which is equal to at least the volume of recharge.

6.2 BOUNDARY CONDITIONS

The model domain is generally strongly influenced by boundary conditions. Boundaries control the flow direction and strongly influence the water balance of a numerical model; hence boundary conceptualisation is of critical importance. Generally internal boundaries are fixed where known interchanges of water take place, and lateral boundaries should be sufficiently extended to zones where it is known no interchange takes place.

The model domain was envisaged as being a discrete interconnected unit bounded by various hydraulic boundaries:

- The catchment watershed containing all the Quaternary catchments where mining is planned was treated as a no flow boundary across which groundwater flow was assumed to be non-existent. The rationale behind this discretisation was that the interchange of water across the topographical divide is negligible. This served as the lateral boundary of the model domain.

- To avoid boundary condition problems, the model utilised a large model domain of 6605 km^2 (all of Quaternaries A71J and K, A72B, A80C, F and G, and part of A80E), well beyond the mining area to ensure impacts of mining would be within the model domain. It was necessary to include a portion of A80E, since that is the Quaternary catchment which contains the southern tributary of the Mutamba, and it flows into A80F.
- Major faults crossing the watershed and where major inflows are believed to occur, were treated as constant head boundaries, where the water level at the boundary is kept constant and water is allowed to enter or exit the system depending on head differences. These boundaries are sufficiently distant from the mine not to be impacted by water level drawdowns from mining. They occur where major faults enter the study area at Waterpoort along the Sand River, and along the Mutamba River at Masekwaspoort.
- The Nzhelele dam was treated as a constant head boundary
- Discharge to springs and pans were simulated using drains, which is a type of boundary that allows water to flow out of the aquifer when the water table is above the set elevation of the drain. The rate of drainage is dependent on the head difference between the elevation of the drain and the water table in that cell multiplied by the set drain conductivity. If the water table falls below the elevation of the drain, the drain dries up and discharge is terminated. Drain cells were allocated where springs were identified. Drain conductivity was set between 0.01-1 m^2/day/m.
- The perennial Kandanama and Mufungudi rivers were treated as a head dependent river boundary, capable of discharging water to the aquifer, or receiving water, depending on the piezometric head in the aquifer in that cell. The Limpopo was also treated as a river boundary as the river recharges the alluvial sand aquifers located along its length. River conductance was calibrated to fit the water levels located adjacent to rivers, and ranged from 0.003-5 m^2/day/m.
- The ephemeral Nzhelele, Mutamba, Brak and Sand Rivers were treated as drains, capable of receiving water when groundwater levels exceed the base of the channel, but not contributing water to the aquifer. Drain conductance was 0.003-0.03, with smaller values along small tributaries.
- The alluvium along all the major channels were identified as green zones on Google Earth, were treated as an evaporation zone, where groundwater could be lost to

vegetation. These were considered zones where evapotranspiration from groundwater occurs and were treated as head dependent boundaries where evapotranspiration occurs at a rate dependent on the aquifer water level. Evapotranspiration was allowed to occur to a depth of 4 m below the surface elevation. Significantly lower evapotranspiration was allowed outside these regions. Pans located at the foothills of the Soutpansberg, fed by runoff and seepage was also considered to be evaporation zones.

- Mine workings were treated as drain cells for all model layers where mining was taking place during the mining interval. Until mine plans are finalised, the pit footprint was assumed to be the drain, with depth progressing from surface to a depth of 200 m over the life of mine. The planned underground mine at Mount Stuart was treated as a drain in layer 2, progressing from surface to a depth of 400 m. This assumes inflows only take place at depth, and the upper layer is dewatered by water seeping down from surface to the lower layer. The drain conductance is equal to the coal conductivity, 0.05 m/d for open cast mines, and to 0.002 m/d for the underground mine. After mining stops the drains in the cells forming the pit were turned off, allowing water levels in the pit to recover.
- The elevation of linear boundaries, like the stream channels was interpolated from surface contours and linearly extrapolated.

Figure 20 shows the model domain, and the internal boundary conditions incorporated. Drainage channels were digitised from the topographic map, and are shown in green where considered ephemeral and as drains, and in blue where they are perennial and considered head dependant boundaries, capable of losing water to the aquifer.

Springs or fountains identified on the topographic and geological maps where treated as drains and are shown in green. Abstraction boreholes identified are shown as brown circles. Topographic divides, which were considered no flow boundaries, across which groundwater does not flow, and served as the boundary of the model domain are shown as a black line.

Where faults cut across the model domain, allowing water to enter or leave the model domain, constant head boundaries were incorporated. These are shown in purple.

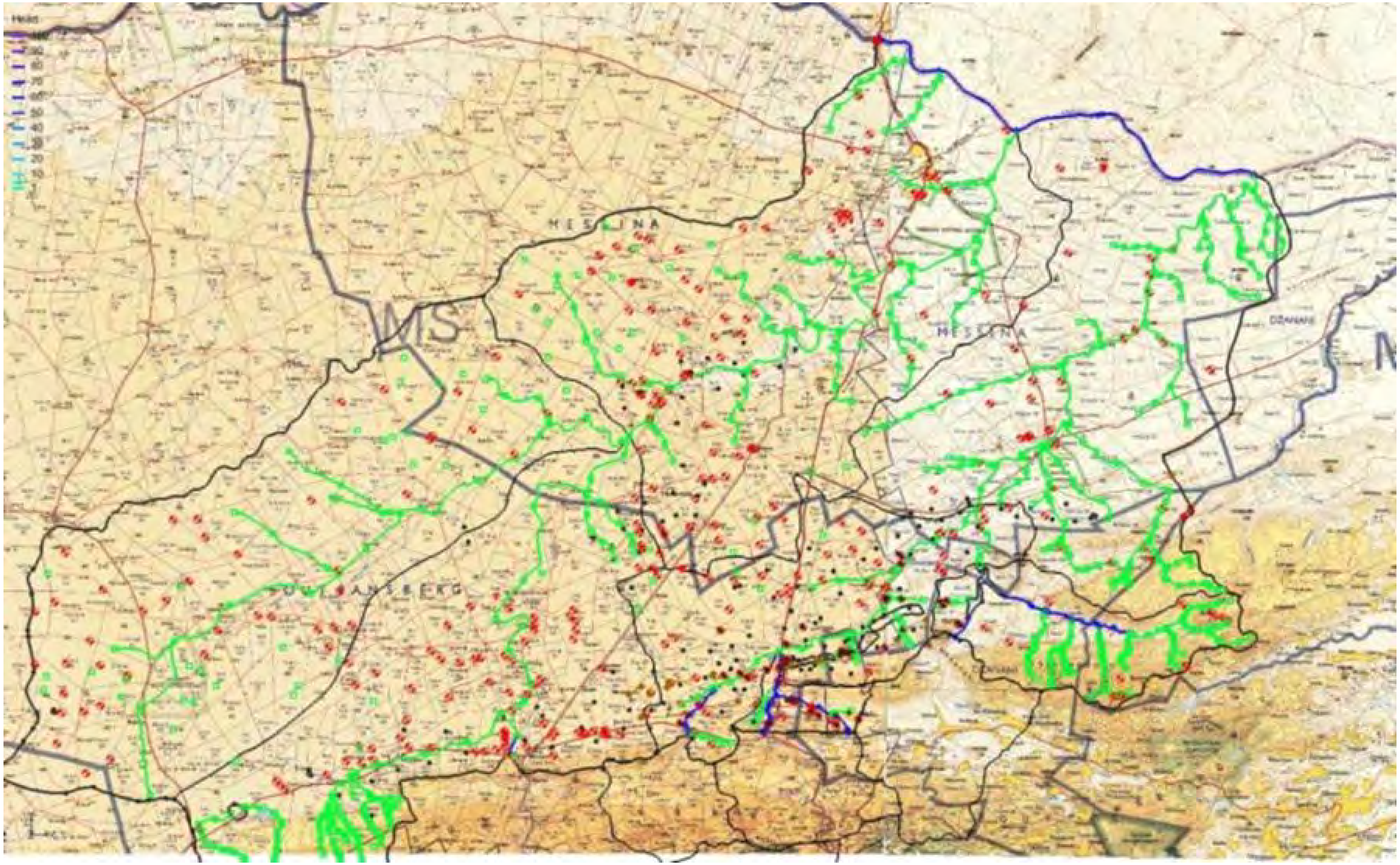

FIGURE 20: BOUNDARY CONDITIONS OF THE MODEL DOMAIN. BLUE = HEAD DEPENDENT RIVER, GREEN = DRAINS, BLACK = NO FLOW, PURPLE= CONSTANT HEAD, RED CIRCLES = EXISTING ABSTRACTION BOREHOLES

6.3 DISCRETISATION OF THE NUMERICAL MODEL

In a finite difference model the aquifer is represented by rectangular cell blocks and individual layers. Each cell is assigned a permeability, specific yield, specific storage, thickness and recharge parameter. Hydraulic heads in each cell of each layer and the exchange of water between cells and across boundaries is calculated simultaneously using finite difference mathematics until a finite solution is found within set convergence parameters. The model can be used to solve for heads under steady-state conditions, which are conditions that will occur when stability in water level and flow rates are reached, or for transient state conditions, which are flow rates and hydraulic heads that will exist after specific time intervals from an initial starting condition.

The regional aquifer was modelled as a 2 layer, 3 dimensional domain. Each layer was considered to be 200 m thick.

The grid was telescoped in the vicinity of the mining pits to provide greater resolution in zones where significant water level changes occur, as shown in Table 12.

TABLE 12: GRID DEVELOPMENT

	Base size (m)	Multiplier	Max. size (m)
Pits	100	1.5	1000

This results in cell sizes increasing outward from their base size by the multiplier up to the maximum size, giving a much finer resolution for head changes in the areas of interest, and in zones where steeper hydraulic gradients exist. For example, cells in the pits would be a minimum size of 100 x 100 m, increasing to 150 x 150 m, once outside the pit. The fine modelling interval allows the steep hydraulic gradients generated by dewatering to be represented. The domain was covered by 552 columns and 312 rows (Figure 21). The grid was oriented 65 degrees NE to be aligned with the orientation of rivers and major faults.

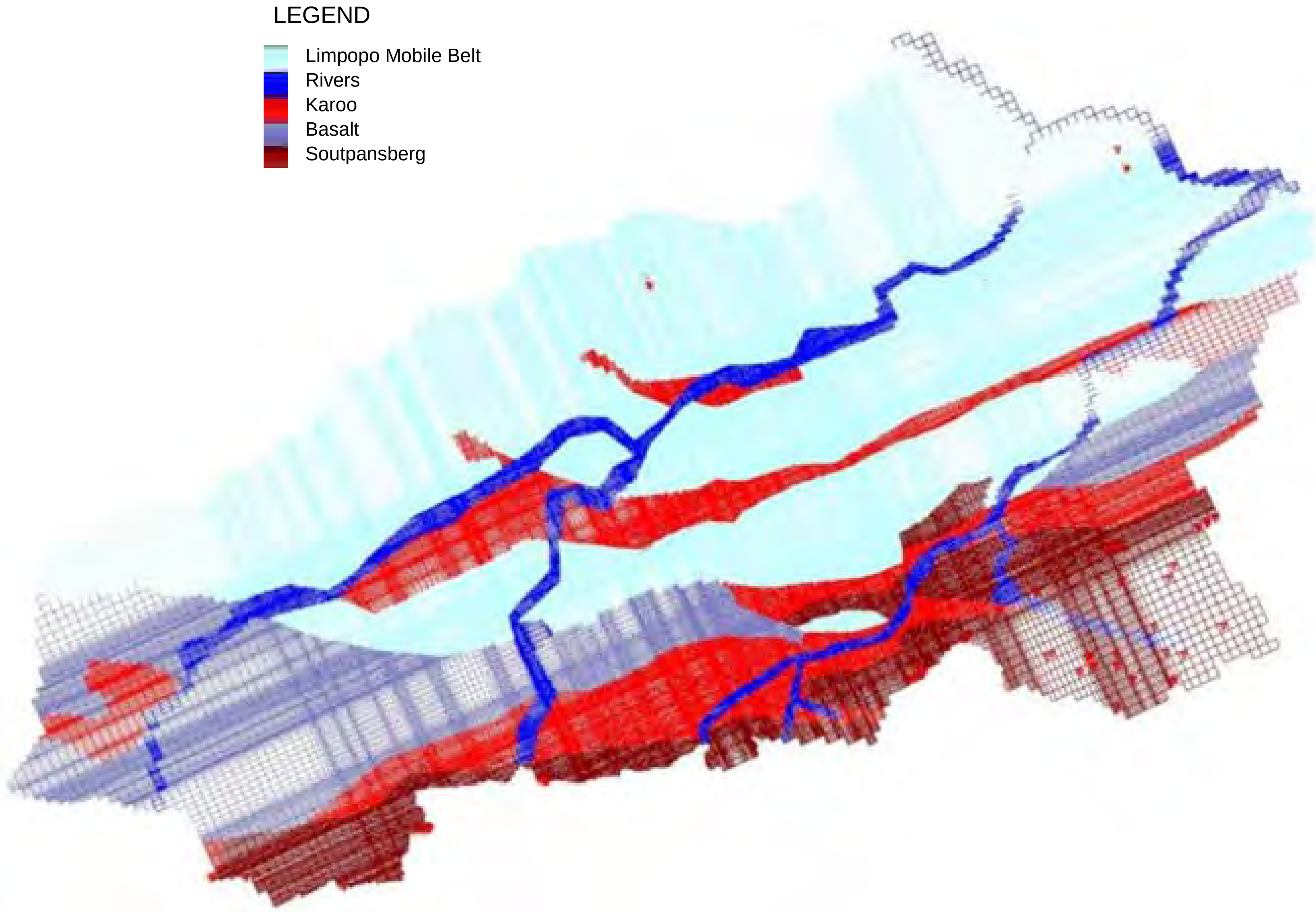

FIGURE 21: ACTIVE CELLS IN THE MODEL DOMAIN, CODED BY LITHOLOGY

The aquifer layer cells were set as confined, becoming unconfined when water levels dropped below the aquifer top. Horizontal anisotropy was set to 1 in the horizontal direction, meaning hydraulic conductivities are the same in the x and y plane, and 10 in the vertical direction, making vertical hydraulic conductivity 10% of the horizontal for flow between layers.

6.4 RECHARGE

Mean annual rainfall in the Quaternary catchments varies from 305-622 mm/a. Rainfall is significantly higher in the Soutpansberg and the catchments of the Kandanama and Mufungudi, hence recharge rates are highly variable, being high in the Soutpansberg, and lower to the north. Recharge also varies by geology due to the presence of low permeability mudstones in the Karoo and Kalahari sand cover in the north-western part of the study area, which reduces runoff and enhances recharge slightly. Recharge was simulated using a constant inflow into defined parameter zones and calibrated against borehole water levels in the steady state model. Recharge was higher in the Soutpansberg where higher rainfall and shallow soils occur and slightly less in regions of the Soutpansberg where vegetation indicates lower rainfall. Low recharge rates were applied to the plains north of the Soutpansberg.

Average recharge across the model domain is 4.7 mm/a, or 1.3% of rainfall. The recharge to the delineated recharge zones are shown in Table 13. Mine pits (brown were considered to have a high recharge of 255 mm/a post mining, declining to 73 mm/a after 3 years, then to 36 mm/a after 6 years (10% of rainfall) when rehabilitation is complete. Mine dumps were considered to grow from 0-3 years after start of mining, have a recharge rate of 73 mm/a, declining to 50 mm/a after the life of mine and rehabilitation.

TABLE 13: RECHARGE IN MM/A

	Mining	Post mining	
		3 years	6 years
Mine pits	0	255	73
Soutpansberg, steep slopes, shallow soil	11-55	11	55
Soutpansberg, deeper soils	1-5	1-5	1-5
Karoo	0.5-6.5	0.5-6.5	0.5-6.5
Basalt	1.2-5	1.2-5	1.2-5
Limpopo Mobile Belt	1-6	1-6	1-6

6.5 EVAPOTRANSPIRATION

Evapotranspiration was assumed to occur from groundwater at a maximum rate of 5.5-25 mm/a) from evapotranspiration zones along rivers, if the water level was at surface, dropping linearly to zero if the water level dropped to 4 m below surface. Away from river channels the maximum evapotranspiration rate was set at 1.5 mm/a. The evapotranspiration rate was calibrated to ensure that no baseflow occurs in rivers known to be ephemeral.

6.6 GROUNDWATER ABSTRACTION

Groundwater abstraction was simulated by discharge boundaries in cells containing production boreholes. Groundwater abstraction was estimated from the DWA WARMS database of registered water use, and from a hydrocensus, however, it was found that the registered use of 46 Mm^3/a is much higher than recharge and that irrigated lands could not be observed to account for the registered water use. The following was concluded:

- The registered water use was not utilised every year

- Farmers along the Nzhelele scheme only utilise boreholes when surface water from the Nzhelele scheme isn't sufficient, hence don't utilise the entire registered use from groundwater
- Much of the groundwater use is from well points or caissons in alluvial sand, replenished during storm events and hence isn't abstraction from the regional aquifer.

Consequently the following resolution was undertaken:

- Irrigated lands were digitised from Google Earth as opposed to cleared irrigable lands in order to estimate water use. Water use was estimated at 7 880 m^3/ha/a due to the seasonal nature of crops.
- Lands located along channels where the hydrocensus indicated abstraction by caissons were not considered, as they assumed to utilise only alluvial water
- Lands along the Nzhelele had only a fraction of the estimated use met from boreholes
- Irrigation was only simulated during calibration if observed water levels in the NGDB were post 1985. The irrigation was subsequently turned on to derive present day water levels.

Actual water use was calculated as 6 Mm^3/a. In addition, the MODFLOW NWT package was utilised, which reduces borehole abstraction proportionally to keep water levels above a present level. A maximum water level of 100 metres below ground level was selected. The subsequent current groundwater abstraction over the whole model domain simulated was 5.3 Mm^3/a of which 0.43 Mm^3/annum is abstracted from the Generaal MRA area.

6.7 PERMEABILITY AND STORAGE COEFFICIENTS

The surface elevation contours were utilised to form a TIN, from which the ground surface was derived. A 200 m depth below the surface was taken as model layer 1. The subsequent 200 m to a depth of 400 m was considered as layer 2. Permeabilities in m/day were assigned to geological zones (Table 14), differentiated by lithology, topography and the proximity to fault zones.

Permeability was calibrated to fit against observed water levels in a steady state model. Results of the packer tests undertaken in Karoo rocks and the coal also show that conductivities for layer 1 range from 0.003-0.08 m/day, which is within the range of calibrated values (Table 13).

TABLE 14: HYDRAULIC CHARACTERISTICS OF LAYERS

Layer	Permeability (m/d)	Transmissivity (m2/d)	Vertical anisotropy	Specific yield	Specific storage
Limpopo mobile belt					
Layer 1	0.001-0.009	0.2-1.8	10	0.001	0.00005
Layer 2	0.0005-0.001	0.1-0.2	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Soutpansberg					
Layer 1	0.005-0.02	1-4	10	0.001	0.00005
Layer 2	0.001	0.2	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Soutpansberg Range					
Layer 1	0.001-0.006	0.2-1.2	10	0.001	0.00005
Layer 2	0.0001-0.0005	0.02-0.1	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Karoo					
Layer 1	0.03-0.08	6-16	10	0.001	0.00005
Layer 2	0.005	1	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Clarens Formation					
Layer 1	0.02-0.05	4-10	10	0.001	0.00005
Layer 2	0.005	1	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Basalt					
Layer 1	0.02-0.07	4-14	10	0.001	0.00005
Layer 2	0.005	1	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Rivers					
Layer 1	0.06-0.08	12-16	10	0.001	0.00005
Layer 2	0.005	1	10	$1.7x10^{-6}$	$1.7x10^{-8}$
Mine fill					
Layer 1	1	200	10	0.1	0.0016

The specific yield value was calibrated from abstraction data collected during the bulk sample excavation of Makhado mine. The bulk sample pit was established over 60 days, during which pumped volumes to keep the cut dry were monitored. The elevation of the bottom of the bulk sample pit was set as a transient state drain in a 90 day transient state model. The specific yield was then calibrated so that inflows into the cut matched pumped volumes. The calibrated specific yield was adjusted downward, since the model layers in this simulation are 3 times thicker than those utilised as Makhado. The specific yield was calibrated so that similar pit inflows were derived for the Makhado mine pits in this study as in the Makhado modelling study.

6.8 HORIZONTAL BARRIERS

The presence of steeply dipping dolerite sills within the Karoo, which act as a low permeability barrier to northerly flow, was incorporated by using horizontal flow barriers. Observed water level differences of 20 m exist across this sill in the vicinity of Fripp. This was simulated as a horizontal flow barrier across both 4 layers. The barrier has a conductance value to restrict the flow of water across the barrier. The conductance value was calibrated to 5×10^{-6} to match water levels in observation boreholes on either side of the barrier.

Horizontal barriers were digitised into the model from existing geological maps. In the vicinity of the proposed mine, drilling data allowed the position of sills to be more accurately established.

6.9 INITIAL HEAD

In order to assess the transient state impact of mining on water levels and on the water balance, a model requires an initial hydraulic head distribution. This is usually achieved by calibration of a steady state model against observed water levels, which serves as the initial head distribution for the subsequent transient state model to simulate what will occur during mining and post-mining. Hence a steady state model is necessary prior to simulating impacts.

The simulated present day steady state flow model was assumed to represent pre-mining conditions with abstraction.

The resulting head distribution from the steady state model was used as the input into a transient state model starting in 2016 once mining begins and water levels begin to be affected.

6.10 MODEL SIMULATION

The simulations undertaken are shown in Table 15.

TABLE 15: MODEL SIMULATIONS PERFORMED

Simulation	State	Time steps (years)	Year From start of mining	Purpose	Impacts
1	Steady			Model calibration,	Abstraction on farms with recent water levels
2	Steady	`		present day water levels	Addition of all abstraction
3	Transient	16	16	Impact of mining	Makhado life of mine, Voorburg, Jutland, Wildebeesthoek, Mount Stuart mine start ups
4	Transient	22	38	Impact of mining	Makhado closure and water level recovery, Voorburg, Wildebeesthoek, Mount Stuart life of mine, Generaal, Chapudi start up
5	Transient	11	49	Impact of Mining	Jutland, Chapudi and Generaal up to the closure of Generaal
6	Transient	12	61	Impact of Mining	Closure of all mines

6.11 MINING LEVELS AND INFLOWS

To simulate expected inflows, dewatering requirements and impacts on water levels, the pit extent were entered as drain polygons. The pit floor was linearly extrapolated from ground surface to 200 m depth over the life of the pit using a transient state drain elevation. The mining plan was utilised to determine the area being mined. Drain conductance was set at 0.05, similar to an average Karoo permeability. For the underground Mount Stuart operation, drain conductance was set to 0.002 m/d and the depth was increased to 400 m over the life of mine, however the drain was set only in layer 2, below 200 m.

Annual time steps were utilised to calculate inflows into the mine workings.

To simulate post mining water levels, the drain polygons were removed, allowing the workings to fill to the decant level, which was identified as the lowest point of the pit surface using Google Earth. Decant points were created by setting a high permeability drain at the appropriate location and elevation. The pit conductivity and specific yield were set as mining fill (Table 14).

Mine pits were considered to have a high recharge of 255 mm/a after being filled, declining to 73 mm/a after 3 years, then to 36 mm/a after 6 years (10% of rainfall) when rehabilitation is complete. Mine dumps were considered to grow from 0-3 years after start of mining, have a recharge rate of 73 mm/a, declining to 36 mm/a after the life of mine and rehabilitation. No change in recharge over natural conditions was utilised for the Mount Stuart underground mine.

6.12 MODEL CALIBRATION

Calibration is the process whereby model parameters and boundary conditions are systematically altered in numerous consecutive simulations until simulated groundwater levels and flows match observed field measurements to within an acceptable error margin. Calibration under known conditions is critical if the model is to be used to forecast scenarios for which no observed data is available.

The trial and error manual calibration method was utilised.

Calibration of the model was based on water levels in 965 observation boreholes identified in the original and subsequent hydrocensus, in the NGDB, and the GRIP database and newly drilled boreholes. 657 boreholes were historic water levels from the NGDB, while remainder were verified in the field from the Makhado and current hydrocensus surveys.

Water levels utilised for calibration were taken at various moments in time, especially from older boreholes in the NGDB, hence, depending on the date when borehole monitoring was undertaken, variations in water levels may exist. Some of the water levels were historic and considered un-impacted by recent abstraction, hence in the vicinity of these water levels, abstraction was excluded.

Measured water levels below ground surface had to be converted to absolute water levels in terms of metres above mean sea level (mamsl). Absolute calibration of water levels is hindered by the fact that errors exist in absolute observed water levels. These can be attributed to:

- Errors in borehole elevation obtained from Google Earth
- Errors in borehole position for historic NGDB boreholes
- Deviations in water level seasonally (± 3 m) due to the different times at which water levels were taken.
- Variations in pumping cycles and local impacts by abstraction on water levels

The results of the calibration are shown in Figures 22-24.Calibration statistics are:

Mean Residual (Head)-1.367645824981

Mean Absolute Residual (Head) 9.3788558502275

Root Mean Squared Residual (Head) 14.497181873258

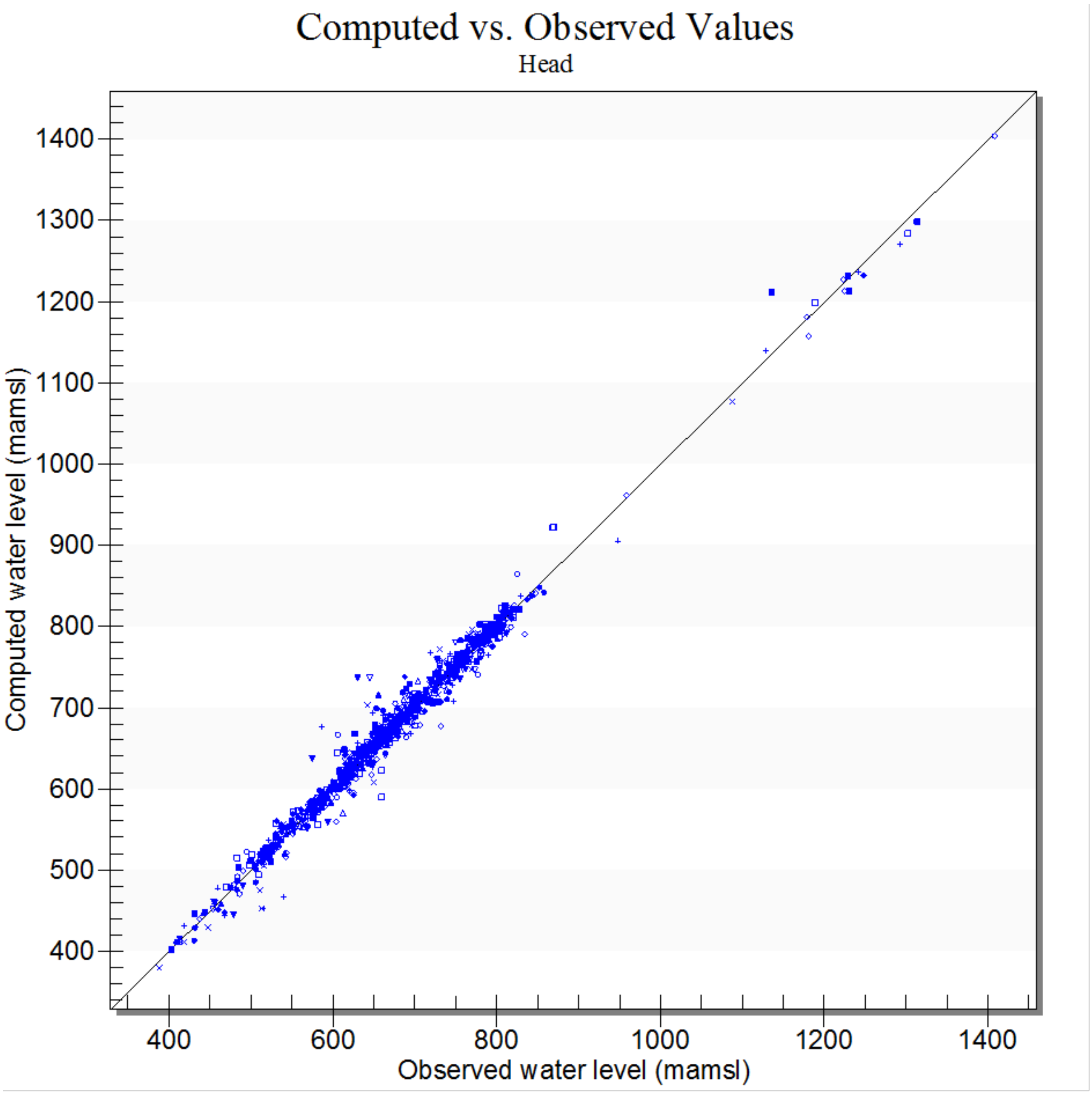

FIGURE 22: OBSERVED VERSUS SIMULATED WATER LEVELS IN METRES

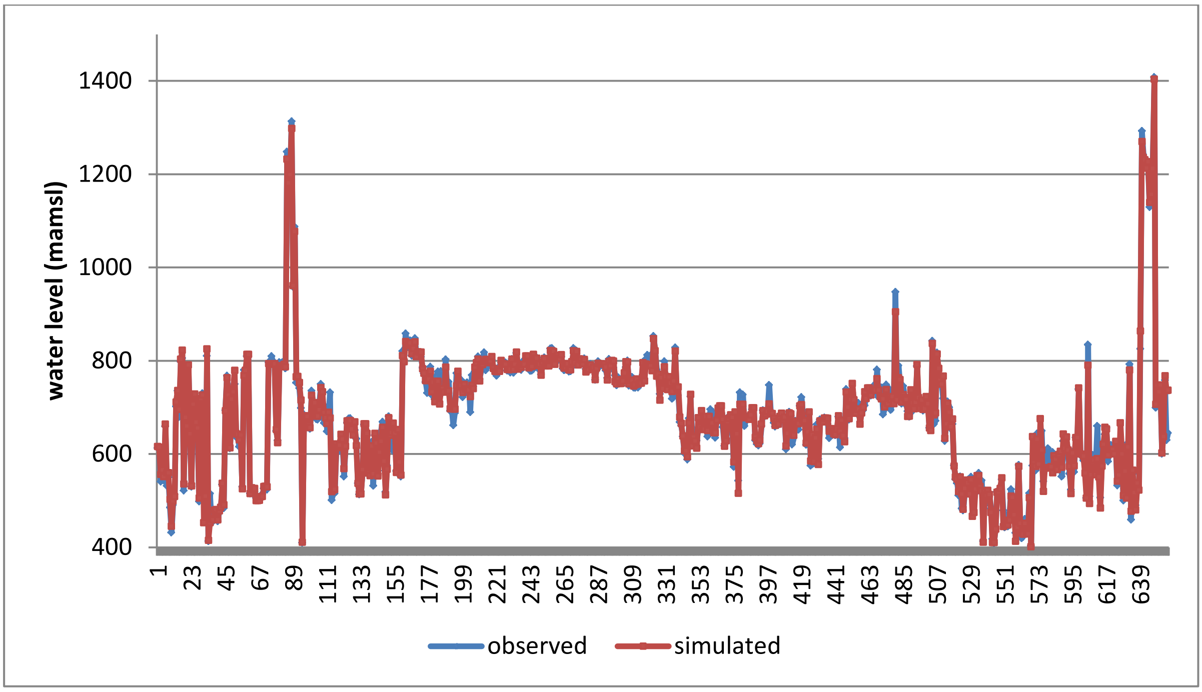

FIGURE 23: CALIBRATION AGAINST NGDB BOREHOLES IN THE CATCHMENT

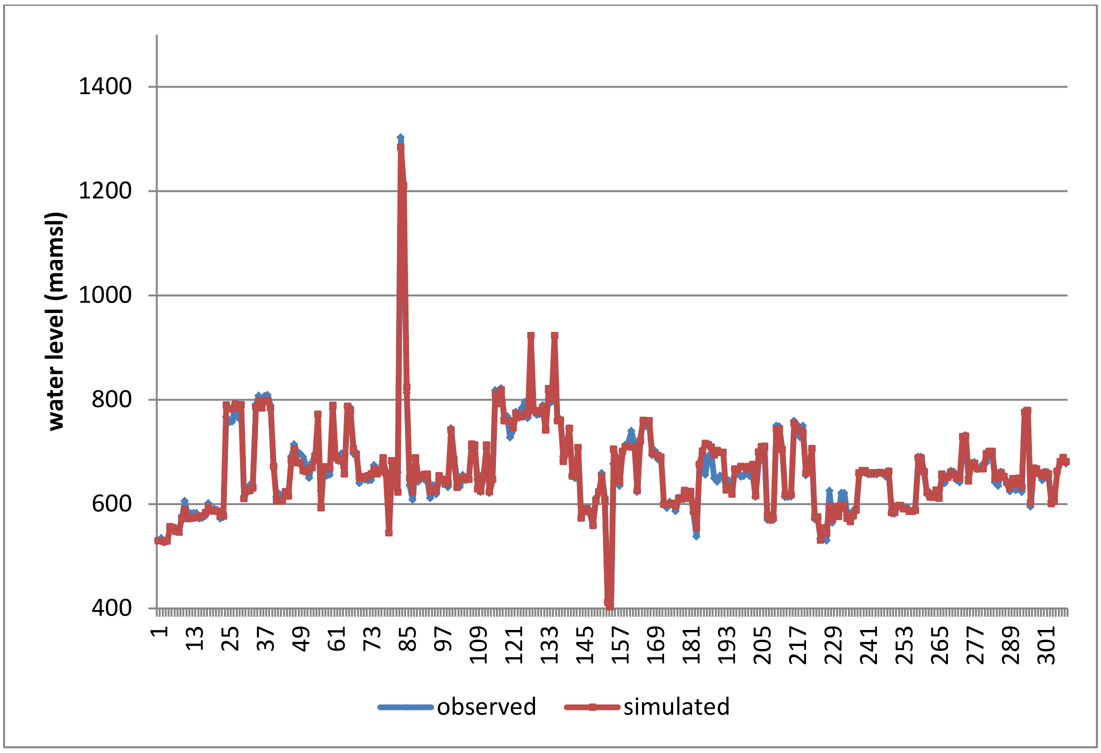

FIGURE 24: CALIBRATION AGAINST HYDRO-CENSUS IN THE VICINITY OF THE GENERAAL MINE

The residual error plot (figure 25) shows no systematic error in heads, with some over and some under simulated. High lying boreholes with water level elevations above 1200 metres above mean sea level show a slight positive residual head, suggesting water levels can be up to 20 m too low.

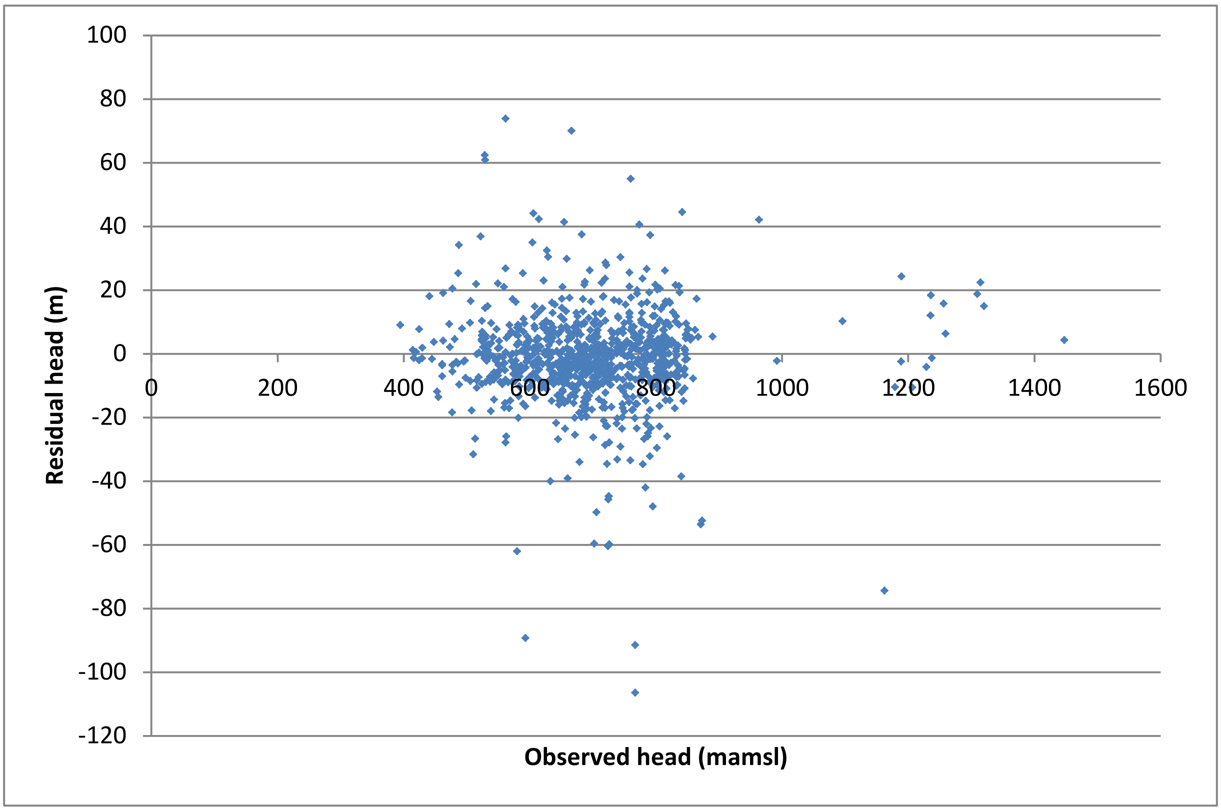

FIGURE 25: RESIDUAL ERROR OF SIMULATED VERSUS OBSERVED VALUES

A plot of residual head versus water levels in metres below ground level (mbgl) shows that boreholes with water levels below 60 mbgl have water levels over simulated (figure 26). These include many historic water levels from the NGDB impacted by abstraction which was not considered in the survey of present abstraction.

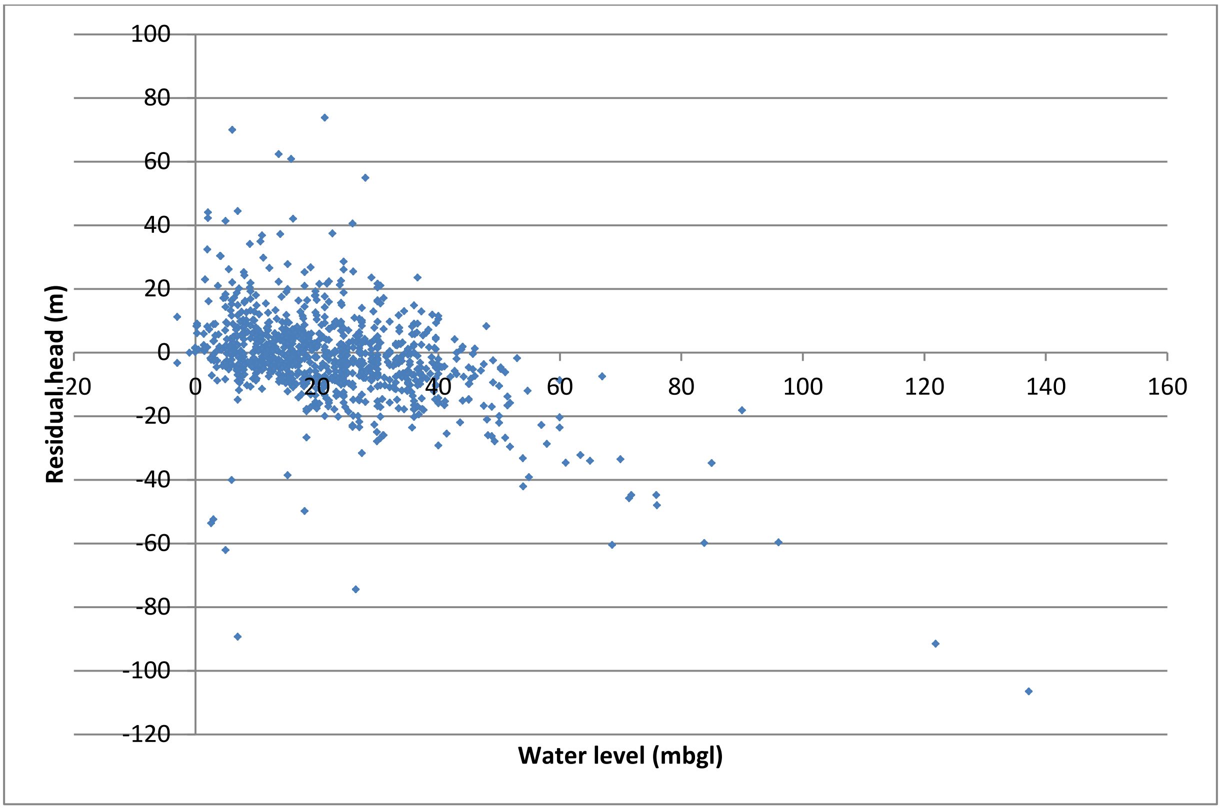

FIGURE 26: RESIDUAL HEAD VERSUS WATER LEVELS BELOW GROUND SURFACE

Model calibration was also undertaken via water balance per Quaternary catchment, to ensure recharge and discharge figures approximate the water balance published in other sources.

7. MODEL RESULTS

Modelling results are expressed as water level drawdowns from a pre-existing condition, or as a water balance, which is a calculation whereby the inflows and outflows of a groundwater system are determined. This is done by considering all the external and internal groundwater gains and losses in the aquifer such as:

Inflow: - groundwater flow into a specific area as a result of difference in gradients, groundwater recharge as a result of rainfall infiltration and losses from rivers.

Outflow: - groundwater leaving the system through the defined flow boundaries of the model due to the hydraulic gradient, borehole abstractions, baseflow to rivers and springs, and evapotranspiration.

7.1 WATER BALANCE

7.1.1 STEADY STATE - PRE MINING CONDITIONS

The water balance of the entire aquifer under natural conditions and present is shown in Table 16. Inflows from rivers occur from the perennial tributary flowing northward to the Mutamba from the Soutpansberg. This tributary loses water to the aquifer due to pumping on Windhoek, Eckland and Overwinning, and flow disappears before it reaches the Mutamba. Inflows also occur along the Tshipise fault and other faults entering the study area from the west and south. Outflows from the aquifer to rivers occur in the south, where the tributary of the Mutamba is perennial and fed by baseflow. Outflow from the study area occurs eastward along the Tshipise fault, and other faults, and to the Nzhelele dam. Evapotranspiration losses occur in alluvium along the Mutamba. Outflow also occurs to numerous springs and water courses as spring flow.

TABLE 16: STEADY STATE WATER BALANCE PRIOR TO MINING

Flow Component	Inflow (m^3/d)	Outflow (m^3/d)
Virgin Conditions		
Faults	768	701
Rivers	2700	11501
Nzhelele dam	186	1681
Evapotranspiration		49485
Springs and ephemeral channels		26438
Recharge	86155	0
Abstraction	0	0
Total	89809	89810
Current Conditions		
Faults	3105	170
Rivers	3517	8725
Nzhelele dam	187	1567
Evapotranspiration		47820

Springs and ephemeral channels		20542
Recharge	86155	0
Abstraction	0	14510
Total	92964	93335

7.1.2 TRANSIENT STATE – MINING CONDITIONS

The water balance of the aquifer during mining is altered due to inflows into the pits, which impact on water levels, and consequently on the aquifer water balance. The simulated water balance of the aquifer is shown in Table 17 for the following years:

Year 4: prior to the start of Wildebeesthoek, with Makhado 4 years in operation

Year 16: final year of Makhado in operation, Voorburg, Mount Stuart and Wildebeesthoek in operation

Year 17: Closure of Makhado

Year 30: Voorburg, Jutland, Wildebeesthoek, Mount Stuart, Chapudi and Chapudi west, Generaal in operation

Year 38: Voorburg, Jutland, Generaal, Chapudi and Chapudi west in operation

Year 49: Chapudi, Chapudi west and Generaal in operation

Year 61 Last year of Chapudi, Chapudi west in operation

TABLE 17: SIMULATED WATER BALANCE OF THE AQUIFER AT VARIOUS STAGES OF THE MINE

Flow Component	Inflow (m^3/d)	Outflow (m^3/d)
Year 4		
Storage	1465	594
Faults	3454	199
Rivers	3513	8670
Nzhelele dam	189	1548
Evapotranspiration	0	47719
Springs and ephemeral channels	0	20440
Recharge	86155	0
Abstraction	0	14862
Mount Stuart	0	0
Makhado	0	745
Total	94777	94776

Year 16		
Storage	8496	279
Faults	3469	198
Rivers	3556	8437
Nzhelele dam	346	1214
Evapotranspiration	0	47216
Springs and ephemeral channels	0	18733
Recharge	86155	0
Abstraction	0	14343
Mount Stuart	0	3283
Other Mines	0	8362
Total	102022	102064
Year 17		
Storage	7210	11683
Faults	3470	197
Rivers	3562	8408
Nzhelele dam	357	1212
Evapotranspiration	0	47190
Springs and ephemeral channels	0	18615
Recharge	92710	0
Abstraction	0	14467
Mount Stuart	0	3667
Generaal	0	0
Other Mines		1983
Total	107309	107422
Year 30		
Storage	9757	3672
Faults	3558	186
Rivers	3581	8323
Nzhelele dam	385	1205
Evapotranspiration	0	46729
Springs and ephemeral channels	1	19710
Recharge	87200	0

Abstraction	0	14350
Mount Stuart	0	3248
Generaal	0	1245
Other Mines		7930
Total	104483	104598
Year 38		
Storage	7660	5850
Faults	3755	170
Rivers	3614	8198
Nzhelele dam	358	1207
Evapotranspiration	0	46590
Springs and ephemeral channels	0	17698
Recharge	87200	0
Abstraction	0	14120
Mount Stuart	0	0
Generaal	0	1551
Other Mines		7241
Total	102589	102624
Year 49		
Storage	6558	6901
Faults	4134	157
Rivers	3659	8039
Nzhelele dam	332	1213
Evapotranspiration	0	46432
Springs and ephemeral channels	0	16127
Recharge	89405	0
Abstraction	0	16354
Mount Stuart	0	0
Generaal	0	1510

Other Mines		6276
Total	104089	104010
Year 61		
Storage	3324	9914
Faults	4083	157
Rivers	3688	7975
Nzhelele dam	311	1219
Evapotranspiration	0	46157
Springs and ephemeral channels	0	19190
Recharge	91725	0
Abstraction	0	14258
Mount Stuart	0	0
Generaal	0	0
Other Mines		4833

7.2 IMPACT OF MINING

The impacts of mining on the water balance are shown in Figure 27.

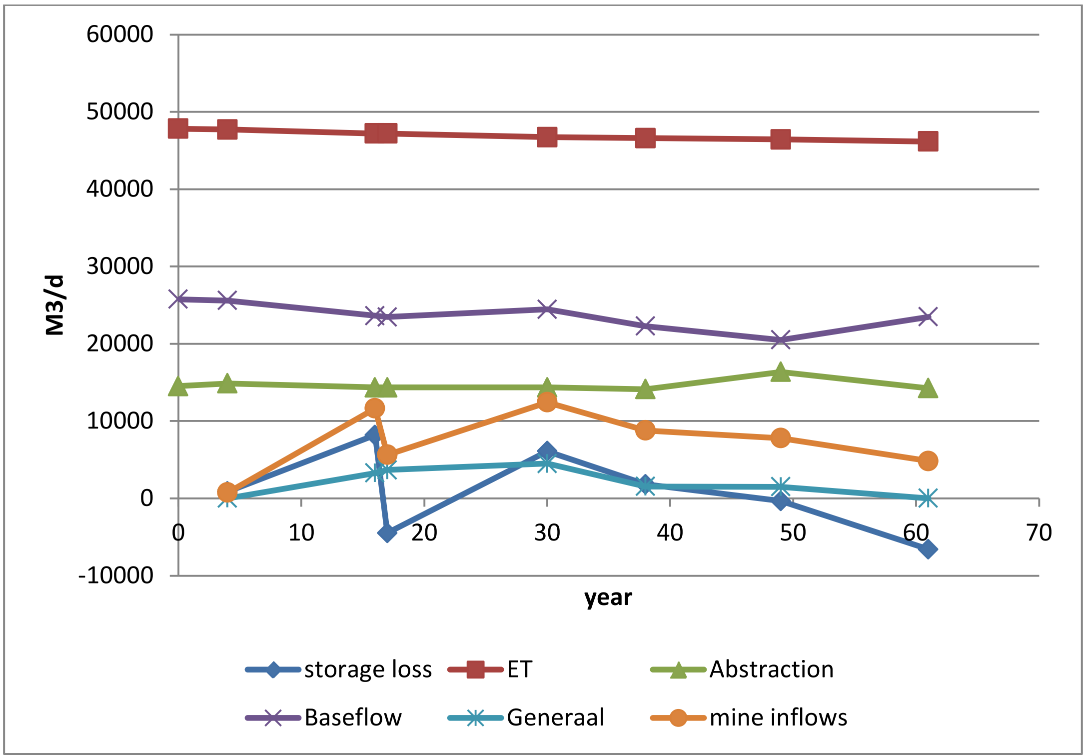

FIGURE 27: MINE ABSTRACTION AND IMPACT ON GROUNDWATER

Evapotranspiration from riverine areas is impacted and decreases from 47.8 Ml/d to 46.4 Ml/d. This reduction occurs largely along the river channels, where drawdown of the water level reduces the availability of shallow groundwater.

Abstraction of groundwater for existing users is reduced from 14.5 Ml/d to a minimum of 14.1.

The bulk of inflows into the pits and to boreholes originate from storage losses from the aquifer, which rises to 8.1 Ml/day by the end of the life of mine of Makhado. They subsequently decline due to the refilling of Makhado and the closure of Mount Stuart underground mine and Wildebeesthoek. Inflows into mines peak at 12.4 Ml/d when all mines except Makhado are in operation, then decline to 8.7 Ml/d by the end of the life of Mopane. During the peak inflows, 4.4 Ml/d are inflows into the Generaal mines. Inflows into Generaal decline to 1.5 Ml/d after the closure of Mount Stuart..

Mine inflows exclude direct rainfall into mine workings, and surface runoff which is not diverted. This is because such inflows are not part of the average daily inflow, and occur only during storm events, which are highly variable. Post mining, recharge to the pits is included in the water balance, since this volume will not be removed as storm water and will replenish the pits.

7.3 INFLOWS INTO MOUNT STUART AND GENERAAL

Inflows into Mount Stuart section increase to 4.7 Ml/d in mining year 21, 16 years after the mine starts, which were simulated assuming a progressive deepening of the mine floor. Subsequently, due to significant dewatering, inflows decline.

Inflows into Generaal section remain low since it is in the dewatered zone created by Makhado. Inflows increase to 1.7 Ml/d by year 37, just before the end of the life of mine, see figure 28.

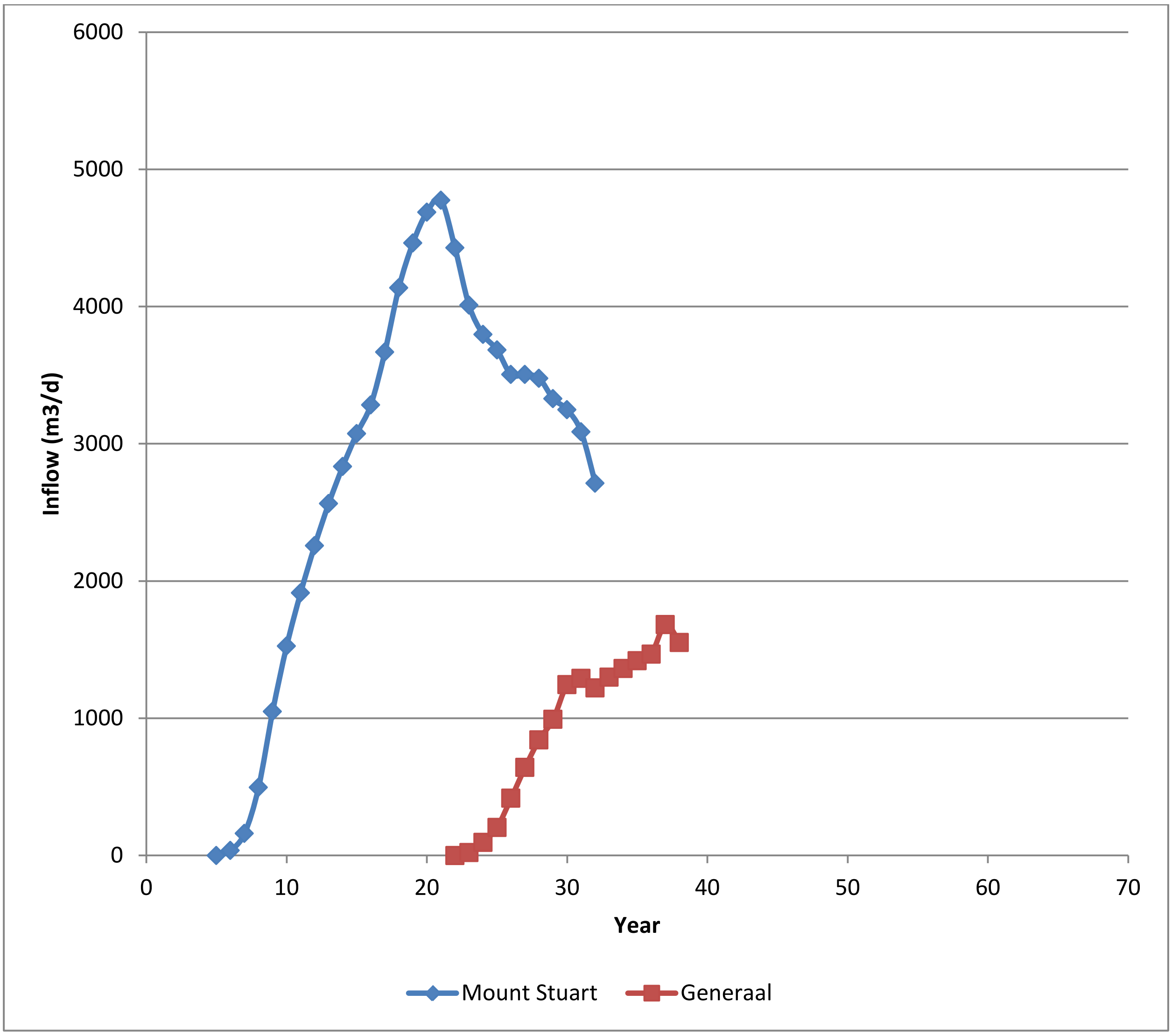

FIGURE 28: INFLOWS INTO MOUNT STUART AND GENERAAL

7.4 DRAWDOWN

Drawdown is the measure of water level decline taken from a bases point, in this case prior to commencement of mining i.e. year 2013. Drawdown of the water level after mining commences is shown for various periods of time in Figures 29-32.

Significant drawdown in water level occurs around the Mount Stuart section by year 16, 12 years after the start of mine, due to the depth of underground operations. Due to the drawdown in water levels the flow at the Tshipise Hot Water Spring some 5kms north of the mine is expected to be affected and could dry up.

By mining year 38, 8 years after the life of mine of the Mount Stuart section, water levels will have recovered to within 30-40 m of the static water level around the Mount Stuart section but drawdowns of over 100 m will exist around the Generaal section. Significant drawdown occurs for a radius of up to 25 km, and the impacts from Makhado, Chapudi, Generaal and Mount Stuart, and Mopane are cumulative and overlap. Drawdown at Generaal section remains at over 100m over the life of mining operations to year 61.

Additional to the villages affected by Makhado mine i.e. Mudimeli, Mukushu and Pfumembe, the water supply to the villages of Doli Doli, Ndouvhada, Gaarside and Smokey could be affected as they are within the drawdown cone. See figures 29 -32.

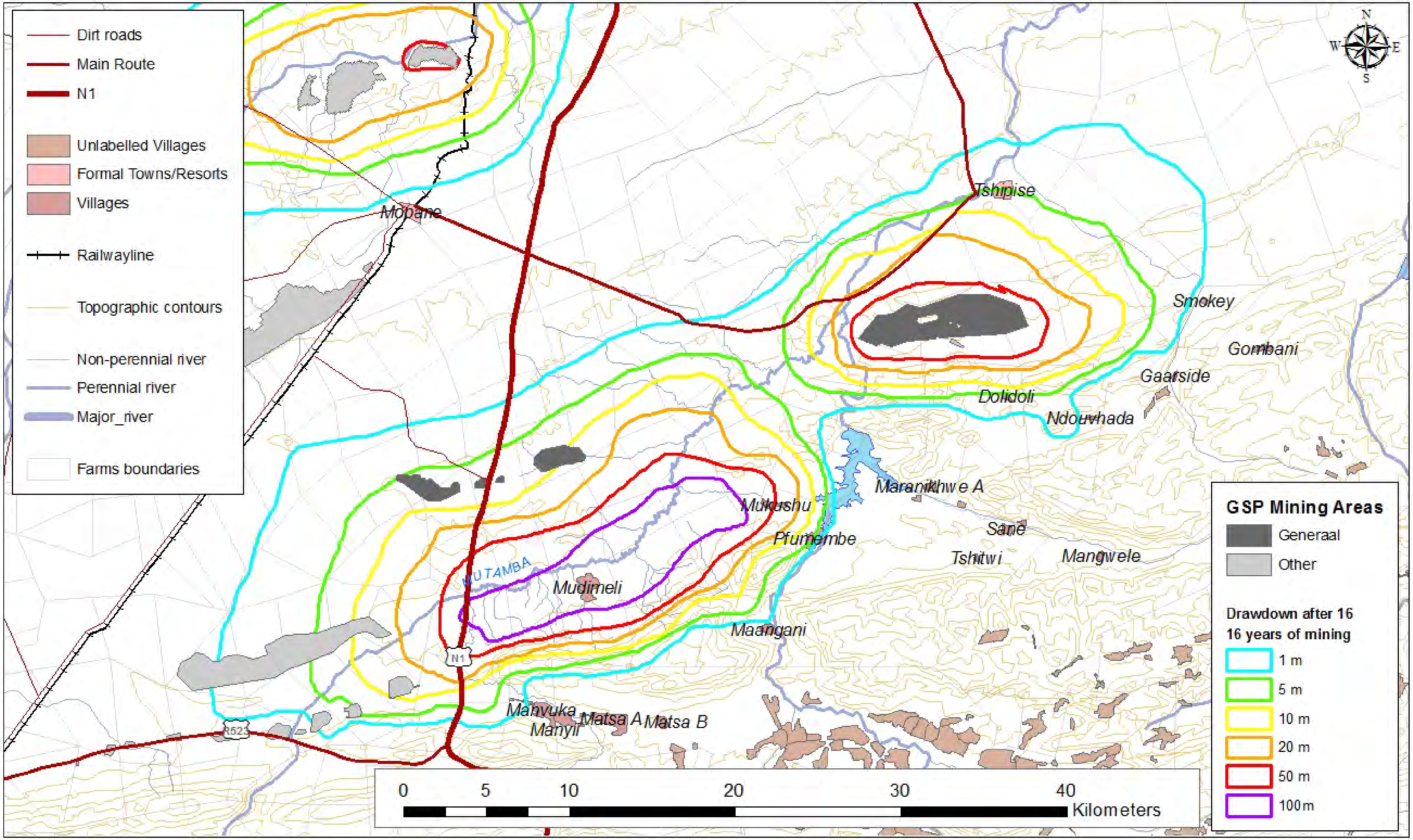

FIGURE 29: DRAWDOWN IN MINING YEAR 16

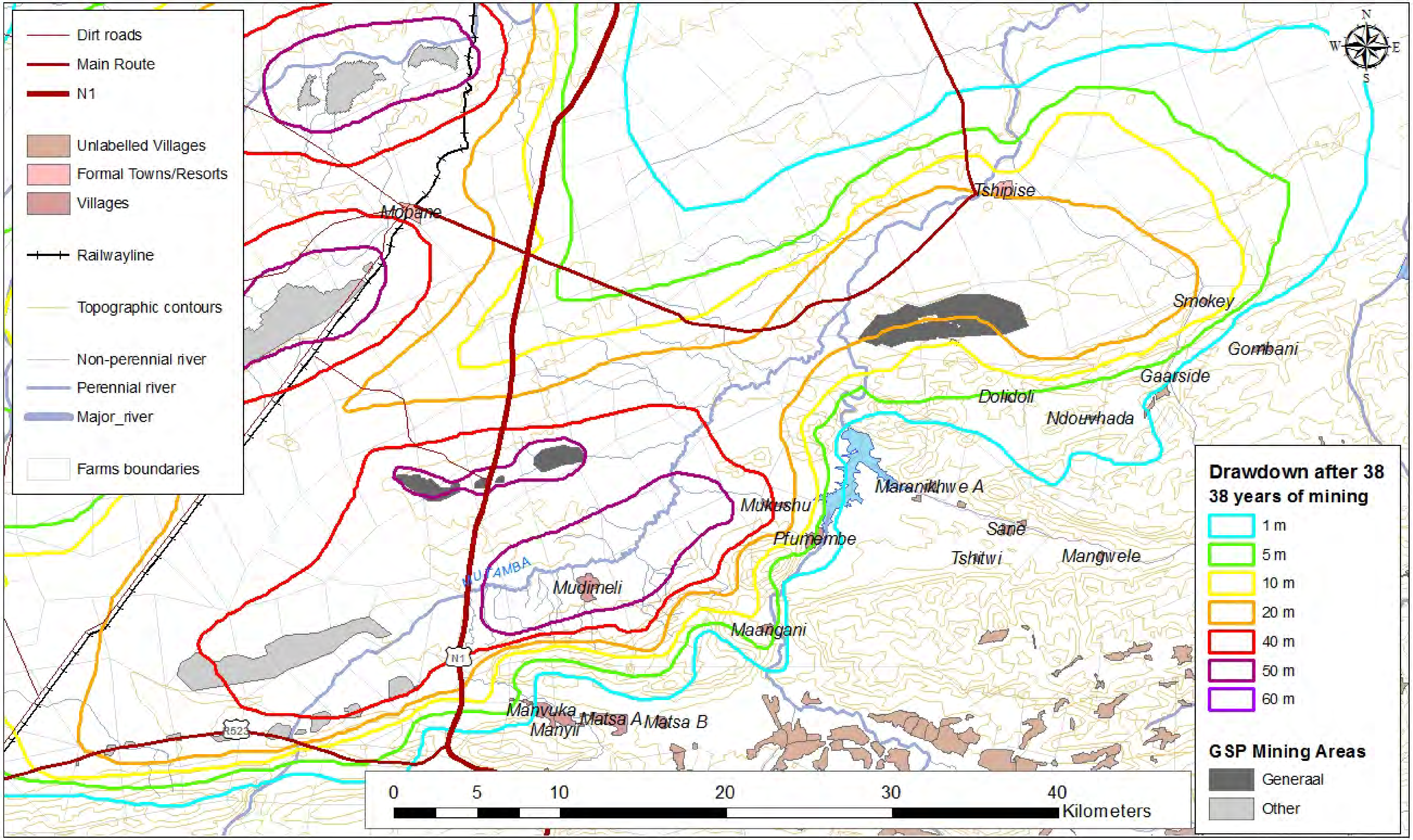

FIGURE 30: DRAWDOWN IN MINING YEAR 38

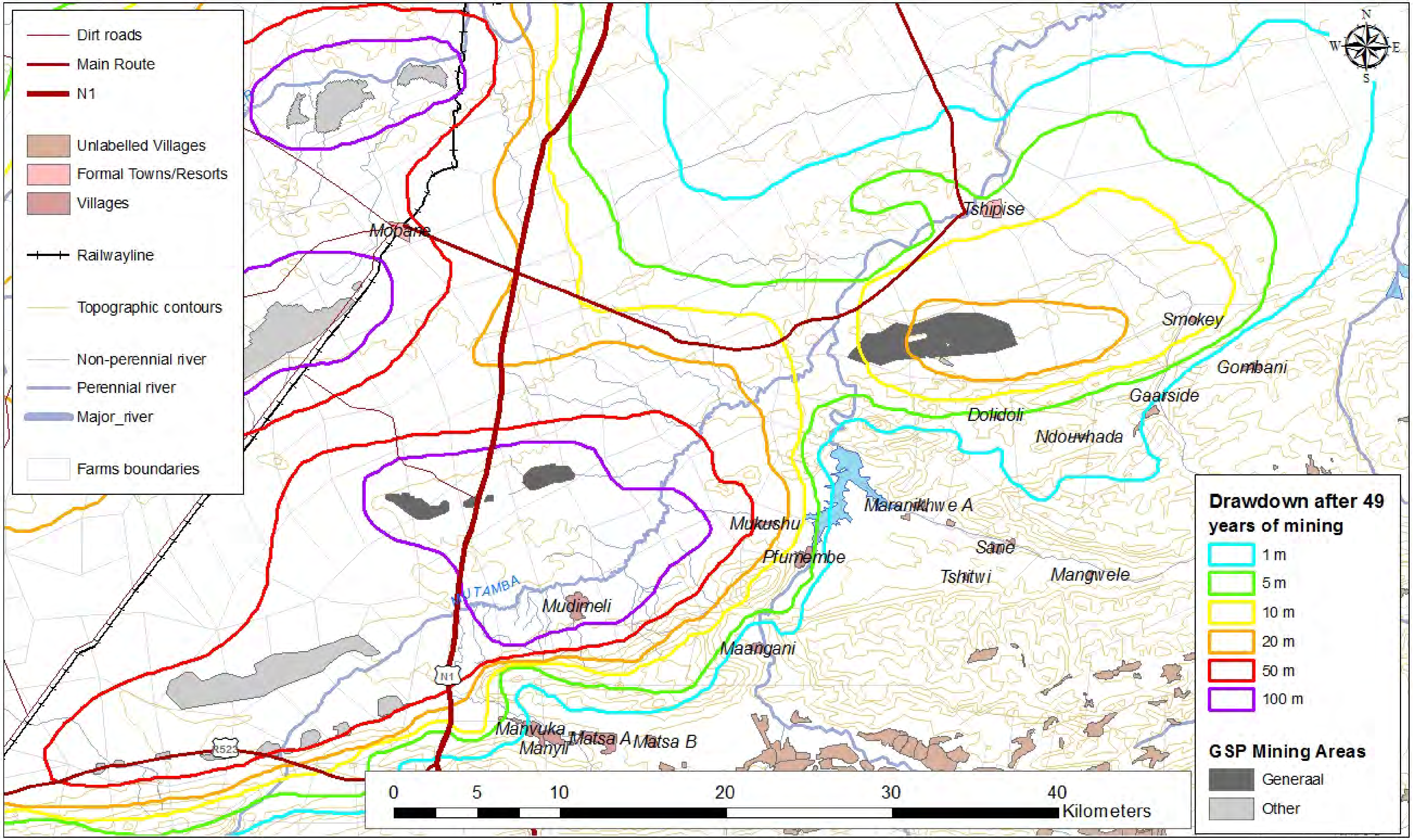

FIGURE 31: DRAWDOWN IN MINING YEAR 49

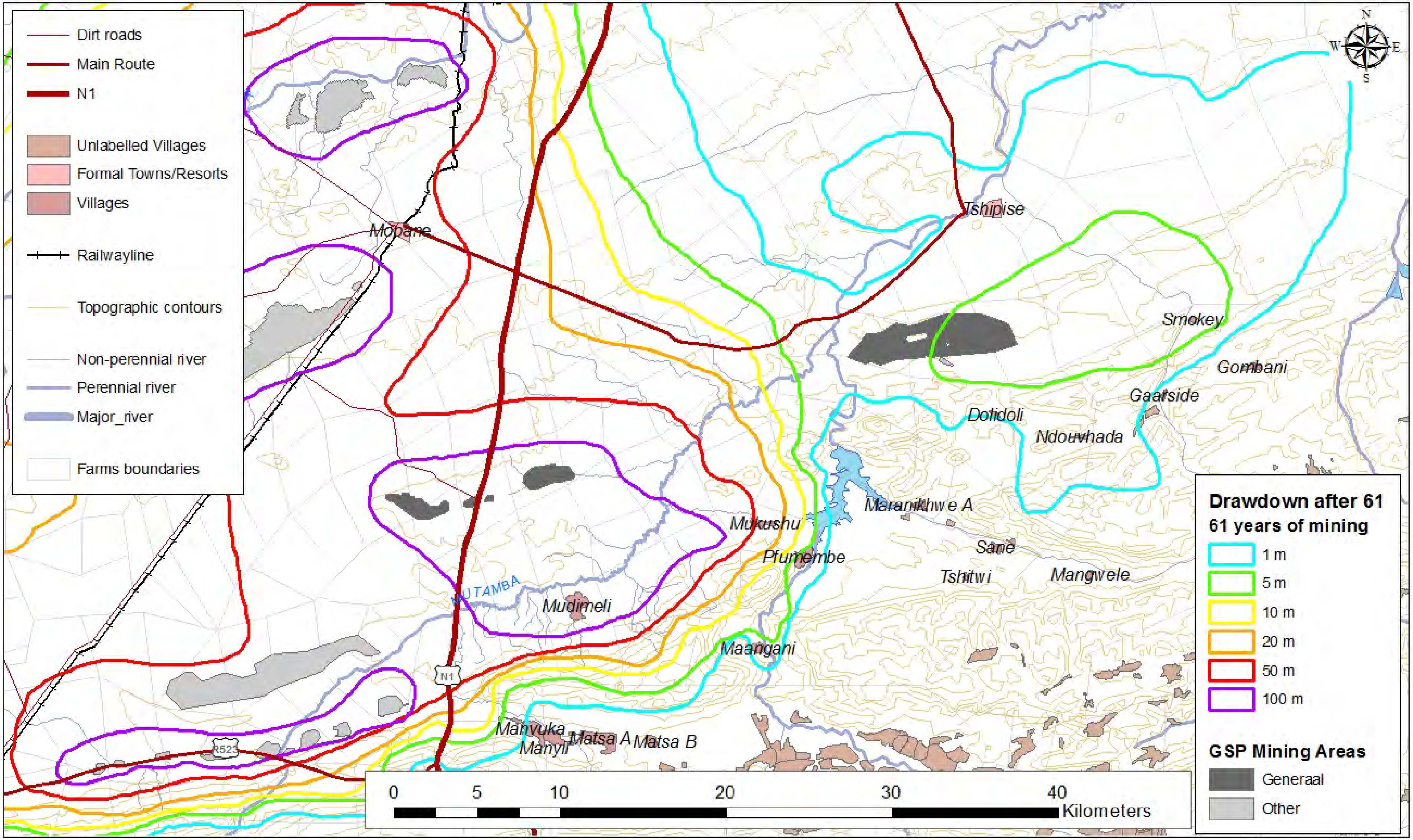

FIGURE 32: DRAWDOWN IN MINING YEAR 61

8. SHORTCOMINGS AND LIMITATIONS

Although, all available data was collected and utilised to develop the groundwater model, and ensure that the model presents the actual situation as accurately as possible, some limitations can be noted:

- Limited and inaccurate data on actual groundwater usage, hence abstraction estimates are based on hectares observed under irrigation. Registered and claimed water uses do not correlate with observed water use based on lands under irrigation. Since recharge to the area is low, abstraction estimates have a significant impact on water levels.
- Current water levels were only obtained from a local hydrocensus. Due to the cumulative impacts of several mining projects, current water levels need to be obtained over a broad area covering the entire impacted area.
- Data collected in a relatively wet period.
- The Mount Stuart underground section only modelled down to 400m depth due to the limitation in the model set up.
- Aquifer storage data based solely on best estimate and inflows into the bulk sample pit undertaken at Makhado. Similar data is required at Generaal to calibrate projected inflows. This is especially important for the deep mining operations at Mount Stuart as the storage parameters at depth will control the total volumes of inflow and rate of dewatering.

9. FURTHER RECOMMENDED WORK

To further improve the conceptual model and validate the conclusions made in this report, several items require additional work:

- Monitoring: Establishment of monitoring piezometers near where initial mine workings will commence. Transient state parameters of mining are at present best estimates based on data collected during the box cut exploration at Makhado. Predictions cannot be calibrated without data collected after mining commences. Water level changes once open bit mining begins should be used to further refine storage parameters in the groundwater model and drain conductance's used for the mine workings. These estimates will affect projections of inflows at other mines and the cumulative impacts of all mining operations in the region.

- Verification of inflows and water levels by monitoring is required to validate model after mining commences.
- Verification of abstractions especially from irrigation farmers.
- Verification of water source for the Tshipise Hot Water Spring to confirm the impact as a result of mining.
- Derivation of local more detailed multilayer models at a monthly time scale for each mine once a more detailed mining plan becomes available.
- Model Sensitivity analysis: Once the model is complete with all the required information, supported by monitoring data, a sensitivity analysis needs to be undertaken to determine how sensitive the model results are to parameters with some uncertainty. This involves simulations with parameter values increased and reduced to determine how it affects the calibration results, and the confidence in the selected parameter values.
- Model Verification: Model verification means comparing model results against an independent data set from that which the model was calibrated against. Monitoring data can be used, as well as the extended model data, and additional data to be obtained from farmers private records not previously submitted to the consulting team.

10. GROUNDWATER IMPACT ASSESSMENT FOR THE GENERAAL PROJECT

Mining at Generaal will involve open cast mining along extended open cuts down to 200m below surface at the Generaal section and underground mining up to 900m (only modelled down to 400m) below surface at the Mount Stuart section.

Groundwater flow will be intersected by the pits and underground workings when below the water table. The water flowing into the pits will need to be pumped out (dewatered) for safe mining operations to continue. The water pumped from the pits will be used on the mine for process water in the plant and dust suppression. The dewatering will result in a lowering of the water table (cone of depression) around the mine pits and underground section, extending for up to 25 kilometres north-eastwards of Generaal Project at the life of mine. This is because water is taken mostly from aquifer storage, as recharge in the area is low and unable to sustain the dewatering. The east-west striking faults such as the Tshipise and Klein Tshipise faults are far more transmissive resulting that the cone of depression is elongated along their axis. Due to the radius of influence of the dewatering cone the Tshipise Hot Water Spring which is some 5kms north of the Mount Stuart underground section is expected to be affected and could stop flowing. Further boreholes yields at the villages of Doli Doli, Ndouvhada, Gaarside and Smokey could also be affected as they lie within the drawdown cone.

Impacts of mining could be significant. These, in order of significance, include:

- Reductions in water available for abstraction and discharge i.e. lower borehole yields or drying up of boreholes and springs in the area of influence.
- Contamination of aquifers downstream of the mining and infrastructure areas due to seepage from the rehabilitated pits and underground workings, discard dumps, stock piles and dirty water dams.
- A reduction in water available for evapotranspiration. Groundwater dependant floral species around springs and seeps could be affected as the water table drops. Riverine vegetation is mostly sustained from surface flows and water stored in the alluvial deposits, however shallow groundwater may be important during extended dry periods.

The classification of all environmental impacts identified is assessed in terms of: -

- their duration,
- their extent,
- their probability,
- their severity.

The above will be used to determine the significance of impact without any mitigation, as well as with mitigation (table 18).

TABLE 18: ENVIRONMENTAL RISK AND IMPACT ASSESSMENT CRITERIA

DURATION		
Short term	6 months	1
Construction	36 months	2
Life of project	16 years	3

Post rehabilitation	Time for re-establishment of natural systems	4
Residual	Beyond the project life	5
EXTENT		
Site specific	Site of the proposed development	1
Local	Farm and surrounding farms	2
District	Makhado Municipal district	3
Regional	Vhembe region	4
Provincial	Limpopo Province	5
National	Republic of South Africa	6
International	Beyond RSA borders	7

PROBABILITY		
Almost Certain	100% probability of occurrence – is expected to occur	5
Likely	99% - 60% probability of occurrence – will probably occur in most circumstances	4
Possible	59% - 16% chance of occurrence – might occur at some time	3
Unlikely	15% - 6% probability of occurrence – could occur at some time	2
Rare	<5% probability of occurrence – may occur in exceptional circumstances	1
SEVERITY		
Catastrophic (critical)	Total change in area of direct impact, relocation not an option, death, toxic release off-site with detrimental effects, huge financial loss	5
Major (High)	> 50% change in area of direct impact, relocation required and possible, extensive injuries, long term loss in capabilities, off-site release with no detrimental effects, major financial implications	4
Moderate (medium)	20 – 49% change, medium term loss in capabilities, rehabilitation / restoration / treatment required, on-site release with outside assistance, high financial impact	3
Minor	10 – 19% change, short term impact that can be absorbed, on-site release, immediate contained, medium financial implications	2

Insignificant (low)	< 10 % change in the area of impact, low financial implications, localised impact, a small percentage of population	1

TABLE 19: RISK ESTIMATION (NEL 2002)

RISK ESTIMATION (Nel 2002)					
	SEVERITY				
PROBABILITY	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
Almost certain (5)	H	H	E	E	E
Likely (4)	M	H	H	E	E
Possible (3)	L	M	H	E	E
Unlikely (2)	L	L	M	H	E
Rare (1)	L	L	M	H	H

E	Extreme risk – immediate action required, detail considerations required in planning by specialists – alternatives to be considered	4
H	High risk – specific management plans required by specialists in planning process to determine if risk can be reduced by design and management and auditing plans in planning process, taking into consideration capacity, capabilities and desirability – if cannot, alternatives to be considered, senior management responsibility	3
M	Moderate risk – management and monitoring plans required with responsibilities outlined for implementation, middle management responsibility	2
L	Low risk – management as part of routine requirements	1

IMPACT SIGNIFICANCE	
Negligible	The impact is non-existent or insubstantial, is of no or little importance to any stakeholder and can be ignored.
Low	The impact is limited in extent, even if the intensity is major; whatever its probability of occurrence, the impact will not have a significant impact considered in relation to the bigger picture; no major material effect on

	decisions and is unlikely to require management intervention bearing significant costs.
Moderate	The impact is significant to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision, and management intervention will be required.
High	The impact could render development options controversial or the entire project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in project decision-making.
Very high	Usually applies to potential benefits arising from projects.

Risk is a combination of the probability, or frequency of occurrence of a hazard and the magnitude of the consequence of the occurrence (Nel 2002). Risk estimation (RE) is concerned with the outcome, or consequences of an intention, taking account of the probability of occurrence and can be expressed as P (probability) x S (severity) = RE. Risk evaluation is concerned with determining significance of the estimated risks and also includes the element of risk perception. Risk assessment combines risk estimation and risk evaluation (Nel 2002).

Potential impacts were identified and assessed by considering the criteria as outlined in table 18. The significance of each impact was determined “without mitigation” and “with mitigation”, taking into consideration alternatives, preventative and mitigation measures.

The groundwater risk and impact assessment is provided in Table 20.

TABLE 20: IMPACTS ON GROUNDWATER

Impact	Extent	Duration	Severity	Probability	Risk estimation	Without mitigation	Mitigation
Reductions in water available for abstraction and discharge	4	5	4	5	4	**Extreme** - Drawdown from mining extends to surrounding farms (up to	Provision of alternative water supply. Implement ASR to limit drawdown

Impact	Extent	Duration	Severity	Probability	Risk estimation	Without mitigation	Mitigation
						25kms). The Hot Water spring at Tshipise could be affected or dry up and boreholes yields at the villages of Doli Doli, Ndouvhada, Gaarside and Smokey could be impacted.	cone
A reduction in water available for evapotranspiration.	3	5	3	3	3	**High** – vegetation around the springs and seeps is supported by groundwater and will be severely stressed.	Implement ASR to limit drawdown cone
Contamination of aquifers down gradient due to seepage from the rehabilitated pits, discard dumps, stock piles and dirty water dams.	2	5	2	3	3	**Moderate** - the Karoo aquifer is already high in sulphates and salts	Placing of carbonaceous material at the bottom of the pit. Lining of discard dumps and dirty water dams.

11. MITIGATION MEASURES PROPOSED

The following mitigation measures should be considered to address the impacts of the proposed mining:

- Revise the mining schedules of the proposed GSP mines to limit the cumulative impacts
- Enter into negotiations with surrounding land owners impacted regarding compensation or alternative water supply
- Implement Aquifer Storage and Recovery (ASR) to minimise depletion of aquifer storage thus limiting the extent of the drawdown cone.

12. MONITORING AND MANAGEMENT

Monitoring of groundwater water levels, water quality, inflows and pumping volumes is necessary to determine if the groundwater system is reacting as predicted. The monitoring programme should be audited for compliance to the stated objectives and adapted when and where required. It must be noted that the monitoring programme is a dynamic system changing over the different life cycle phases of the mine. A proper data and information management system should also be established to ensure that the monitoring is done effectively and that the information created is best utilised for the management of the mine. The following monitoring components have been identified:

- Monitoring Climate: rainfall, rainfall intensity and evaporation would be required
- Monitoring of water levels should be done up gradient and down gradient of the mining area, along geological structures. Continuous recorders can be installed on selected boreholes and monthly readings taken at other boreholes.
- Groundwater Quality to be monitored in all the aquifers surrounding the mine, and in the pits, area should be done on a quarterly basis. All macro elements should be determined.
- Inflows to the opencast and underground areas should be monitored by means of measuring the volume of water pumped out. Measurements should be done on at least a monthly basis
- Any leachate formed should be monitored for quantity and quality on at least a monthly basis. Sulphates, pH and trace metals need to be included in the quality analysis

- All abstraction including dewatering, irrigation, plant and domestic use, needs to be measured on at least a quarterly basis.

It is recommended that a monitoring committee be established and that these monitoring activities be done in conjunction with the neighbouring farmers in order to obtain a greater regional perspective and ensure transparency.

13. LEGAL CONSIDERATIONS

The approval of the mining right application is dependent on the compliance with various legislative requirements. With respect to groundwater these would include the following, (National Water Act, Act 36 of 1998, Section 21):

- 21a) taking water from a water resource
- 21d) engaging in a stream flow reduction activity (any activity that can impact on the flow or reserve of a water course);
- 21e) engaging in a controlled activity (any activity deemed by the minister to have a detrimental impact on a water resource such as irrigation with water containing waste);
- 21g) disposing of waste in a manner which may detrimentally impact on a water resource;
- 21g) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people.

11 December 2013

SIGNED FOR TEAM **DATE**

Team	Person	Qualifications	Professional Registration SACNASP
Responsible Director	C Haupt	BSc(Hons)	Geology (400031/94)
Report and modelling by	K. Sami	MSc	Geology and Hydrology (400043/01)
Assisted by	P Wilken	BSc(Hons)	Geology (400038/97)
Assisted by	E Mmbi	BSc(Hons)	In training

APPENDIX A
STATEMENT OF INDEPENDANCY
AND PROJECT TEAM CV'S

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TO WHOM IT MAY CONCERN

DECLARATION

We the undersigned hereby declare that, as professionally registered Scientists, employed by WSM Leshika Consulting (Pty) Ltd, an independent consultancy firm, that we have prepared the report entitled “Generaal Project, Groundwater Flow Impact Assessment” free from influence or prejudice.

C J Haupt BSc(Hons) Pr.Sci.Nat. (400031/1994)
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Responsible Director

K Sami MSc Pr.Sci.Nat (400043/2001)
Hydrogeologist
Associate

P Wilken BSc(Hons) Pr.Sci.Nat. (400098/1997)
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BACKGROUND

WSM Leshika has a staff compliment of over 30 professionals and 19 administrative staff members with offices that service Limpopo, Gauteng, E Cape, North West and Mpumalanga Provinces in South Africa. Our pool of professional staff enhances the potential of the Company's ability to provide top class engineering and scientific services to our valued clients. Our personnel have worked extensively throughout Africa, South Africa and internationally, providing consulting services to various government departments, non-governmental organisations, industries and mines.

SERVICES AND EXPERTISE PROVIDED

Our professional team, many of whom have more than 30 years' experience in their field provided the following technical specialist skills to the Generaal Coal Project:

TECHNICAL EXPERTISE PROVIDED

- Groundwater Specialist Services

KEY PROFESSIONAL STAFF

Carel Haupt Pr.Sci.Nat. (Director, Principal Hydrogeologist)

Carel Haupt is a registered natural scientist with more than 30 years' experience. He has a post graduate degree in Engineering Geology specialising in the evaluation of ground water potential and hydrogeological mapping. He has worked on numerous groundwater development projects, developing groundwater resources for water supply to mines, towns and villages, hydrogeological evaluations for mines and the design and development of monitoring systems for groundwater wellfields. He is the director responsible for all the Hydrogeological aspects of the Generaal Project. He is a founder member and director at WSM Leshika Consulting and has held the position of Chairman of the Ground water Division of the Geological Society of South Africa as well as an executive member of the South African Chapter of the International Association of Hydrogeologists.

Karim Sami Pr.Sci.Nat. (Principal Hydrogeologist)

Karim Sami is registered as a geological and hydrological scientist with the South African Council of Natural Scientific Professions. He has a Master's Degree in Hydrology from Trent University in Canada and has 22 years' work experience throughout Africa. He specializes in groundwater development and has published internationally on ground water exploration, ground water recharge estimation, groundwater surface water interactions, borehole and aquifer test pumping, borehole and aquifer sustainable yield evaluation, groundwater geochemistry, saturated and unsaturated zone hydraulics, rural water supply implementation and planning, hydrological modeling, environmental tracers for hydrogeology, acid rock drainage and contamination from mining activities. He is responsible for the hydrogeological modeling and impact assessment for the Generaal Project. Karim is an associate at WSM Leshika Consulting.

Pierre Wilken Pr.Sci.Nat (Principal Hydrogeologist)

Pierre graduated with an honours degree in geology at Rhodes University, Grahamstown South Africa in 1986 and has 27 years' experience. He has worked over Africa in the geological and hydrogeological fields and has specialized in ground water exploration and development, data manipulation using GIS, ground water recharge estimation, borehole and aquifer test pumping, borehole and aquifer sustainable yield evaluation, ground water geochemistry and geophysical surveys. Pierre is responsible for the data collation, geological interpretation, mapping and water quality evaluation for the Generaal Project. He is an associate at WSM Leshika Consulting.

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