GREATER SOUTPANSBERG
CHAPUDI PROJECT

SURFACE WATER ASSESSMENT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT

NOVEMBER 2013

WSM LESHIKA CONSULTING (PTY) LTD

SABI

CESA

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TO WHOM IT MAY CONCERN

DECLARATION

We the undersigned hereby declare that as employees of WSM Leshika Consulting (Pty) Ltd which is an independent consultancy firm, we have prepared the following report

Greater Soutpansberg Chapudi Project
Surface Water Assessment for the Environmental Impact Assessment
November 2013

according to requirements of applicable Acts, *inter alia* the National Water Act, Act 36 of 1998 and concomitant Regulations, free from external influence.

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GREATER SOUTPANSBERG
CHAPUDI PROJECT

SURFACE WATER ASSESSMENT
TABLE OF CONTENTS

ITEM **PAGE NO.**

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

A	Area
APP	Approved Professional Person for designing and inspecting Category II and III dams in terms of Chapter 12 of the NWA
CSIR	Council of Scientific and Industrial Research
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (pre 2009)
ECSA	Engineering Council of South Africa
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity Rating
EMP	Environmental Management Plan
IFC	International Finance Corporation
GIS	Geographical Information System
GN704	Government Notice 704 of June 1999
HecRas	Hydraulic Engineering Centre's River Analysis System
LOM	Life of Mine
mamsl	metre above mean sea level
M2	1:2-year 24 hour rainfall event
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MIA	Mining infrastructure area
MPRDA	Mineral and Petroleum Resources Development Act (Act 28 of 2002)
MRA	Mining right application
Mtpa	Million ton per annum
NEMA	National Environmental Management Act (Act 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act (Act 36 of 1998)
PCD	Pollution Control Dam
PDF	Probability distribution function
PES	Present Ecological State
PIA	Plant Infrastructure Area
PrEng	Professional Engineer
RHP	River Health Program
RLT	Railway Load-out Terminal
RMF	Regional Maximum Flood
ROM	Run of Mine
SANBI	South African National Biodiversity Institute
SANRAL	South African National Roads Agency
SATS	South African Transport Services

SDF	Standard Design Flood
WR90	Surface Water Resources 1990 study
WR2005	Water Resources 2005 study
WQT	Water Quality Threshold

1. INTRODUCTION

1.1 Background

WSM Leshika Consulting (Pty) Ltd was appointed by Coal of Africa Limited to undertake the surface water assessment as part of the Environmental Impact Assessment for the Greater Soutpansberg Chapudi Project.

The Chapudi Project is situated in the magisterial district of Vhembe, in the Limpopo Province, approximately 22 km (direct) and 38 km (via road) north-west of the town Makhado and some 21 km east of Waterpoort railway station in the Makhado Local Municipal area– refer to **Figure 1.1.**

The Chapudi Project, consisting of the Central, Western and Wildebeesthoek Sections, is well situated with respect to major infrastructure, including rail, road and power. The Chapudi Central and Wildebeesthoek Sections link to the N1 road via the regional road R523 some 10 km in length travelling eastwards. The Western Section is located further west of the previous sections and is also linked by the R523 road some 24 km travelling westwards. Private roads to connect mine infrastructure will need to be established.

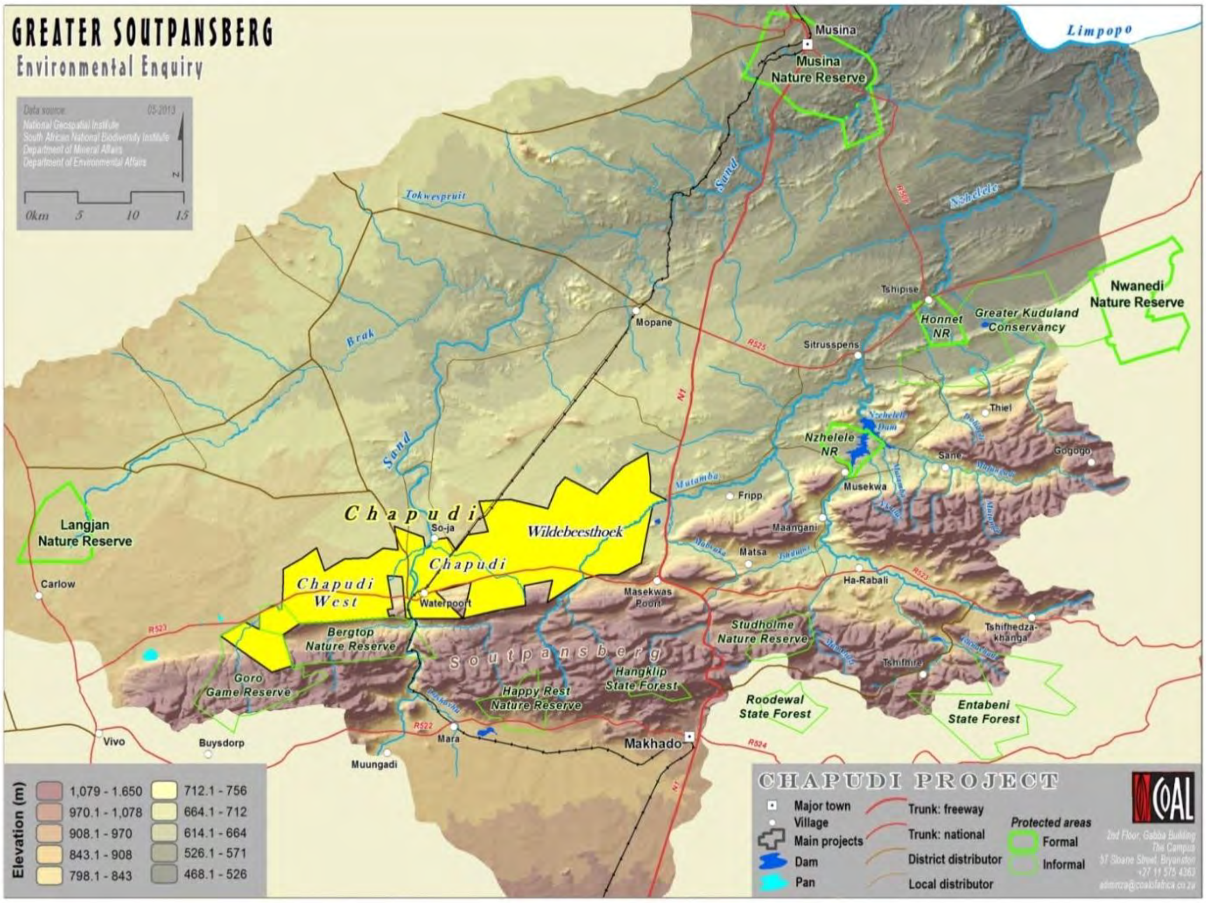

FIGURE 1.1: LOCALITY MAP

1.2 Scope of work

This report describes the results of the study done of surface water and related aspects as part of the Environmental Impact Assessment phase.

In the first step, climate data for the hot, semi-arid region has been collected asdescribed in Section 3.1 in the report. A hydrological analysis of major stream crossings that may be impacted by the proposed infrastructure, as well as of the three major rivers, the Sand, Sandsloot and Mutamba Rivers, has been done (Section 4). The flood peaks thus determined were used to simulate the riverflow whereby the flood zones for various recurrence intervals were obtained. The model created in HecRas utilised the site survey to 0.5 m contour intervals. The contour map was provided by Patrick Matdibe and Associates.

River water samples were obtained and tested. The results were evaluated in respect of aquatic, drinking water, irrigation and livestock water quality standards.The impact of the development on the quantity of surface water resources was determined, based on regional data described in the Water Resources 2005 study (*Middleton and Bailey 2009*). A conceptual layout of a stormwater management systems which would adhere to the requirements of Government Notice 704 (GN704) and follow the principles set out in the Best Practice Guidelines of the Department of Water Affairs (DWA), are indicated. The report concludes with an assessment of potential impacts, an identification of risks and description of proposed mitigation measures.

1.3 Project team

The team consisted of Anna M Jansen van VuurenPrEng, hydrology and hydraulics expert, assisted by Rian Coetzee, a technician experienced in surface water analyses. Their qualifications and relevant experience are summarised below. Junior staff was employed in draughting and routine analyses.

- AM Jansen Van Vuuren. Civil Professional Engineer (ECSA Reg No 770359)

Years of experience:	36
Academic qualifications:	M Eng (Hydraulics), University of Pretoria, 1983
	B Eng (Hons)(Civils) University of Pretoria, 1977
	B Eng (Civils) University of Pretoria, 1972
Professional societies:	Fellow of SAInstitute of Civil Engineering

Key experience:

Anna van Vuuren is a water engineer working in the field of water supply, stormwater management, hydrology and specialised hydraulic designs. Expert in the analysis of flood lines, hydraulic characteristics related to bridge and large drainage structures, as well as urban flood studies and stormwater management. Experience is widespread and includes planning, analysis, design and construction supervision of water supply schemes and in the field of hydrology, the calculation of main catchment area runoffs and routing of flows as well as assessment of spillway capacity for dam safety inspections. She has attended post-graduate courses on flood hydrology jointly presented by Pretoria University and the Department of Water Affairs and Forestry, RSA. She is external examiner (Hydraulics, final year) at the University of Pretoria and has contributed to the SANRAL Drainage Manual (Chapter 8).

Recent involvement in the field of mining development includes the following projects:

Stormwater study: Sishen South Iron Ore Mine, Postmasburg, Northern Cape, RSA. (2003 – 2007).*Complete assessment of surface water aspects for EIA, including floodlines and conceptual design of stormwater to divert clean water around pits and waste dumps, followed later by amendments for the changed mine layout and finally designing the structures for the surface water diversions, sizing the equipment required to dewater the pits and to pump rainwater from the pits. Client: Kumba Resources*.

Project Phoenix: Thabazimbi (2006). Project manager for the pre-feasibility study for bulk water supply and pit de-watering, including also cost estimates, a groundwater model and flood mitigation measures for the re-vitalised pit and new plant developments. Client: Kumba Resources.

Surface water assessment input to EIA/EMP of Vele Mine. (2008-2010). *Complete assessment of surface water aspects for EIA and EMP, including floodlines (for site streams and the Limpopo River) and conceptual design of stormwater systems to divert clean water around pits and plant area. Client: Jacana Environmentals cc.*

- **Rian Coetzee.** Senior Civil Engineering Technician

  Years of experience: ***16***

  Academic qualifications:National Diploma (Civil Engineering)

  Diploma (Project Management

  Professional societies: ***None***

  Key experience:

  Rian Coetzee is a specialist in the water and sanitation fields and hydrology. He is particularly experienced in the planning of civil engineering infrastructure and in stormwater studies. He was responsible for the design and site supervision of the Glen Alpine Dam flood damage repair work and rehabilitation work of the flood damaged Capes Thorn Dam in the Limpopo Province (Spies Dam), which included the hydraulic design of the spillway, earth embankment rehabilitation and downstream protection measures. He was also responsible for the hydrological and hydraulic calculations for the Tshituni, Dutuni, Rabali and Matangari dams.

He has undertaken numerous flood studies for development projects and his tasks included site inspections, calculations and drafting of reports. Recent involvement in related fields includes the following:

Resource assessment for the Groot Marico Eco Estate: Included project management for the geotechnical investigation, geohydrological investigation, hydrological investigation and bulk services for water and sanitation.

Water Resource Assessment in the Phalala River: Investigated water resources to augment and or supply water to the Phalala villages, population projections, water demands, report writing and compilation of GIS maps.

Strategic Planning to augment water to the Lower Steelpoort mines Identify possible sources, sizing of infrastructure, report writing and GIS.

Project Phoenix: Thabazimbi (2006).***Involved in floodline studies and water balances for the pre-feasibility study for the re-vitalised pit and new plant developments. Client: Kumba Resources.***

Surface water assessment input to EIA/EMP of Vele Mine. (2008-2010).***Involved in floodline studies (for site streams and the Limpopo River) and conceptual design of stormwater systems to divert clean water around pits and plant area. Client: Jacana Environmentals cc.***

Surface water assessment input to EIA/EMP of Makhado Mine. (2010-2012).***Involved in floodline studies (for site streams and the Mutamba River) and conceptual design of stormwater systems to divert clean water around pits and plant area, including proposed diversion structure in the Mutamba River along with access bridge hydraulic design. Client: Jacana Environmentals cc.***

1.4 Project description

The Chapudi and Chapudi West Sections cover an area of 4 321 ha and the Wildebeesthoek Section covers approximately 3 254 ha, for mining and infrastructure development.

For the purpose of the surface water report the Chapudi Project's opencast pit footprint areas were delineated and covers an approximate area of 2 400 ha of opencast pits. A further 1653 ha for infrastructure development such as carbonaceous stock piles, haul roads and plant area were delineated.The Chapudi Central mining pits cover approximately 560 ha, the Chapudi West mining pits cover approximately 350 ha and the Wildebeesthoek mining pits cover approximately 1 136 ha. These figures were adopted in **Section 8** of the report to quantify the impact on surface water runoff.

The mining and infrastructure layouts are shown in **Figure 1.2**. This drawing demonstrates the total extent of mining and is not a moment in time. The pits will be backfilled concurrent to mining and it is anticipated that no more than 600 ha will be open at any one time.

The Chapudi Project has the potential to produce good quality semi soft coking coal and a domestic thermal coal product. Measured and indicated resources are approximately 1 3874 million ton mineable in situ.

The current planning is that construction and mining will commence at the Wildebeesthoek Section first where the coking coal yields are the highest. It is expected that mining operations at the Chapudi Sections will only commence much later (in terms of current data towards 2033) by which time the Transnet infrastructure will be have been enhanced to cope with the greater annual production of coal from the Project.

The Wildebeesthoek Section will be mined at 12.5 Mtpa, whilst the Chapudi Centraland Chapudi West Sections combined will be mined at 12.5 Mtpa and the life of mine (LOM) is expected to exceed 30 years.

From the date of granting of the mining right (anticipated to be in 2015) further prospecting, feasibility studies and final design studies will be undertaken. Construction will only commence in 2018.

The Chapudi Project is planned as open pit operations where the extraction of coal is a total extraction mining method using conventional truck and shovel. The mining process involves stripping, drilling, blasting, loading and hauling of overburden to the waste dumped and run of mine (ROM) stockpile or processing plant area.

Infrastructure to support the mining activities has been laid out and engineered to best suit the topography and mining pit layouts, but can be influenced by the environmental impact assessments and stakeholder engagement process.

Each of the Wildebeesthoek, Chapudi Central and Chapudi West Sections will require a dedicated coal beneficiation plant. The total ROM capacity for the Wildebeesthoek beneficiation plant is 12.5Mtpa. Two mining areas will be exploited for the Chapudi Section with the Chapudi Central Section supplying8 Mtpa to a large beneficiation plant and the Chapudi West Section supplying 4.5 Mtpa to a smaller beneficiation plant.

The mine infrastructure areas (MIA) comprise all the facilities, roads, servicesand systems required for the mine to operate optimally. The individual mining sections will be provided with workshops and other necessary infrastructure required for the mining operation.

The centrally located infrastructure will comprise a coal beneficiation plant, personnel support structures, vehicle support structures, water management structures and management and monitoring systems.

Buildings will include management offices, production offices, change house,medical and fire fighting facility, shift changing facility, security and access control, training centre,control room and contractors accommodation camp (during construction only).

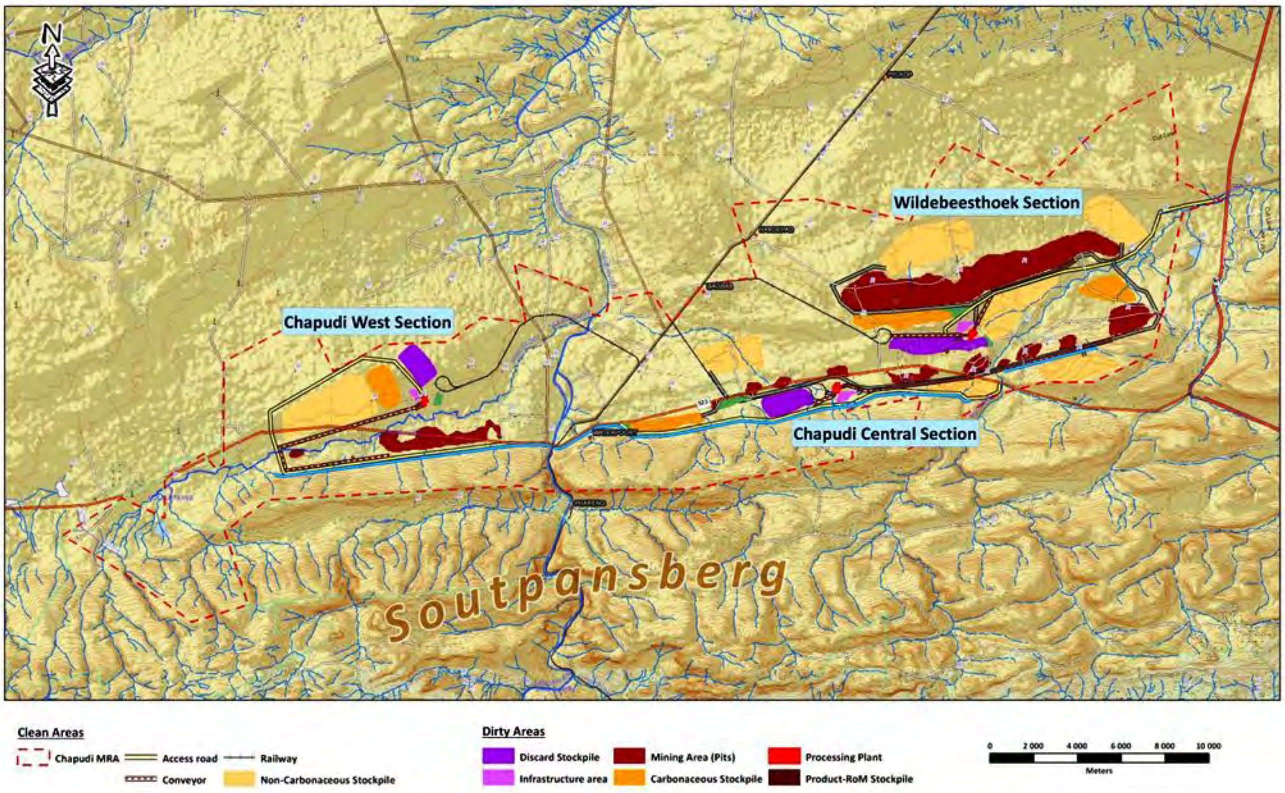

FIGURE 1.2: LOCATION OF PROPOSED MINING PITS IN RELATION TO MAJOR DRAINAGE LINES

Other mine infrastructure includes:

- Access and on-site haul roads
- Topsoil stockpiles and berms
- Overburden (carbonaceous and non-carbonaceous) stockpiles for initial placement, thereafter to be disposed in-pit
- ROM coal storage area
- ROM coal processing plant (primary, secondary and tertiary crusher)
- Associated conveyors from the processing plant to the product storage areas
- Product stockpile areas

- Carbonaceous discards stockpile
- Storm water management infrastructure (i.e. clean and dirty water runoff canals and dams)
- On-site water management and reticulation systems
- Change houses and offices
- Wastewater (sewage) treatment plant
- Bulk electricity supply infrastructure
- Bulk water supply infrastructure
- Railway Siding and rail loop
- Rapid Load-out Terminal (RLT)

2. APPLICABLE LEGISLATION

2.1 South African legislative and standards frameworks

The methodology followed in the surface water assessment is largely prescribed by the legal requirements, as elaborated on in the best practice guidelines. In this regard the following Acts and guideline documents are of relevance:

Mineral and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002) and relevant regulations
National Environmental Management Act (NEMA) (Act 107 of 1998) and relevant regulations
National Water Act (NWA) (Act 36 of 1998)
Government Notice No. 704 (GN 704) (June 1999) on the use of water for mining and related activities aimed at the protection of water resources
DWAF's Best Practice Guidelines:

G1 for Stormwater Management (2006)
G2 for Water and Salt balances (2006)
G3 for Water Monitoring Systems (2006)
A5 for Water Management for Surface Mines (2006)
(Note that not all of the BPG's are deemed relevant for the EIA/EMP phase, since some focus on detail design issues)

Mining and associated infrastructure development is guided by the provisos in the GN 704, particularly regulations 4, 6 and 7.

Locality is addressed in regulation 4, where estimated flood zone widths are set as buffer zones for development, or zone widths are prescribed, as summarised hereunder:

a. No **facility**, including residue deposits, dam, reservoir within the 1:100-year floodline or within 100 m from any watercourse, borehole or well
b. No underground or opencast **mining or any other operation or activity** under or within the 1:50-year floodline or within a horizontal distance of 100 m, whichever is the greatest
c. No disposal of any residue or substance likely to cause pollution of a water resource in the workings of any underground or opencast mine
d. No placement of any sanitary convenience, fuel depots reservoir for any substance likely to cause pollution within the 1:50-year floodline

The *capacity requirements* of clean and dirty water systems are given in regulation 6 and the relevant issues are listed below:

(i) Clean water systems should not spill into any dirty water system more than once in 50 years

(ii) Likewise, any dirty water system should not spill into clean water systems more than once in 50 years

(iii) Any dam that forms part of a dirty water system to have a minimum freeboard of 0.8 m above the full supply level

(iv) In summary, the water systems should be designed, constructed and maintained to guarantee the serviceability for flows up to and including the 1:50-year flows

Measures to *protect water resources* are listed in regulation 7 and include for the collection and re-use, evaporation or purification of water containing waste; measures to be taken to minimise the flow of any surface water into any mine or opencast workings; prevention of erosion or leaching of materials from any stockpile; ensuring that process water is recycled as far as practicable.

Of note is the fact that exemption from requirements of regulations 4 to 8 and 10 to 11 may be obtained from the Minister.

In the identification and quantification of impacts in **Chapters 7 and 8,** the regulations are applied and problem areas, based on the conceptual designs available at this stage, have been identified.

The *major stormwater management principle* prescribed in GN 704 is the one indicating that clean and contaminated stormwater should be kept separate by draining contaminated water to lined dams or ponds for re-use or evaporating and diverting clean stormwater around dirty areas.

Based on the above requirements, the first step in the surface water study is to estimate the flood peaks along affected drainage lines and determine the associated flood zone widths. For this exercise proper site survey data is required to apply standard, accepted methods such as the Rational Method or to do statistical analyses of available data to determine the flood peaks. By using the survey data to model the river flow in the Hec-Ras software, the flood widths are determined. The results of this exercise are described in **Section 4**.

By overlaying the proposed development on the site map, the layout of an adequate stormwater management system is determined and conceptually designed, as described in **Section 7** of this report.

2.2 International standards and guidelines

The IFC performance standards and guidelines and Equator principles were studied and the present conclusion is that most of the aspect listed in these documents had been covered by the local legislation and standards.

2.3 Licencing requirements

The following applications and licences for surface water will probably be required by the Department of Water Affairs and Forestry, in terms of the National Water Act (Act 36 of 1998):

Art 21: Licencesmay be required for the following water uses:
- Taking water from a water resource
- Storing water
- Impeding or diverting the flow of water in a watercourse
- Disposing waste
- Altering the bed, banks, course or characteristics of a watercourse

Art 27: Considerations for issue of general authorisations and licences

Art 25(2):Transfer of water use authorisations

Art 120: Registration of a dam with a safety risk

If any of the storage dams has a wall higher than 5 m and a capacity larger than 50 000 m³, the dam must be registered at DWAF. If classified as a category 2 dam, it must be designed and the construction monitored by an Approved Professional Person (APP).

The procedure for applying for a licence is set out in Article 41 of the NWA.

3. DESCRIPTION OF THE BASELINE ENVIRONMENT

3.1 Regional climate

The Chapudi Project area is situated in a semi-arid zone to the north of the Soutpansberg. 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 southern Sand River Basin is within a cold semi-arid zone summer rainfall area of 500 to 600 mm precipitation. The Chapudi Project is located in the hot-arid zone to the north of the Soutpansberg where the rainfall decreases to 400-500 mm. High precipitation occurs on the Soutpansberg which creates high local runoff. 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.

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 Temperature

Average monthly minimum and maximum temperatures for the Tshipise weather station (No. 0766277 1) some 50 km north-east of the Chapudi Project area is shown in **Table 1** 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 1: TEMPERATURE DATA FOR TSHIPISE FOR THE PERIOD 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 3.1** and**Figure3.2**, indicate the maximum and minimum annual temperature for the region that was obtained from their natural resources atlas on climate.

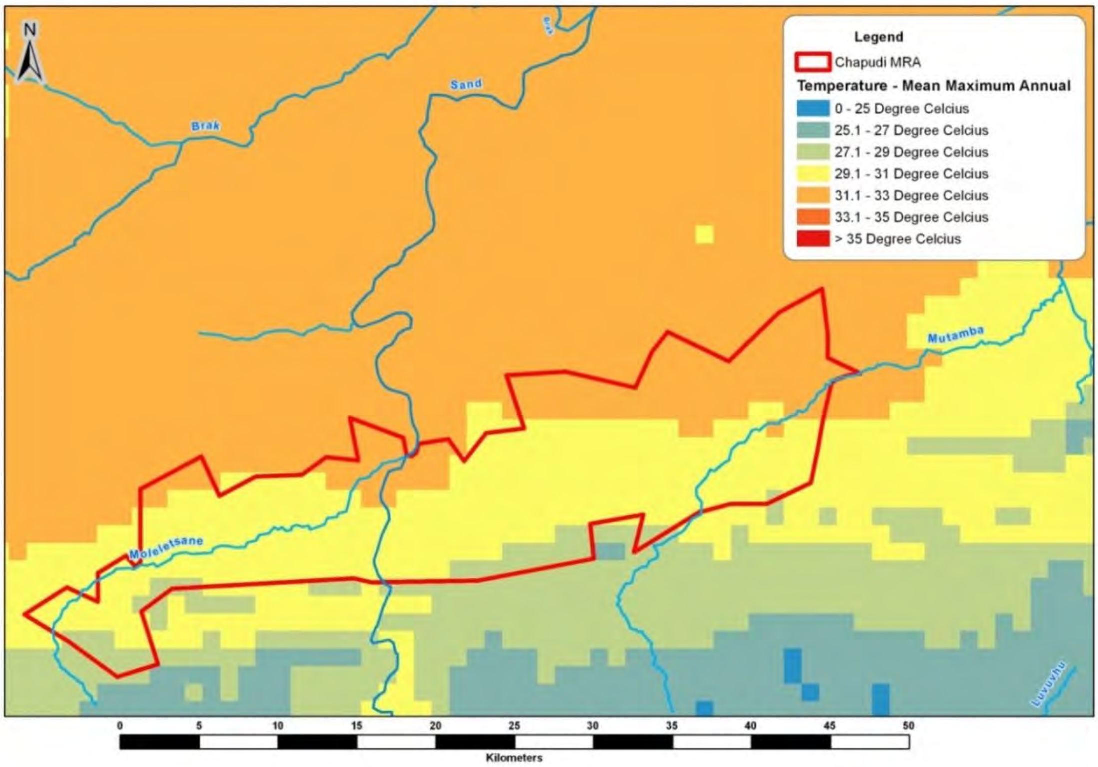

FIGURE 3.1: MEAN ANNUAL MAXIMUM TEMPERATURE

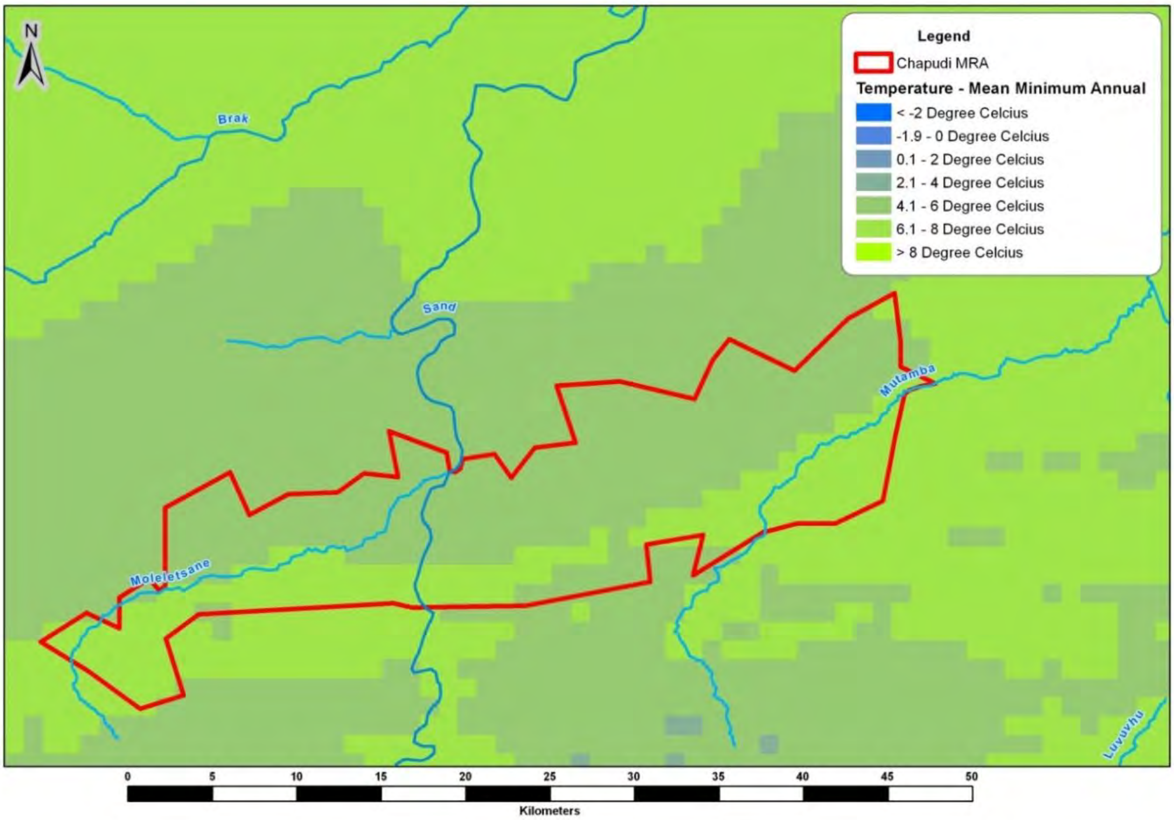

FIGURE 3.2: MEAN ANNUAL MINIMUM TEMPERATURE

3.3 Mean annual precipitation (MAP) and mean monthly rainfall

The Chapudi Project is located in both the Sand River Basin (to the west) and the Nzhelele River Basin (to the east). The Sand and Nzhelele Rivers are tributaries of the Limpopo River, located on the northern boundary of the RSA. The major rivers of concern, the Sand and the Sandsloot/Moleletsane, fall within the Sand River Basin, while the Mutamba River, which originates just south of the Chapudi project along the northern slopes of the Soutpansberg, falls within the Nzhelele River Basin. The Sand River originates further to the south along the flanks of the Ysterberg between Polokwane and Mokopane.

The Chapudi Project is located in the hot-arid zone to the north of the Soutpansberg where the rainfall ranges between400-500 mm. High precipitation occurs on the Soutpansberg which creates high local runoff. The Basin's mean annual precipitation (MAP) distribution is shown in **Figure 3.3** below.

Note that the region is also within the impact zone of tropical cyclones occurring in the Indian Ocean which may cause high-intensity rainfalls leading to peak runoff 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 project spans across quaternary catchment A71J, A80D and part of A80F as defined in the WR2005, Study *(Middleton and Bailey, 2009*) as described in **Section 3.5** and shown in **Figure 3.6.**

The quaternary catchment A71J is located in Rainfall Zone A7C, whereas catchments A80D and A80F fall within Rainfall Zone A8A. The mean monthly precipitation values are given in **Table 2** below. The maximum monthly rainfall occurs in January and the lowest in August. The monthly distribution pattern of rainfall in the quaternary catchment is shown in **Table 3** and **Table 4**.

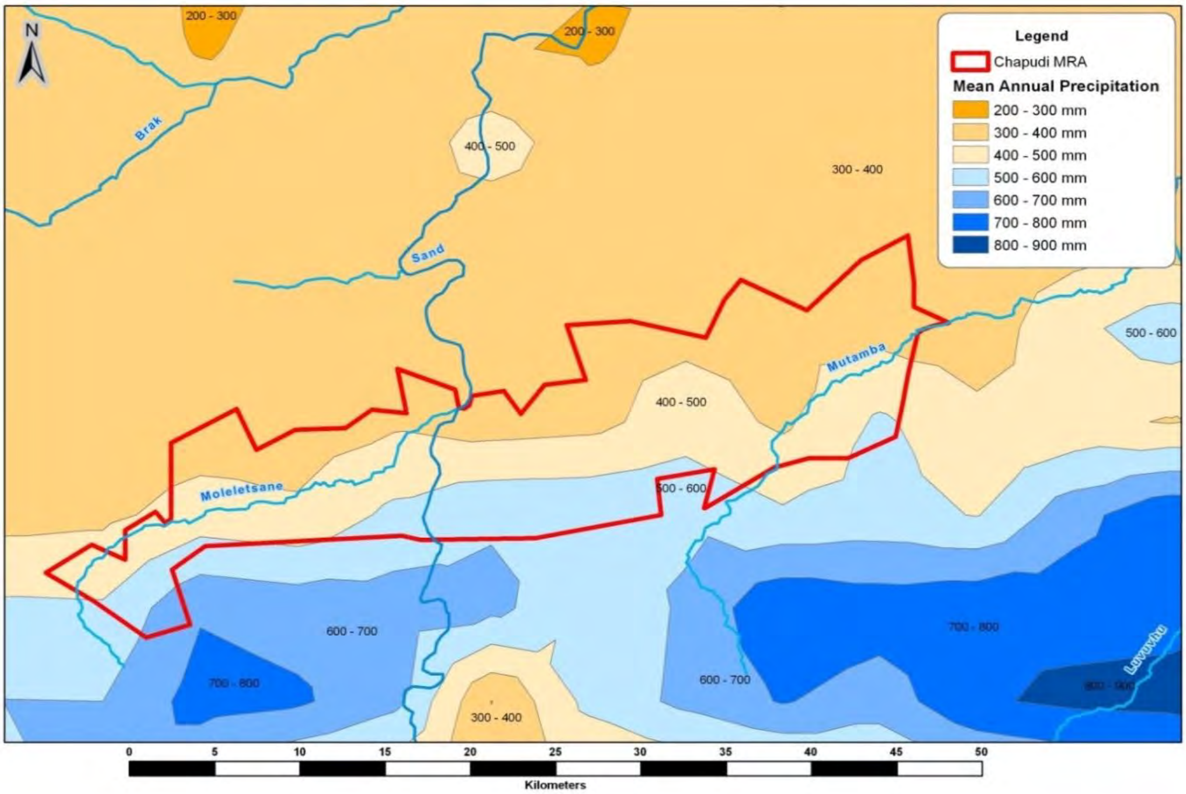

FIGURE 3.3: CHAPUDI PROJECT MEAN ANNUAL PRECIPITATION

TABLE 2: MEAN MONTHLY RAINFALL DISTRIBUTION OF SITE RAINFALL ZONE A7C AND A8A

Rainfall Zone	Mean Monthly Precipitation (% Distribution)											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A7C	7.33	15.11	16.81	19.04	16.23	12.55	5.83	2.54	1.25	1.01	0.77	2.39
A8A	6.46	11.81	15.17	20.17	18.66	13.16	5.40	2.29	1.63	1.66	1.15	2.43

(Source: Middleton, B.J. and A.K. Bailey (2009). Water Resources of South Africa, 252005 Study. WRC Rep No TT381. Pretoria)

The absolute monthly rainfall (% distribution x MAP) in the Sand River Basin for the site quaternary catchment is shown in **Table 3** below. The average rainfall for the catchment has been determined and the maximum rainfall of 81mm occurs in January and the lowest of 1mm in August. The data in the table is shown in the bar chart below **(Figure 3.4)**.

TABLE 3: MEAN MONTHLY QUATERNARY A71J RAINFALL (mm)

Quaternary Catchment	Mean Annual Precipitation (mm)	Rainfall Zone	Mean Monthly Precipitation (mm)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A71J	396	A7C	29	59	68	81	68	47	21	8	5	3	1	10

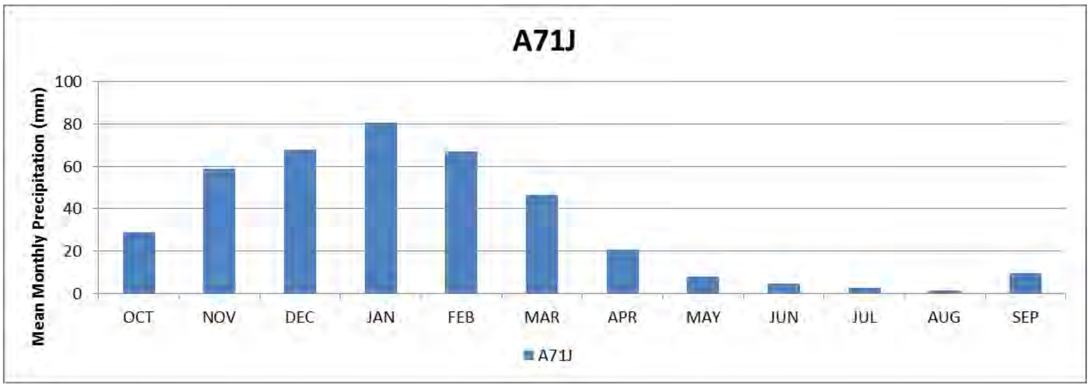

FIGURE 3.4: DISTRIBUTION OF MEAN MONTHLY PRECIPITATION IN mm

The absolute monthly rainfall (% distribution x MAP) in the Nzhelele River Basin for the site quaternary catchments are shown in **Table 4** below. The average rainfall for the catchment has been determined and the maximum rainfall of 125mm occurs in January and the lowest of 7mm in August. The data in the table is shown in the bar chart below **(Figure 3.5)**.

A baseline study of the Chapudi site was conducted in November 2009 by SRK Consulting (Pty) Ltd. In their surface water report, Report Number 395099/SW/1, they utilised data from the Waterpoort rainfall station (0765234AW), which is located in the center of the Chapudi Project area, to approximate a mean annual precipitation from the entire record beginning in October 1977 and ending in October 2008. The mean annual precipitation that they calculated was 389 mm per annum.

This correlates to the 396mm mean annual precipitation for rainfall zone A7C and quaternary catchment A71J.

The variability of rainfall further upstream from the Sand River will however have an effect on the surface water runoff for the Sand River itself, but for the local catchments within quaternary catchment A71J, the mean annual precipitation of the quaternary catchment of 396mm would suffice in terms of surface water runoff calculations.

TABLE 4: MEAN MONTHLY QUATERNARY RAINFALL FOR MUTAMBA RIVER (mm)

Quaternary Catchment	Mean Annual Precipitation (mm)	Rainfall Zone	Mean Monthly Precipitation (mm)											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A80D	622	A8A	40	76	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

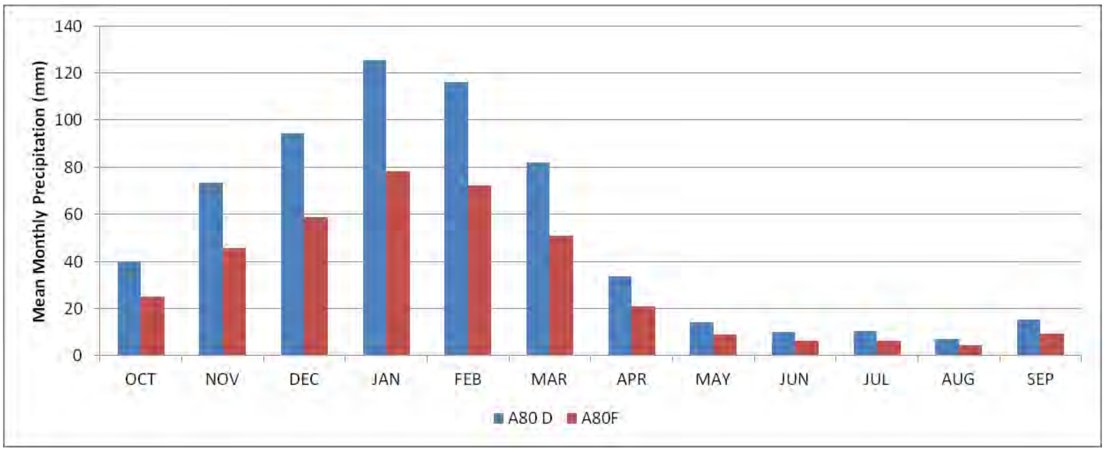

FIGURE 3.5: AVERAGE RAINFALL FOR CATCHMENT IN mm

The quaternary catchment in the region of the proposed development as defined in the WR90 Study (Midgley et al, 1994) are shown in **Figure 3.6**. The Chapudi Project area is situated within catchments A71J, A80D and A80F.

The stormwater runoff calculations for the local catchments within this area were based on the rainfall station Siloam (0766324), which has a mean annual precipitation of 470mm.

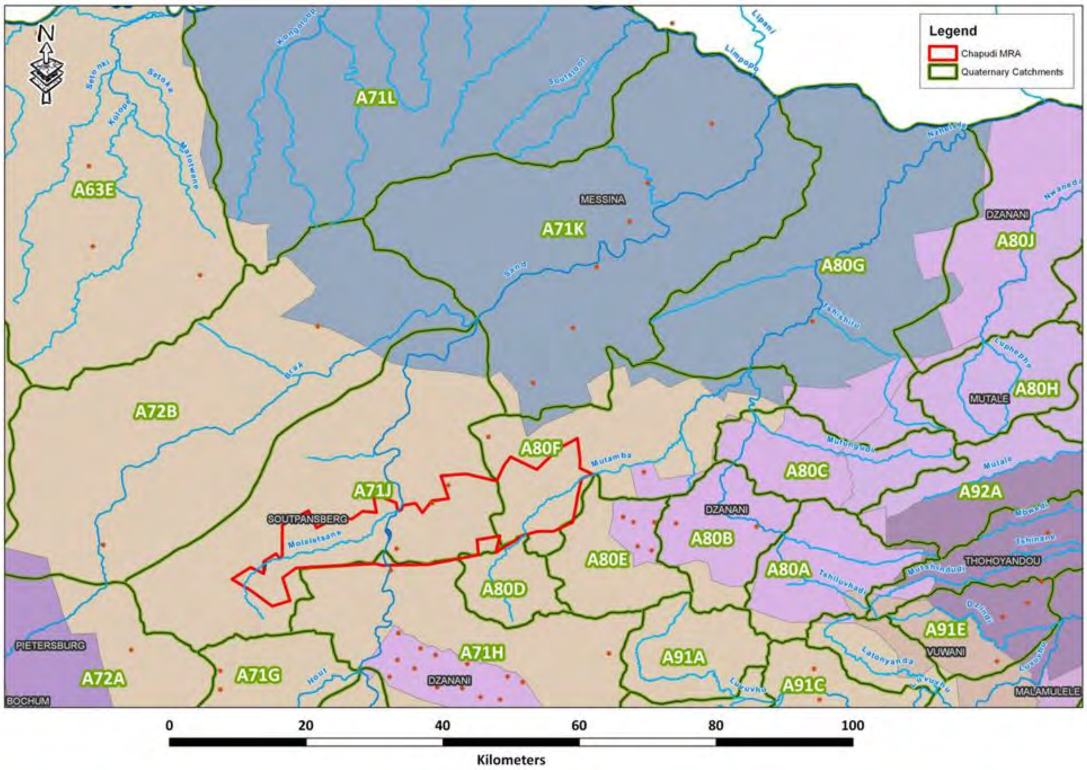

FIGURE 3.6: QUATERNARY CATCHMENTS AFFECTED BY THE CHAPUDI PROJECT

3.4 Runoff and evaporation

3.4.1 Sand River runoff

The DWA has delineated the country's river systems into 22 major drainage basins, referred to as 'Primary' catchment areas. Each basin has subsequently been subdivided into secondary, tertiary and quaternary catchment areas. The Limpopo River Basin was designated as river basin 'A' and the proposed development is located within this basin. It is situated within the Sand River Sub-Basin, which is a tributary of the Limpopo River. The Sand River Sub-Basin has been subdivided into two tertiary subdivisions, A71 and the smaller A72 which includes the Brakrivier. This tributary has its confluence with the Sand River some 40 km downstream of the northern boundary of the Chapudi development.

The total net catchment area at the point where the Sand River exits the A71J catchment is 8 499 km^2, approximately 75 km directly south of the Limpopo River confluence. The upper reaches of the Sand River originates from the Ysterberg Mountain range in the vicinity of Polokwane and Mokopane, approximately 185 km south of the Chapudi Project Area.

The catchment hydrological data of this summer rainfall region are summarized in **Table 5** below. Note that catchment A71J includes an endoreic area, i.e. areas which do not contribute run- off to defined continuous streams. The MAR values are based on the net catchment areas shown in the table.

Runoff data were generated on a quaternary catchment area scale in the WRSM2000 model, an enhanced version of the original Pitman rainfall-runoff model. The parameters in the model were calibrated by using available long-term runoff data in the Sand River Sub-Basin. Note that the present day MAR in the Sand River is not reflected in the table since it shows the **naturalized runoff** generated within the catchment. To obtain the present runoff, all surface water uses in the catchment area must be subtracted.

TABLE 5: CATCHMENT DATA (FROM WR2005)

Quaternary catchment	Net area(km^2) A	Mean Annual Precipitation (mm) MAP	Mean Annual Runoff (mm) MAR	Mean Annual (gross) Evaporation (mm) (Zone 1B) MAE	Irrigation area (ha)	Forest Area (ha)
A71J	905	396	9.69	1800	286	0

The naturalized runoff in the whole of the Sand River upstream of the outlet of quaternary catchment A71J has been compiled from data in WR2005 and the resultant MAR is 57.13 million m^3/a as shown in **Table 6**.

The naturalized unit runoff, based on the net catchment area of 8 499 km^2, amounts to 9.69 mm. Note that the DWA Internal Strategic Perspective (ISP) document gives the unit runoff for the Sand River as a mere 1 mm, but this may be based on current conditions, i.e. it includes for abstractions.

TABLE 6: SAND RIVER NATURALIZED RUNOFF

QuaternaryCatchment (km^2)	NetCatchment Area(km^2)	River(s)	NaturalizedMAR (millionm^3/a)
A71A	1144	SandandBloed	8.75
A71B	882	DiepandTurfloop	6.25
A71C	1331	Sand, DwarsandKoperspruit	7.16
A71D	892	Sand	3.73
A71E	893	Hout	4.01
A71F	683	Strydomsloop	2.63
A71G	875	HoutandMogwatsane	4.46
A71H	894	Sand	11.37
A71J	905	SandandMoleletsane	8.77
TotalNetCatchmentArea	**8 499**	**TotalMAR(millionm^3/a)**	**57.13**

The mean monthly naturalized runoff data for the affected catchment, A71J, is shown in **Table 7**.

TABLE 7: SIMULATED AVERAGE NATURALIZED MONTHLY RUNOFF FOR QUATERNARY CATCHMENTS A71J

Quaternary Catchment	Area (km^2)	Mean Monthly Natural Runoff (mm)												MAR (mm)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
A71J	905	0.14	0.30	0.42	2.37	4.30	1.42	0.19	0.12	0.11	0.11	0.10	0.10	9.69

3.4.2 Mutamba River runoff

The total net catchment area where the Mutamba River, a tributary of the Nzhelele River, exits the A80F catchment is 758 km^2. The upper reaches of the Mutamba River originates from the Soutpansberg Mountain rangeapproximately 17 km south of the Chapudi Project.

The catchment hydrological data of this summer rainfall region are summarized in **Table 8** below. The MAR values are based on the net catchment areas shown in the table.

TABLE 8: CATCHMENT DATA (FROM WR2005)

Quaternary catchment	Net area (km^2) A	Mean Annual Precipitation (mm) MAP	Mean Annual Runoff (mm) MAR	Mean Annual (gross) Evaporation (mm) (Zone 1B) MAE	Irrigation area (ha)	Forest Area (ha)
A80F	491	388	9.69	1750	0	0

The naturalized runoff in the whole of the Mutamba River upstream of the outlet of quaternary catchment A80F has been compiled from data in WR2005 and the resultant MAR is 9.21 million m^3/a as shown in **Table 9.**

TABLE 9: MUTAMBA RIVER NATURALIZED RUNOFF

Quaternary Catchment (km^2)	Net Catchment	River(s)	Naturalized MAR (million m^3/a)
A80D	128	Mutamba	5.84
A80F	491	Mutamba	3.37
Total Net Catchment	**619**	**Total MAR (million m3/a)**	**9.21**

The mean monthly naturalized runoff data for the affected catchment, A80F, is shown in **Table 10**.

TABLE 10: SIMULATED AVERAGE NATURALIZED MONTHLY RUNOFF FOR QUATERNARY CATCHMENTS A80F

Quaternary Catchment	Area (km^2)	Mean Monthly Natural Runoff (mm)												MAR (mm)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
A80F	491	0.08	0.18	0.37	2.08	2.58	1.10	0.21	0.06	0.06	0.05	0.05	0.04	6.86

3.4.3 Evaporation

Mean Annual Evaporation data is given in **Table 5 and Table 8**, while the monthly evaporation pattern (as percentages of the total) is given in **Table 11** below. Note that both the Sand River and the Mutamba River fall within the same evaporation zone.

TABLE 11: 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

3.5 Surface Water

3.5.1 Locality and background information

Figure 3.7 below shows the Chapudi Project in relation to the quaternary catchments areas of the Sand and Mutamba Rivers. The Sand River Sub-Basin is regarded as by far the driest of the river basins in the Limpopo River Water Management Area (WMA) (*ISP, Limpopo WMA, DWA 2004*). The surface water resources are thus regarded as very limited and there is no scope for construction of dams.

The existing major dams in the Sand River catchment are located upstream namely:

- Seshego Dam in the Blood River (Polokwane Local Municipality)
- Hout River Dam (supply to rural villages)
- Turfloop Dam in the south-eastern part of the Basin
- Spies Dam in the Dorps River about 20 km west of Louis Trichardt

There are no major dams in the Mutamba River catchment.

There is no government developed irrigation scheme but extensive private and commercial irrigation schemes have been developed, mostly in the central reaches of the basin. The bulk of the water requirements are met almost exclusively by the ample groundwater resources. (*Limpopo WMA Water Resources Situation Assessment, DWA 2002*).

In the upper region of the Basin, Polokwane and other larger towns rely on transfers of water from other WMA's.

The Chapudi Project is bisected by the watershed of quaternary catchment A71J (Sand River)and A80F (Mutamba River). The Western Section is inside Quaternary Catchment A71J, while the Central section is almost wholly inside catchment A80F. The Wildebeesthoek Sections falls within catchmentA80F. Hydrological data of the quaternary catchments are given in **Section 3.3 and 3.4.**

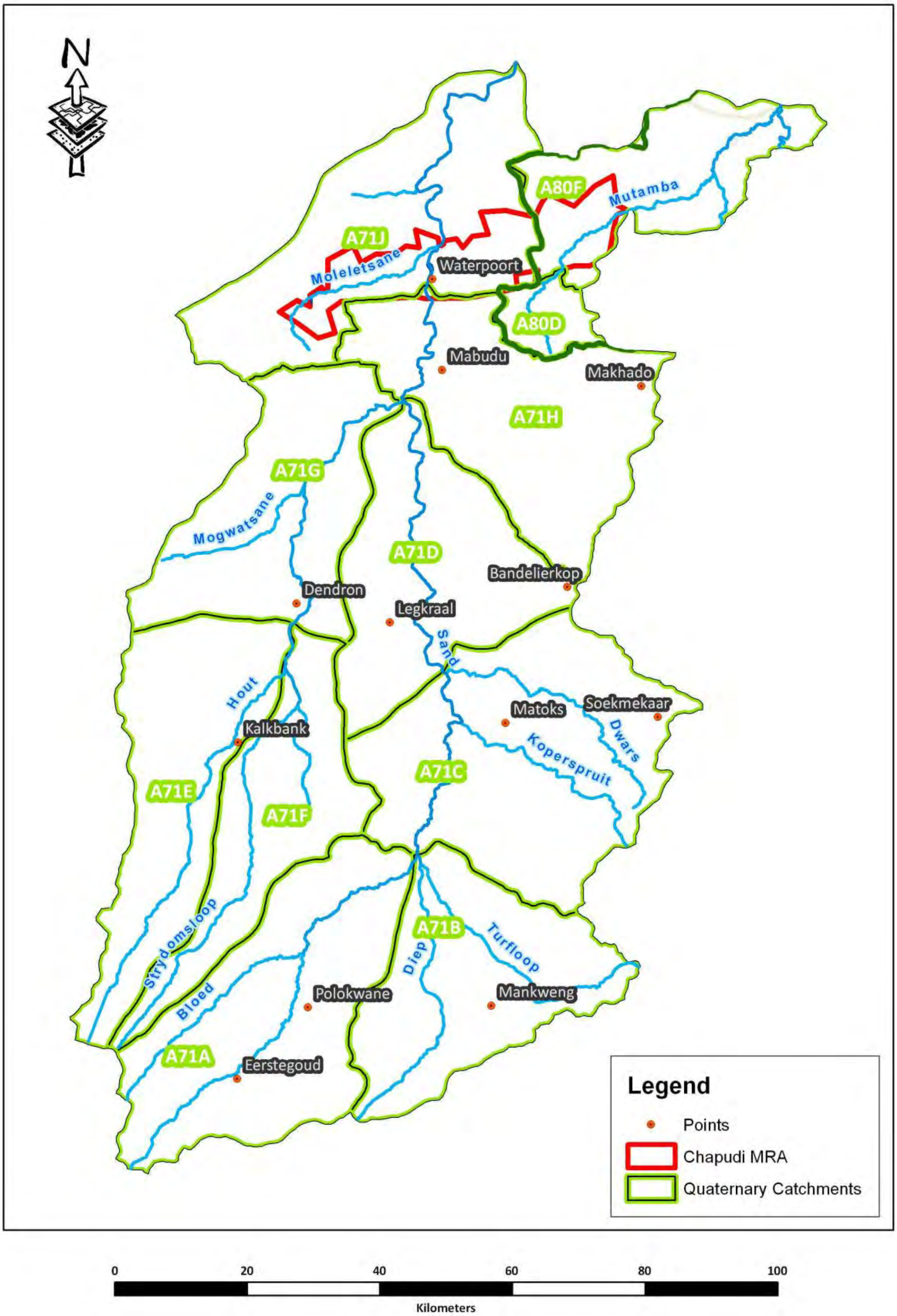

FIGURE 3.7: CHAPUDI PROJECT IN RELATION TO THE QUATERNARY CATCHMENTS AREAS OF THE SAND AND MUTAMBA RIVERS

3.5.2 Surface water quality

According to the Water Resource Situation Assessment, the upper and central Sand River receives "large quantities" of industrial and domestic effluent from large towns and high density rural towns along its banks. The mineralogical water quality of the whole of the catchment was thus classified as "marginal" (DWA, 2002).

In contrast to this assessment, the ISP study (DWA, 2004) states that apart from problems with groundwater quality in the Vivo and Dendron areas there are no major water quality problems in the Sand River Key Area (the Key area includes the Sand River Sub-Basin and other smaller rivers draining to the Limpopo River).

A Baseline Study of the water chemistry of the Limpopo Basin (Univ. of Zimbabwe, 2009) found that in the Vhembe District, which includes the Sand River, nitrate levels increased with groundwater flow towards the Sand River and high levels of nitrate were recorded in both the river and alluvial groundwater during the raining season. It was suggested that the nitrate is from dry land cropping, overgrazed pastures and, in some areas, pit latrines. High fluoride was noted in the area north of the Soutpansberg and has been attributed to high evaporation.

DWA has a river water quality monitoring station at Waterpoort (22°54'37 S, 29°26'41 E), which is relevant to the Chapudi project area.

Figure 3.8 below shows the locality of the water quality monitoring stations.

TABLE 12: WATER QUALITY MEASURED AT WATERPOORT (STATION A7H001)

Macro-elements

Element	Unit	DWA Gauge "Waterpoort" : STATION A7H001 in QuaternaryCatchment A71J							Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
DATE		4/2000	12/2001	10/2002	01/2003	04/2004	08/2005	02/2006				
pH		8.2	8.5	8.2	7.9	7.8	7.8	7.7		6.0 - 9.0	6.5-8.4	
E.C	mS/m	70	253	20	36	19	10	10		150	40	
TDS	mg/l									1000		1000
NO3	mg/l	0.8	0.02	0.07	0.12	0.06	0.04	0.04	0.5	6	5	100
F	mg/l	0.21	0.41	0.13	0.23	0.1	0.05	0.11	0.75	1	2	2
SO4	mg/l	34	207	6	16	7	2	5		400		1000
Cl	mg/l	105	565	12	41	13	8	6		200	100	1500
Ca	mg/l	34	77	14	23	14	8.5	5		150		1000
Mg	mg/l	22	92	8	8	7	3	3		100		500
Na	mg/l	64	287	7	28	10	4	6		200	70	2000
TAL	mg/l	34	207	6	16	7	2	5				
HCO3	mg/l											
CO3	mg/l											
P	mg/l											

NOTE: VALUES IN GREEN SHOW CONSTITUENTS WHERE RANGE TESTED NOT FINE ENOUGH TO COMPARE TO TARGET WATER QUALITY RANGE

Table 12 above shows water results for the most recent seven yearsof data at Waterpoort. This station has a long record of monthly sampling but these values were selected to give an indication of more recent water quality, albeit upstream of the site and of irrigation areas. Elevated levels of pH, EC, chloride and sodium occurred after the extreme flood of 2000 and also in the following year. Instead of a dilution effect, this data may indicate the effect of higher wash-off from contaminated areas.

Table 13 below shows the water quality results for the sample taken by WSM Leshika during a site visit in June 2013. Refer to**Figure 3.8** below for the locality of the sample. The macro elements as tested are all below the WQT range.

TABLE 13: WATER QUALITY IN SAND RIVER DOWNSTREAM OF WATERPOORT ON FARM BERGWATER 712

Macro-elements

Element	Unit	Sand River downstream of Waterpoort in Quaternary Catchment A71J							Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
DATE		27/06/2013										
pH		7.47								6.0 - 9.0	6.5-8.4	
E.C	mS/m	13.7								150	40	
TDS	mg/l	67								1000		1000
NO_3	mg/l	<0.017							0.5	6	5	100
F	mg/l	0.105							0.75	1	2	2
SO_4	mg/l	<0.04								400		1000
Cl	mg/l	9.15								200	100	1500
Ca	mg/l	12								150		1000
Mg	mg/l	5.52								100		500
Na	mg/l	5.97								200	70	2000
TAL	mg/l	52.5										
HCO3	mg/l											
CO3	mg/l											
P	mg/l											

Table 14 below includes the test results of samples collected in the Sand and Mutamba Rivers by SRK in 2008/2009 and the results are as follows:

Mutamba River:

- Three upstream samples (MRU) were taken in May June and October 2009, and two downstream (MRD) samples in May and June 2009, the watercourse being dry in October.
- The TDS increased from 107 mg/ℓ in May to 152mg/ℓ in October fairly uniformly across all major ions, presumably as the upstream catchment concentrated through the dry season.

The downstream samples (MRD) were very similar to their upstream counterparts (with TDS ranging from 100 to 120mg/ℓ), other than there being no equivalent sample in October 2009.

All constituents tested in the Mutamba River remained below the WQT range.

TABLE 14 : FLOW IN THE MUTAMBA AND SAND RIVERS SAMPLED BY SRK

CHAPUDI PROJECT

Macro-elements

Element	Unit	SRK Consulting results (December 2008 to October 2009)							Aquatic Ecosystem WQT	Drinking Water WQT	Agriculture WQT (irrigation)	Agriculture WQT (livestock)
		MRU	MRD	SRU	SRD							
pH		7.0-7.5	7.2-7.5	6.7-8.6	8.3-8.5					6.0 - 9.0	6.5-8.4	
E.C	mS/m	15-25	15-17	7.6-19	71-109					150	40	
TDS	mg/l	98-152	100-120	52-95	460-750					1000		1000
NO_3	mg/l	0.2-0.3	0.2-0.3	0.1-2.4	0.1-0.4				0.5	6	5	100
F	mg/l	0.1	0.1	0.1	0.2-0.3				0.75	1	2	2
SO_4	mg/l	4.2-8.3	4.3-8.5	0.6-3.7	41-85					400		1000
Cl	mg/l	18-31	18-29	7.9-11	87-168					200	100	1500
Ca	mg/l	5.2-12	4.8-15	5.5-16	43-44					150		1000
Mg	mg/l	5.1-7.7	5-5.8	2.8-6.8	24-36					100		500
Na	mg/l	14-31	15-19	4.7-7.6	76-128					200	70	2000
TAL	mg/l	40-71	43-49	27-76	186-260							
HCO3	mg/l											
CO3	mg/l											
P	mg/l											

MRU - Mutamba River Upstream
MRD - Mutamba River Dow nstream
SRU - Sand River Upstream
SRD - Sand River Dow nstream

Sand River

- Four upstream samples (SRU) were taken from the Sand River in December, May, July and October, but only two downstream samples (MRD) were available, in May and July 2009.
- The TDS in SRU declined through the year from 95 to 64 to 55 to 52mg/ℓ while the downstream samples showed no chemical relationship with SDU, having TDS of 490mg/ℓ and 750mg/ℓ in May and July. Presumably this is explained by the strong influence of the saline tributary, the Sandsloot joining the Sand River approximately 10km upstream of the SRD sampling point. There is no sampling point in the Sandsloot.
- The pH, nitrate, chloride and sodium WQT ranges were exceeded

Table 14.1 below shows the water quality results for the sample taken in the Mutamba River by WSM Leshika in May 2011 and again in January 2013. Refer to **Figure 3.8** below for the locality of the sample.

Except for a slight exceedance of nitrate, all constituents tested within the WQT range.

TABLE 14: FLOW IN THE MUTAMBA RIVER SAMPLED BY WSM

Macro-elements

Element	Unit	SMON-1 (May 2011)	SMON-1 (2013/01/17)	Aquatic Ecosystem Water Quality Threshold	Drinking Water Quality Threshold	Agriculture Water Quality Threshold (irrigation)	Agriculture Water Quality Threshold (livestock)
pH		8.2	7.2		6.0 - 9.0	6.5 - 8.4	
E.C	mS/m	27.1	14		150	40	
TDS	mg/l	132	91		1000		1000
NO_3	mg/l	0.80	<1.4	0.5	6	5	100
F	mg/l	0.20	<0.10	0.75	1	2	2
SO_4	mg/l	7	11.68		400		1000
Cl	mg/l	38.00	20.90		200	100	1500
Ca	mg/l	7	3.78		150		1000
Mg	mg/l	10	4.05		100		500
Na	mg/l	38	15.98		200	70	2000
TAL	mg/l	68					
HCO3	mg/l	68					
CO3	mg/l	<5					
P	mg/l	<0.2	0.06				

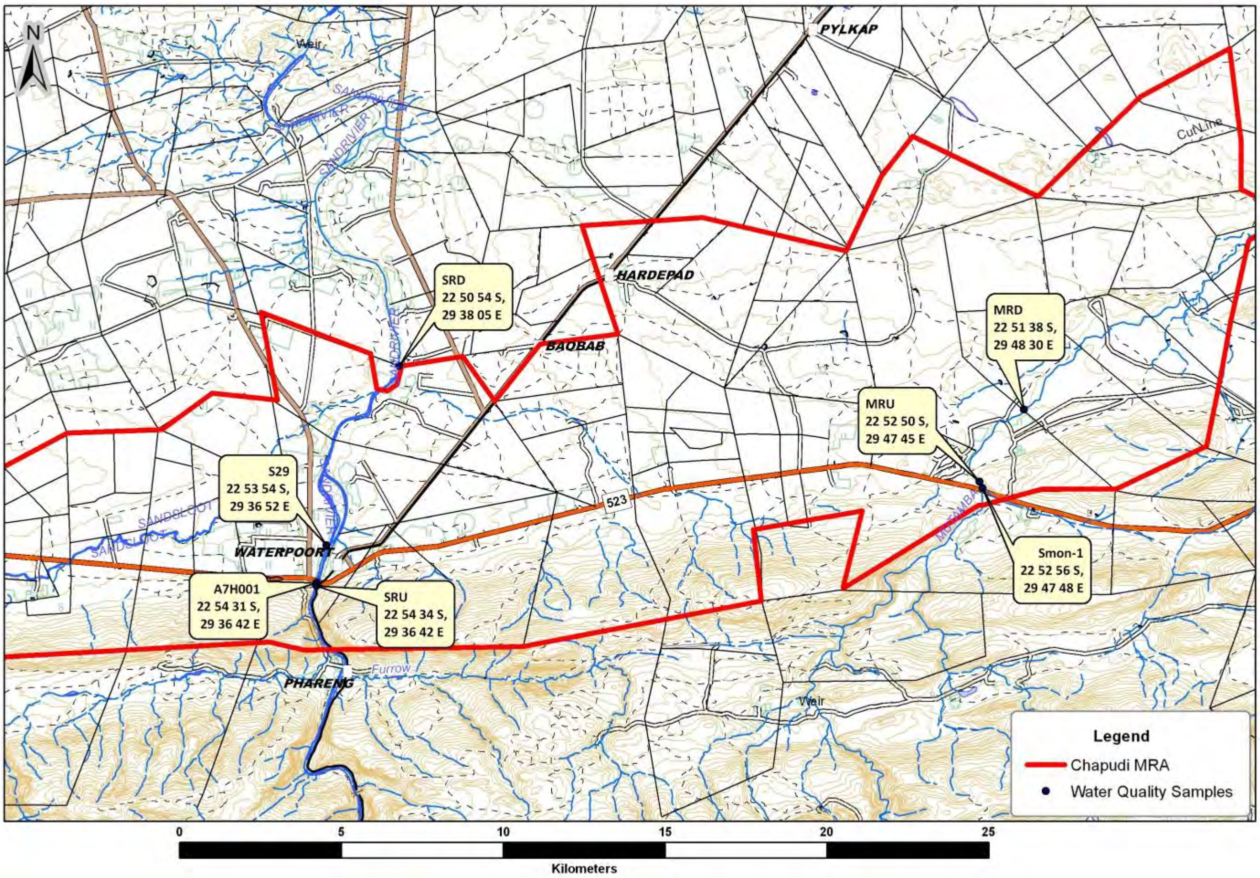

FIGURE 3.8: WATER QUALITY MONITORING POINTS FOR THE SAND AND THE MUTAMBA RIVERS

3.5.3 Extent of current irrigated areas and water use

The study region, situated in the Vhembe District Municipality, is located immediately north of the Soutpansberg, between the N1 route and westwards for about 45 km to the western limit of the MRA. The area is sparsely populated. Apart from Musina close to the Limpopo River there are no other towns within the portion of the Sand River Basin beyond the Soutpansberg.

The water used for domestic water supply and crop production in the study area is sourced from groundwater, including well points in the sandbed of the rivers. Due to the ephemeral nature of river and stream flows, surface water is not used except where small earth dams catch some runoff for cattle and game watering in the wet season. The extent of irrigated areas was determined in the Groundwater Assessment by WSM Leshika (as shown in **Figure 3.9**). The result was used as input to the estimate of groundwater usage. The estimated area cultivated in the MRA totals 2 773 ha, or 6.9% of the total MRA of 402.6 km^2. Note that of the 2 773 ha, only about 537 ha is currently (2009) under irrigation and the balance is dry land,or “cleared land” as described in **Table 15**.

Groundwater use figures were derived from various sources i.e. estimates of cultivated land areas using google images from January 2009 to determine cleared lands and evaluating irrigated areas (**Figure 3.9**), verbal communication with farmers, the registered use (WARMS data) and the various report estimates.

The irrigation use was estimated by using an irrigation application of 7 880 m^3/ha/annum. Irrigation use is mainly on the farms Bergwater, Enfield, Waterpoort, Koodoobult, Varkfontein, Coniston, Albert, Princes’s Hill, Kliprivier, Wildebeesthoek, Bushy Rise and Vleifontein.

Of the other groundwater uses the relatively high use on the farms Sandstone Edge, Castle Koppies and M’tambaVlei is mainly for aesthetic purposes, i.e. irrigation of gardens around the lodges and filling of water holes.

TABLE 15: CHAPUDI GROUNDWATER USE

Owner/Business	Farms	Total farm unit area (ha)	Census data- current pumping capacity (kl/day)	Cleared area from Google Earth (ha)	Estimated Irrigated area (ha)	Irrigation area ground water use (kl/day)	Other Groundwater use (kl/day)	WARMS Registration Volume (Ml/ annum/ farm)	Overall Estimated Ground water Use (Ml/ annum)
Ekland Safaris	Castle Koppies	659	130	0	0	0	130	0	182
	Kalkbult	915	0	0	0	0	0	3	
	Koschade	1 154	43	0	0	0	43	6	
	M'tamba Vlei	547	282	0	0	0	282	0	
	Pienaar	1 865	14	0	0	0	14	0	
	Qualipan	606	9	0	0	0	9	3	
	Sandilands	1 262	22	0	0	0	22	0	
Bertha Trust	Malapchani	500	8	0	0	0	8	0	142
	Sandstone Edge	1 273	376	0	0	0	376	0	
	Mapani Ridge	1 411	6	0	0	0	6	0	
L Erasmus	Mountain View	687	205	16	0	0	10	0	4
Unknown	Princes's Hill	1 371	296	30	14	296	0	0	108
Unknown	Queensdale	737	5	17	0	0	5	0	2
Unknown	Albert	1 063	410	40	19	410	0	168	150
Unknown	Bergwater	1 318	No data	420	159	3 439	0	870	1 255
Unknown	Bergwater-2	387	No data	80	0	0	14	5	5
Unknown	Brosdoorn	779	No data	36	0	0	5	0	2
Unknown	Dorprivier	1 416	No data	99	0	0	5	442	2
Unknown	Chapudi	666	7	0	0	0	7	30	3
HML Boerdery	Coniston	1 954	552	40	25	540	7	72	200
Unknown	Enfield	1 038	No data	194	110	2 375	0	0	867
Unknown	Grootvlei	1 003	No data	22	0	0	7	648	3
JJB Knoetze	Kliprivier	1 484	193	91	9	194	0	45	71
Unknown	Koodoobult	1 584	936	150	43	928	8	321	342
Unknown	Rochdale	1 361	5	45	0	0	5	284	2
Unknown	Sterkstroom	1 531	No data	103	0	0	5	715	2
Unknown	Sutherland	1 072	11	20	0	0	11	57	4
MJ Scheepers	Varkfontein	1 012	879	120	40	864	15	921	321
Unknown	Waterpoort	772	No data	453	100	2 159	0	790	788
Piet Espag	Wildebeeshoek	1 224	168	78	8	173	0	4	63
Brink Schlesinger	Blackstone Edge	1 019	11	0	0	0	11	32	50
	Bushy Rise	1 690	562	70	6	121	0		
	Woodlands	1 850	5	0	0	0	5		
Unknown	Bluebell	1 836	No data	0	0	0	5	0	2
Unknown	Bwana Spots	858	No data	0	0	0	5	0	2
Unknown	Driehoek	1 032	No data	0	0	0	5	0	2
Unknown	Grootboomen	629	No data	0	0	0	5	0	2
Unknown	Middelvlei	581	No data	0	0	0	5	100	2
Unknown	Ridge End	1 225	No data	0	0	0	5	0	2
Unknown	Sandpan	1 300	No data	0	0	0	5	0	2
Unknown	Vastval	777	No data	84	0	0	5	0	2
Unknown	Vleifontein	1 670	No data	28	5	106	0	0	39
	Totals	**47 117**		**2 236**	**537**	**11 604**	**1 050**		**4 619**

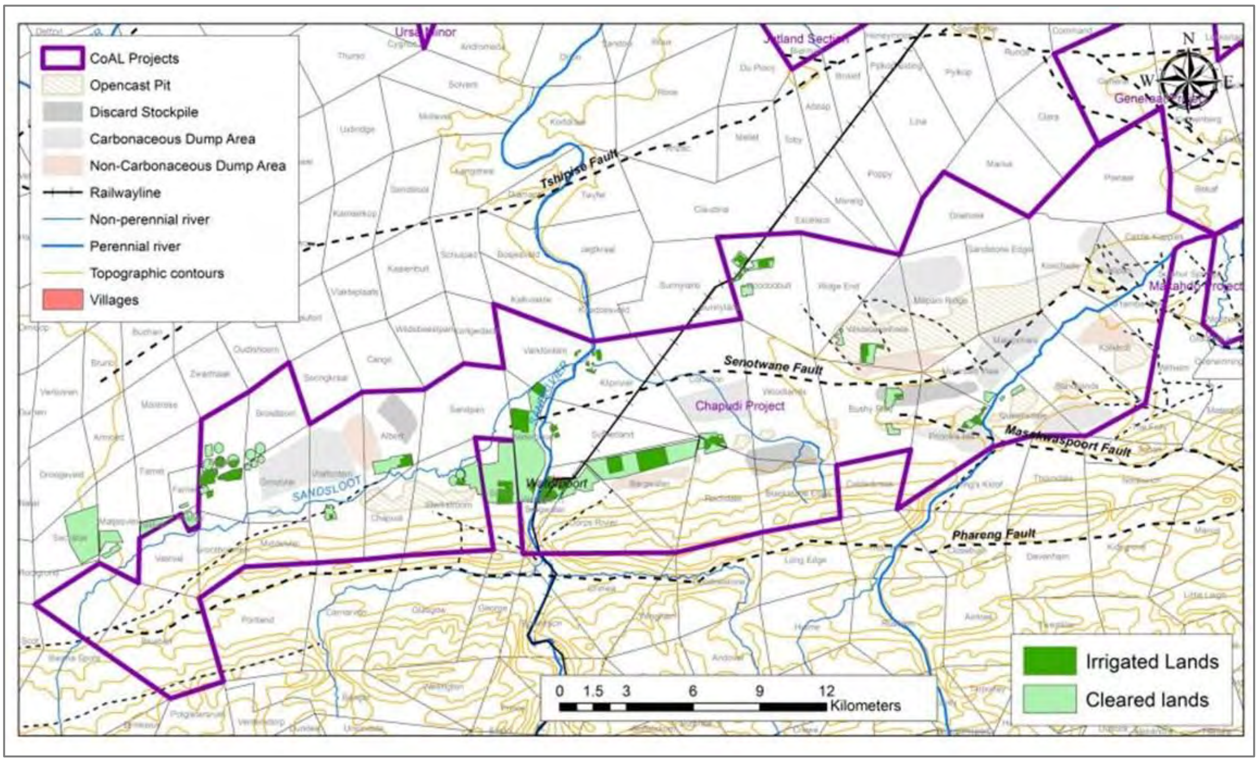

FIGURE 3.9: EXTENT OF IRRIGATED AREAS WITHIN THE CHAPUDI PROJECT AREA

3.5.4 Current drainage system

Figure 3.10 shows the major rivers and the general flow directions of the drainage systems for the Sand River, the Mutamba River as well as the local catchments within the project area. The 1:100- year flood-lines for the major rivers have been determined as described in **Section 4** and are shown in **Figure 3.11** and **Figure 3.12**.

Figure 3.10 also gives a graphical representation of the drainage density of the catchments which indicates that though the site is situated in a dry region and even the large rivers are ephemeral, surface water flows do occur, after rainfall events, in a defined network. The drainage density in the east in the Mutamba River section appears to be somewhat less than in the western section of the site towards the Sandsloot Section. This may reflect the different geology of the steeper mountain slopes in the east of the mountain range. Note that the broken blue lines, which is well defined in Figures 3.11 and 3.12, denote ephemeral streams on this map scale.

A description of the river classification system proposed by DWA (2005) is summarized in sub-section 3.5.4.1 below.

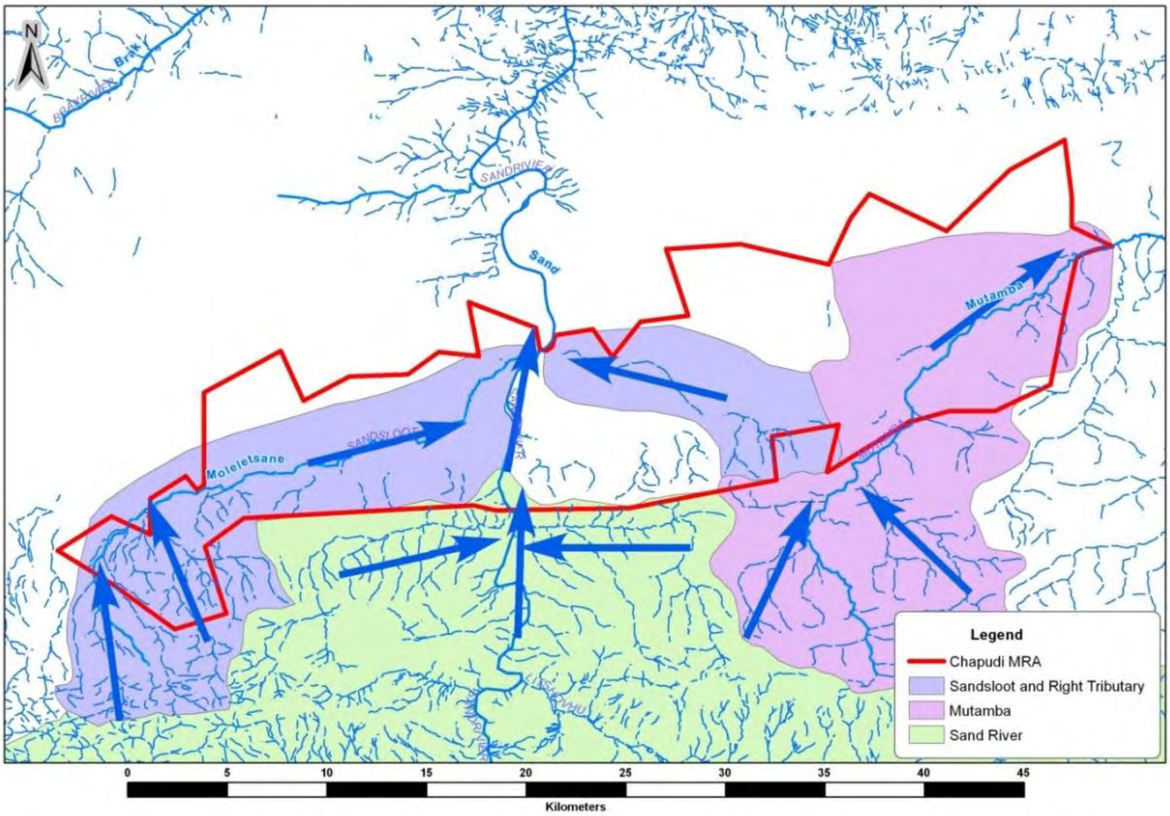

FIGURE 3.10: MAJOR RIVERS AND GENERAL DRAINAGE DIRECTION IN CHAPUDI

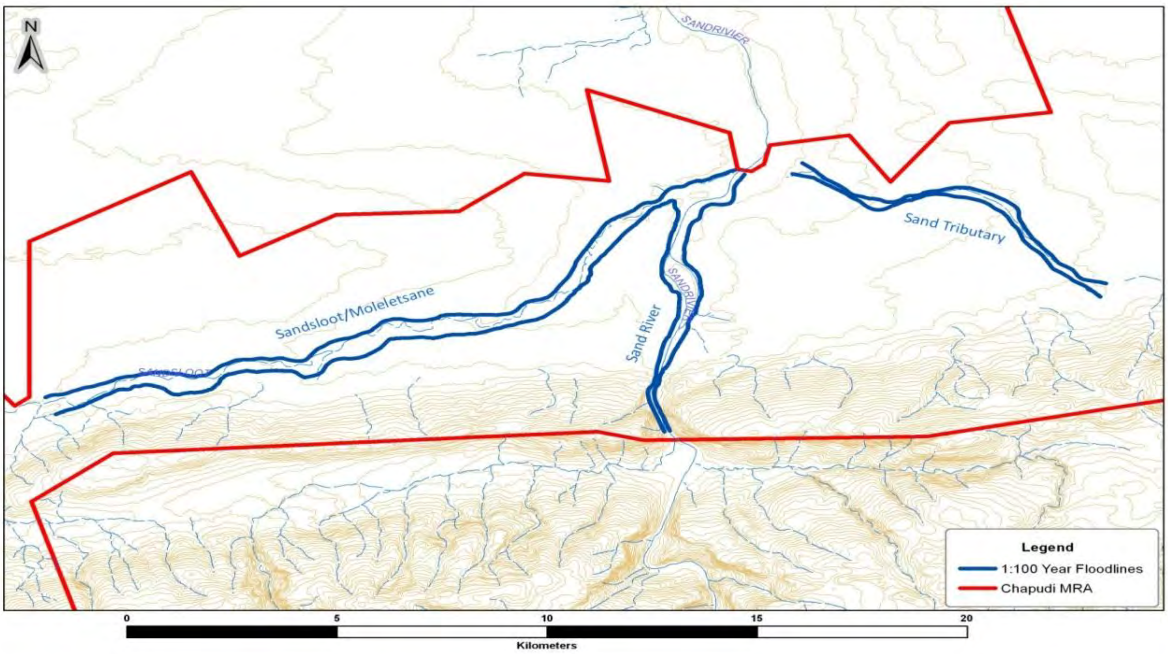

FIGURE 3.11: WESTERN SECTION DRAINAGE LINES AND MAJOR RIVER FLOOD-LINES

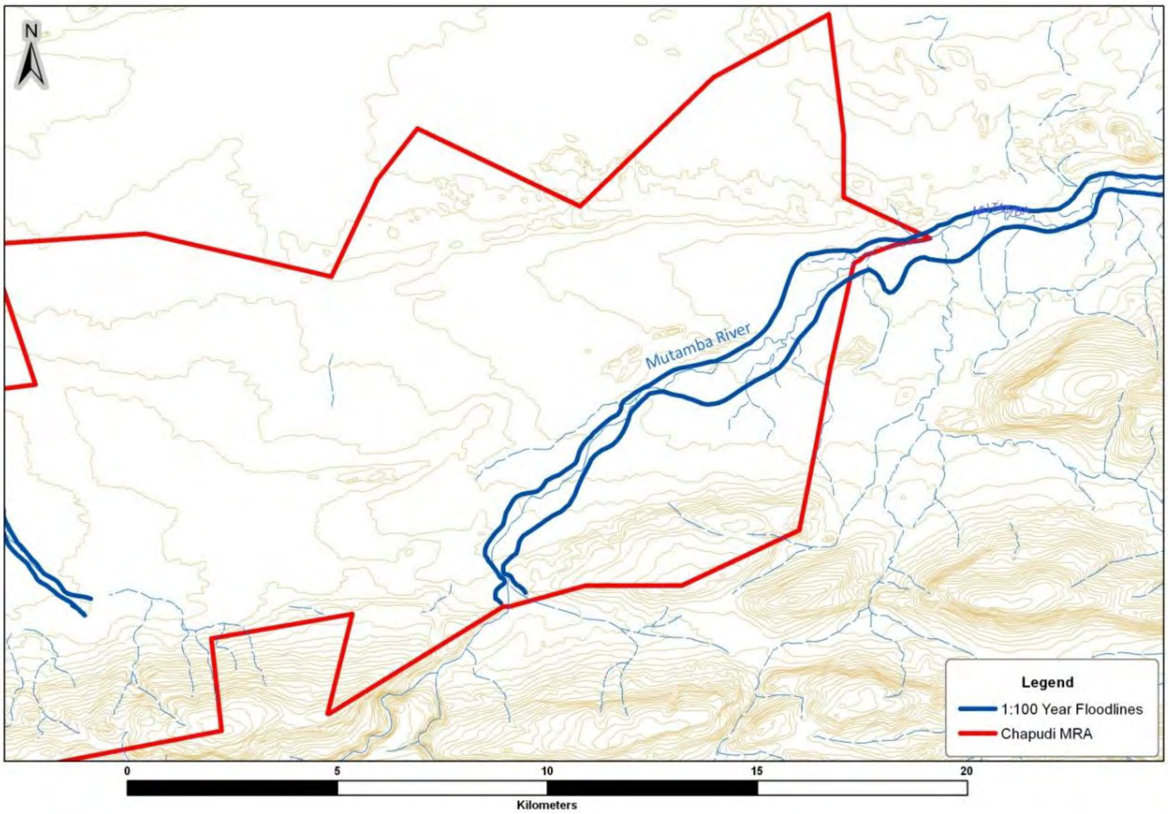

FIGURE 3.12: EASTERN SECTION DRAINAGE LINES AND MAJOR RIVER FLOOD-LINES

3.5.4.1 Stream classification

A 'water course' is defined in the NWA as follows:

(a) River or spring;

(b) A natural channel in which water flows regularly or intermittently;

(c) A wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse,and a reference to a watercourse includes, where relevant, its bed and banks.

Based on the above definition, smaller drainage lines such as discontinuous V-shaped topographical features were subsequently identified on the detailed survey map and all of these are classified as “streams”. However, the smaller drainages were deemed to be nominal drainage lines or 'A Section' streams as described below, with many located within the impact zone of the pits, stockpiles or defined dirty water area where it will be severely disturbed.

River channels may be classified according to guidelines by DWA in "*A practical field procedure for identification and delineation of wetlands and riparian areas*" as shown in **Figure 3.13** (taken from DWA, 2005). Three sections along the length of a watercourse is defined, with the upper Section A defined as being above the zone of saturation and it therefore does not carry baseflow. They are mostly too steep to be associated with alluvial deposits and are not flooded with sufficient frequency to support riparian habitat or wetlands. This type does however carry storm runoff during fairly extreme rainfall events but the flow is of short duration, in the absence of baseflow.The 'A' watercourse sections are the **least sensitive watercourses** in terms of impacts on water yield from the catchment.

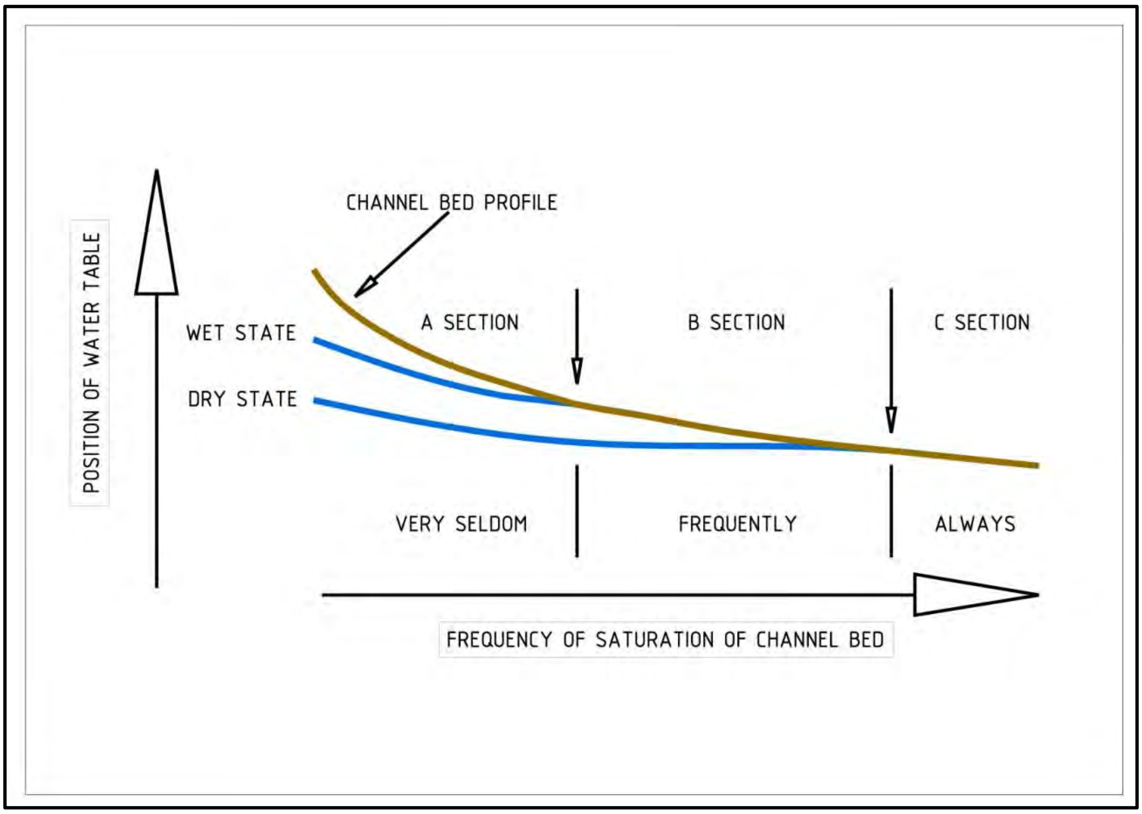

FIGURE 3.13: RIVER CLASSIFICATION (DWA 2005)

On the site, Section A channels occur on the mountain slopes and foothill slopes in this dry region, also along the smaller streams on the lower region.

Even the Mutamba and Sand Rivers are classified as only Section B streams. According to the DWA's guidelines,the B Sections are those channels that are in the zone of the fluctuating water table and only have baseflow at any point in the channel when the saturated zone is in contact with the channel bed. In these B Sections **baseflow is intermittent**, with flow at any point in the channel depending on the current height of the water table. Because the channel bed is in contact with, or in close proximity to, the water table, residual pools are often observed when flow ceases. The gradient of the channel bed is flat enough in these Sections for deposition of material to take place and initial signs of flood plain development may be observed.

Included below is a photograph taken in September 2013 showing the sand bed of the MutambaRiver.

MUTAMBA RIVER (on the farm Kalkbult) : "B" River Section

3.5.4.2 *Springs*

According to the groundwater study report (*WSM Leshika Consulting, November 2013*), springs occur where the water table intersects the surface, usually along some structure. The Sandsloot River appears to have its origin in a spring on the farm Bwana Spots to the west of the project. The Zoutpan Salt Mine was also historically fed by springs. A spring existed on the farm Sitapoat Luna Spa but has dried up probably after irrigation started.

From google images springs or “seeps” appear to exist all along the foot of the Soutpansberg Mountain.The local topography on the northern slope of the mountain leads to a particular surface flow pattern, as follows: the relatively high mountain peaks to the south create a very steep slope towards the main rivers, with a drop of some 335 m over about 1 645 m which equals a slope of 20%. The streams draining the mountain slope have thus carved out well-defined incised streambeds. When these streams enter the relatively flat terrain at the foot of the mountains, the flow velocity decreases and sediment is deposited which leads to the creation of sediment fans. In some instances riverflow ceases as water is transported as subsurface flows through the sediment fans and no discernible streambeds occur, hence the discontinuity of drainage lines shown on the topographical maps.

Further down the slope towards the major streams and rivers, surface flow is re-established as springs or seepsdevelop. Lush vegetation usually characterize these springs and due to high evapotranspiration, the contribution to surface water flows is often much reduced.

4. FLOOD PEAK CALCULATIONS AND FLOODLINE DETERMINATION

The flood peaks of the Sand River and its major tributaries have been calculated, using the methods described in the SANRAL Drainage Manual (Kruger, 2006). These are generally categorised as deterministic, statistical or empirical methods:

- ***Deterministic methods*** include those methods where the flood magnitude (the effect) is derived from an estimate of the catchment characteristics, including rainfall (the cause), for the required annual exceedance probability. Note that these methods have been calibrated according to selected regions and flood events and its application is usually limited to the size of catchment on which they can be applied. Included in this category are the Rational, Unit Hydrograph and Standard Design Flood methods.

- ***Statistical methods*** use actual annual series flood peak data, to which a statistical Probability Distribution Function (PDF) is applied. The validity of the result depends on the record length, the quality of the data and the aptness of the applied PDF. A graphical presentation of the data and the fitted curve should be made to select the best PDF, which include the Log-normal, Log-Pearson Type 3 and General Extreme Value functions.

- ***Empirical methods*** are calibrated equations that may be partially based on a deterministic relationship, such as the Midgley-Pitman method. Also included in this category is the Regional Maximum Flood method developed by Kovaćs.

  Note that the flood analyses were based on the gross catchment area to include for the possibility that the endoreic catchments may contribute to storm water runoff in large flood events.

4.1 Statistical analysis of the Sand River flood peaks

There is a long term river flow gauge (A7H001, starting year 1958) on the Sand River in the Waterpoort (where the river crosses the Soutpansberg). Although not constructed to measure high flows, the DWA has determined the high flood peaks at this site by other calculations. For example, the 2000 flood peak has been determined as 5 100 m^3/s and published by Alexander (2001). It is, however, not a very reliable gauge in that only 28 years of complete records exist in the 54 years of its existence. An analysis has been carried out (refer to Table 14) and the results of the Log-Pearson Type 3 and Log-Normal were selected as reflecting the most probable range of results in Southern African conditions. The results are given in **Table 16**.

TABLE 16: RESULTS OF STATISTICAL ANALYSIS OF FLOOD DATA AT WATERPOORT (GAUGE A7H001)

PDF	RECURRENCE INTERVAL (years)				
	1:10	1:20	1:50	1:100	1:200
Log-Normal	631	992	1 660	2 361	3 233
Log-Pearson Type 3	679	1 325	3 023	5 482	9 753
Log-Gumbel	650	1 317	3 284	6 510	12 876
GEV	1 232	1 783	2 642	3 417	4 320

NOTE: (PEAK FLOW RATE IN m^3/s)

4.2 Deterministic methods applied to the Sand River

The flood peaks were also determined by applying deterministic methods of analysis even though not all are fully applicable over such a large catchment area. The Standard Design Flood and the Alternative Rational Methods as described in the SANRAL Drainage Manual (Kruger 2006), using software developed by Sinotech cc (Utility Programs for Drainage, version 1.0.2), were used. The results were also compared to the flood peak estimates based on the Regional Maximum Flood as proposed by Kovaćs (1988).

Note that the impact of cyclones (or tropical weather systems) that occur occasionally in the north eastern parts of the country has been allowed for. The flood peak estimations are partially based on the statistical analyses of site specific rainfall data which includes the high rainfall events.

The flood peaks have been calculated at the point where the river exits quaternary catchment A71H at the Waterpoort weir. The river's catchment data are shown in **Table 17**. The Mean Annual Precipitation (MAP) of 442 mm used (in some of the methods) is the weighted average precipitation over the catchment area, determined by application of the Thiessen polygon method. In order to apply the Alternative Rational Method to the total catchment, the weighted 1:2-year 24-hour rainfall (M2) has also been estimated by this method as 51 mm.

The results are summarised in **Table 18**.

TABLE 17: SAND RIVER CATCHMENT CHARACTERISTICS AT THE WATERPOORT WEIR SITE

DESCRIPTION	VALUE
Gross Catchment area (km^2)	7 703
Mean Annual Catchment Precipitation (mm)	442
Mean M2 catchment rainfall value (mm)	51
Length of watercourse to boundary (km)	175.85
Average stream slope (m/m)	0.0033
Rational Method Runoff factor	0.248
Veld Type (Unit Hydrograph procedure)	n.a.
SDF Method Drainage Basin No	3
RMF Method K-value	5

TABLE 18: ESTIMATED PEAK FLOWS FOR THE SAND RIVER

METHOD USED	Flood peaks per recurrence period (m^3/s)		
	1:20	1:50	1:100
Rational Method with rainfall intensity from Alexander method	1 027	1 575	2 204
Standard Design Flood	2 336	3 602	4 783
Kovaćs RMF method (RMF = 8 777m^3/s)	.	4 483	5 326

4.2.1 Selected floods for the Sand River

The final flood peak selection was based on a graphical presentation **(Figure 4.1)** of the information shown in **Tables 16 and 18**. In selecting the flood peaks less weight was given the Kovaćs Method and the results of the Standard Design Flood since both are based on conservative upper envelope curves of observed storm events and tend to always give upper limits in flood peak calculations. On the other hand the Rational Method applied on large catchments tends to under-estimate the larger events. The selected values, as indicated by the dark green line on the graph, are shown in **Table 19**.

TABLE 19: SELECTED FLOOD PEAKS FOR THE SAND RIVER AT WATERPOORT

FLOOD PEAKS IN m^3/s (for recurrence interval in years)			
1:10	1:20	1:50	1:100
700	1100	1850	2700

The values above were used to determine the 1:100-year flood-line for the main river and major tributaries of the Sand River section, using the Hec-Ras software, as shown in **Figures 7.2 and 7.3**.

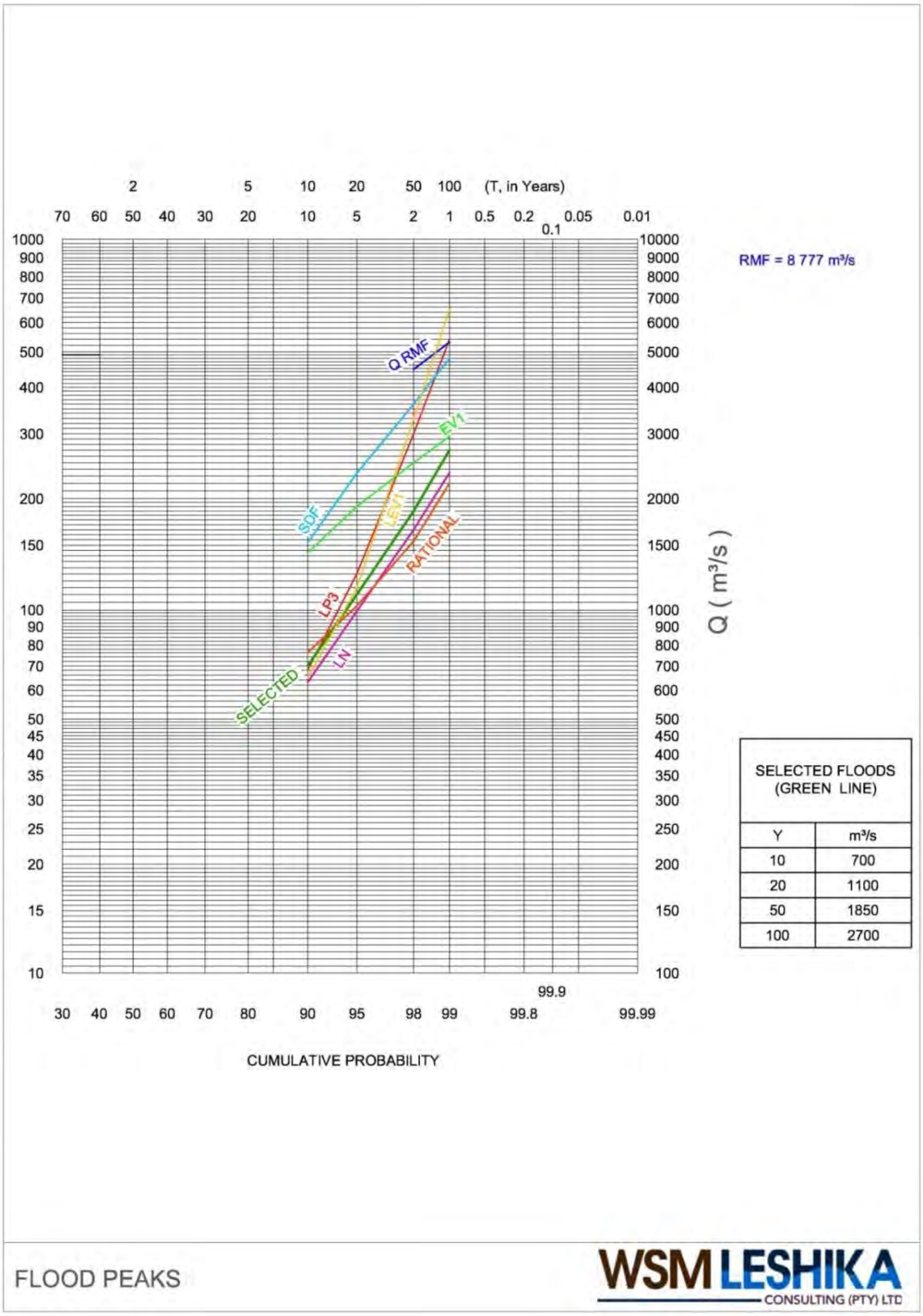

FIGURE 4.1: PRESENTATION OF FLOOD PEAK RESULTS FOR THE SAND RIVER.

4.3 Flood peak determination of major tributaries

The flood peak assessment of the major contributing rivers to the Sand River at the site, namely the Sandsloot (west) and another smaller tributary of the Sand River has been done by SRK Consulting (Pty) Ltd in November 2009 in their surface water report, Report Number 395099/SW/1.

The catchment characteristics for these two rivers were adopted from the mentioned report and applied to calculate peak flows to model and delineate the floodlines as shown in **Figure 3.11**above. The adopted information as reflected in Report Number 395099/SW/1 are shown in **Table 20** below (WSM Leshika Consulting has verified this information).

TABLE 20: CATCHMENT CHARACTERISTICS FOR THE MAJOR CONTRIBUTING RIVERS OF THE SAND RIVER

Catchment	Area (km^2)	Longest Watercourse (km)	10:85 Slope (m/m)	Tc (hours)
Entire Sandsloot	212	35	0.016	5.10
Right Tributary	19	7	0.005	2.15

The Alternative Rational Method as described in the SANRAL Drainage Manual (Kruger 2006), using the software developed by Sinotech cc (Utility Programs for Drainage, version 1.0.2), were used to calculate the flood peaks which are summarised in **Table 21** below:

TABLE 21: SELECTED FLOOD PEAKS FOR THE MAJOR CONTRIBUTING RIVERS OF THE SAND RIVER

Catchment	FLOOD PEAKS IN m^3/s (for recurrence interval in years)	
	1:50	1:100
Entire Sandsloot	400	484
Right Tributary	70	84

Hydraulic modeling of the site streams was performed by means of the Hec-Ras program with the draughting of the lines by “River Cad” software. A Manning roughness coefficient of 0,045 $s/m^{1/3}$ was used. The associated 1:100-year flood levels are shown on **Figure 7.2 and 7.3.**

4.4 Flood peak determination in the Mutamba River

The flood peak assessment of the Mutamba River to the east which contributes to the Nzhelele River some 30 km downstream of the site, was also done.

The catchment characteristics for Mutamba River as shown in **Figure 3.12** are summarised in **Table 22** below:

TABLE 22: CATCHMENT CHARACTERISTICS FOR THE MUTAMBA RIVER

DESCRIPTION	VALUE
Gross Catchment area (km^2)	248
Mean Annual Precipitation (mm)	470
Mean M2 rainfall value (mm)	64
Length of watercourse to boundary (km)	35.7
Average stream slope (m/m)	0.0207
10:85 Slope (m/m)	555
SDF Method Drainage Basin No	3

The Standard Design Flood method as described in the SANRAL Drainage Manual (Kruger 2006), using the software developed by Sinotech cc (Utility Programs for Drainage, version 1.0.2), was used to calculate the flood peaks and the results of the flood peak calculations are summarised in **Table 24** below:

TABLE 23: SELECTED FLOOD PEAKS FOR THE MUTAMBA RIVER

Catchment	FLOOD PEAKS IN m^3/s (for recurrence interval in years)	
	1:50	1:100
Mutamba River	590	760

The flood peaks above were used to model the flood zone widths using the HecRas software, as indicated by the 1:100-year flood line in **Figure 7.4**. Note that the 1:50 and 1:100-year flood zones are quite close and only the slightly wider 100-year zone is shown on the drawings.

5. ECOLOGY OF THE RIVERS AND STREAMS IN THE REGION

The information below was sourced from Kleynhans, Thirion&Moolman (2005).

5.1 Eco-regions

The Chapudi Project falls within the 2.02 and 2.03 second level eco-regions which are part of the first level Soutpansberg eco-region as shown in **Figure 5.1** below.

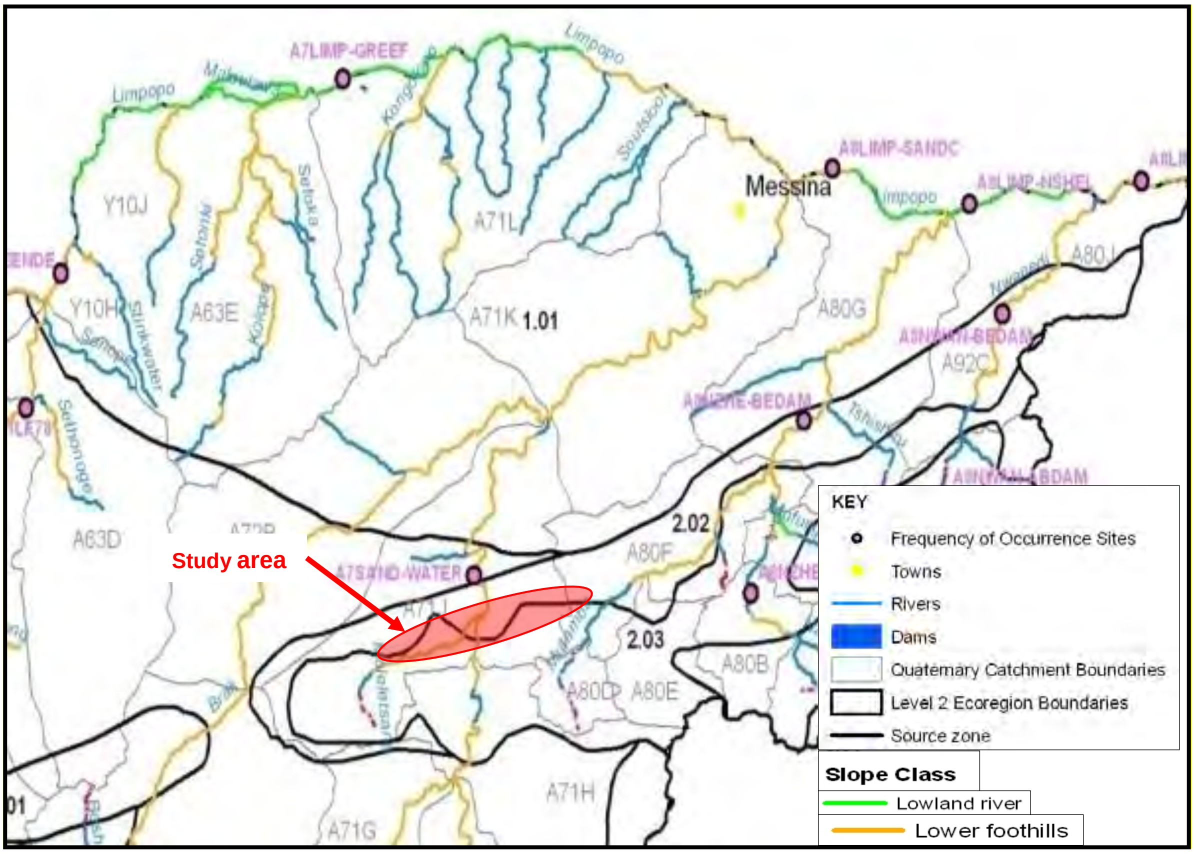

FIGURE 5.1: LOCATION OF THE STUDY AREA IN ECO-REGION

The Soutpansberg eco-region is a mountainous area characterised by moderate to high relief and vegetation consisting mainlyof Bushveld types but with patches of Afromontane Forest. The Blouberg to the west of theSoutpansberg is included in this region.

The characteristics of this eco-region are shown in **Table 24** below.

TABLE 24: CHARACTERISTICS OF THE SOUTPANSBERG LEVEL 1 ECO-REGION

MAIN ATTRIBUTES	**SOUTPANSBERG** (dominant types in bold)
Terrain Morphology: Broad division	Plains; Low Relief; (limited) Plains; Moderate Relief; (very limited) Lowlands; Hills and Mountains; Moderate and High Relief; **Closed Hills; Mountains; Moderate and High Relief;**
Vegetation types (Primary)	**Sour LowveldBushveld;** **Soutpansberg Arid MountainBushveld;** MopaneBushveld (very limited) Patches AfroMontane Forest.
Altitude (m a.m.s.l.)	300-1700
MAP (mm)	200 to 1000
Coefficient of variation (% of annual precipitation)	<20 to 40
Rainfall concentration index	55 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to >22
Mean daily max temp (°C) February	22 to 32
Mean daily max temp (°C) July	16 to >24
Mean daily min temp (°C) February	14 to >20
Mean daily min temp (°C) July	4 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 to 200; >250 (limited)

Source: (Kleynhans CJ, Thirion C, Moolman, J 2005).

The characteristics of eco-region 2.02 are shown in **Table 25** below.

TABLE 25: CHARACTERISTICS OF THE SOUTPANSBERG LEVEL 2.02 ECO-REGION

MAIN ATTRIBUTES	**SOUTPANSBERG 2.02** (dominant types in bold)
Terrain Morphology: Broad division	Plains; Low Relief Plains; Moderate Relief **Lowlands; Hills and Mountains; Moderate and High Relief;**
Terrain Morphology	Plains; Slightly undulating plains Extremely irregular plains (low hills) and pans Lowlands with hills
Vegetation types (Primary)	**Soutpansberg Arid MountainBushveld;**
Altitude (m a.m.s.l.)	300-900 (900-1700 limited)
MAP (mm)	200 to 500
Coefficient of variation (% of annual precipitation)	<25 to 39
Rainfall concentration index	60 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to >22
Mean daily max temp (°C) February	24 to 32
Mean daily max temp (°C) July	18 to >26

Mean daily min temp (°C) February	18 to >20
Mean daily min temp (°C) July	4 to >10
Median annual simulated runoff (mm) for quaternary catchment	<5 (limited) to 40

Source: (Kleynhans CJ, Thirion C, Moolman, J and Gaulana, L 2005).

The characteristics of eco-region 2.03 are shown in **Table 26** below.

TABLE 26: CHARACTERISTICS OF THE SOUTPANSBERG LEVEL 2.03 ECO-REGION

MAIN ATTRIBUTES	**SOUTPANSBERG 2.03**(dominant types in bold)
Terrain Morphology: Broad division	Plains; Low Relief **Closed Hills; Mountains; Moderate and High Relief;;**
Terrain Morphology	Slightly undulating plains **Low Mountains**
Vegetation types (Primary)	Soutpansberg Arid Mountain Bushveld;
Altitude (m a.m.s.l.)	300-1500
MAP (mm)	300 to 700
Coefficient of variation (% of annual precipitation)	20 to 34
Rainfall concentration index	60 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to >22
Mean daily max temp (°C) February	22 to 32
Mean daily max temp (°C) July	16 to >24
Mean daily min temp (°C) February	14 to >19
Mean daily min temp (°C) July	4 to >9
Median annual simulated runoff (mm) for quaternary catchment	5 to 10; 20 to 100; (80 to 100 limited); 150 to 200 (limited)

Source: (Kleynhans CJ, Thirion C, Moolman, J and Gaulana, L 2005).

5.2 Status of river systems in the area

Water resources are generally classified according to the degree of modification or level of impairment. The classes, used by the South African River Health Program (RHP), are presented in **Table28** below and will be used as the basis of classification of the systems in future field studies.

TABLE 27: CLASSIFICATION OF RIVER HEALTH ASSESSMENT CLASSES IN LINE WITH THE RHP

Class	Description
A	Unmodified, natural
B	Largely natural, with few modifications
C	Moderately modified
D	Largely modified
E	Extensively modified
F	Critically modified

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined and it serves as a useful guideline in determining the importance and sensitivity of the aquatic ecosystems.The results are summarised in **Table 29**.

TABLE 28: SUMMARY OF THE ECOLOGICAL STATUS OF QUATERNARY CATCHMENTS A71J, A71H AND A80F

Catchment	Resource	EIS	PEC	DEMC
A71J	Sand River	Low/Marginal	Class B	D: Resilient system
A80F	Nzhelele River	High	Class D	B: Sensitive system

Source: Kleynhans, 1999

A71J

According to the ecological importance classification for the quaternary catchment, the system can be classified as a resilient system which, in its present state, can be considered a Class B (largely natural) stream.

The points below summarise the impacts on the aquatic resources in the A71J quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been moderately affected by bed modification as a result of erosion, grazing and sedimentation within the catchment.
- Flow modification within the catchment is considered very low.

- Marginal impacts from inundation of the system occur as a result of weirs within the catchment.
- Riparian zones and stream bank conditions are considered to be moderately impacted by erosion, grazing and sedimentation.
- A very low impact occurs as a result of the introduction of in-stream biota.
- Impacts on water quality in the system are considered very low.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- The riverine systems in this catchment have a marginal diversity of habitat types.
- The site has a very low importance in terms of conservation.
- The riverine resources in this system have no intolerance to flow and flow related water quality changes.
- The aquatic resources in the area have a marginal importance in terms of migration of species.
- The system is considered to be of no importance in terms of rare and endemic species conservation.
- The aquatic resources in this catchment are marginally important in terms of the provision of refuge areas.
- The riverine resources in this system have a low sensitivity to changes in water quality and flow.
- The aquatic resources in this area are of moderate importance in terms of Species/Taxon richness with up to 10 different species present.
- The system is of no importance with regards to unique or endemic species.

A80F

According to the ecological importance classification for the quaternary catchment, the system can be classified as a Sensitive system which, in its present state, can be considered a Class D (largely modified) stream.

The points below summarise the impacts on the aquatic resources in the A80F quaternary catchment (Kleynhans 1999):

- The aquatic resources within this quaternary catchment have been marginally affected by scouring of the system.

- Flow modification within the catchment is considered very high due to the control of flow by a dam upstream.
- Marginal impacts from inundation of the system occur.
- Riparian zones and stream bank conditions are considered to be moderately impacted by erosion.
- A low impact occurs as a result of the introduction of in-stream biota with special mention of Azzola sp. (Water Fern) and Cyprinus sp. (Carp).
- Impacts on water quality in the system are considered high as water released by the dam has a modified temperature and quality.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- The riverine systems in this catchment have a high diversity of habitat types.
- The site has a moderate importance in terms of conservation with special mention of a gorge in the system.
- The riverine resources in this system have a moderate intolerance to flow and flow related water quality changes.
- The aquatic resources in the area have a high importance in terms of migration of species and form a transition zone between mountain and lowveld. Special mention is made of the migration of eels, fish and birds.
- The system is considered to be of high importance in terms of rare and endemic species conservation. Some species may occur upstream of Nzhelele Dam.
- The aquatic resources in this catchment are moderately important in terms of the provision of refuge areas.
- The riverine resources in this system have a moderate sensitivity to changes in water quality and flow. The gorge area is particularly sensitive to changes in flow.
- The aquatic resources in this area are of high importance in terms of Species/Taxon richness with up to 16 different species present.
- The system is of high importance with regards to unique or endemic species with special mention of Barbuseutenea (Orangefin Barb), Barbuslineamaculatus (Line-spotted Barb) and Barbusmaculatus.

6. DESCRIPTION OF EXPECTED IMPACTS AND GENERALISED MITIGATION MEASURES IN OPEN CAST COAL MINES

6.1 Generalised expected impacts

6.1.1 Impact of the proposed development on site streams and drainage lines

The surface water impacts of the Project can be divided into two aspects, namely:

- Impacts on surface water quantity
- Impacts on surface water quality

It should however be kept in mind that water quality is naturally linked to water quantity due to the fact that changes in water quantity are likely to affect the dilution of pollutants. Please note that reference made to the major rivers include the Sandsloot/Moleletsane, Sand, Tributary of Sand and the Mutamba Rivers.

6.2 Impacts on quantity

6.2.1 Impact on mean annual run-off to major rivers

Mean annual run-off (MAR) from the Project site into the major rivers is anticipated to be primarily affected by the following:

- Direct rainfall in the opencast pits. Rain falling directly into the pits will collect in a sump at the bottom of the pit/s and thus be polluted. This water may be recycled for use, or evaporated in dirty water dams, thereby decreasing the MAR.
- Run-off from stockpiles. Rain falling directly onto the ‘dirty’ stockpiles will either seep into the stockpile or run-off the sides of the stockpile. Any run-off or horizontal seepage from the stockpile will be captured in control dams or a leaching system for water quality control reasons, and thus subsequently be prevented to discharge to tributaries and into the major rivers.
- Concentration of flow when run-off is intercepted by canals. The canal system will intercept run-off that would otherwise have flowed naturally over the ground surface until reaching a defined watercourse. Vegetation and surface topography, particularly in flatter areas, would in the natural state have encouraged interception and infiltration.

- Once water has been intercepted by a canal however, no further interception or infiltration is likely until the canal discharges the flow into a watercourse. Even once discharged back into a watercourse, the concentration of flow would still discourage interception and infiltration. There is thus likely to be a marginal increase in MAR resulting from the construction of the canal system.

6.2.2 Change to peak flow rates in the major rivers during flood conditions

A substantial increase to the peak flow of flood events in the rivers could cause erosion and change in channel character and dimensions, destroy riverine vegetation, alter bed roughness and cause eroded sediment to be deposited downstream.

It is expected that Project activities will cause a change to peak flows in the receiving rivers downstream of the Project site, due to the following factors:

- Change in surface coverage. Development of the Project area will change the surface coverage in some areas from vegetated soil to buildings, hardened gravel roads, paved areas (parking), and compacted earth. These new surface types will allow somewhat less infiltration into the soil, resulting in more surface run-off following storms and consequently higher local peak flow rates.
- Capture of run-off. Capture of rainfall in the ‘dirty’ area would lower peak flow rates.
- Canalisation of run-off. Intercepting run-off from the hill-slopes above the opencast pits and canalising the flow could reduce the amount of time that water would take to reach the major rivers. This is due to the decreased friction on the water associated with concentrated flow in a concrete-lined canal as opposed to sheet flow on the hill slopes, and the consequently lower flow velocities. In technical terms, the time of concentration would be reduced, reducing the time of concentration results in higher peak flow rates. This effect is dependent on the design of the canalisation system, as increasing the length of flow paths, and implementing other detention measures, could negate this effect.

6.2.3 Drying up of tributaries and establishment of new watercourse due to canalisation

A cut-off canal system is required to separate unpolluted (‘clean’) and polluted (‘dirty’) water, which is a positive intervention. However, intercepting the tributaries that flow from the water divide across the mining areas, and redirecting them via canals around the pits, will starve those same water courses of water along their reach between the point of interception and the major rivers.

Furthermore, if the canals only extend as far as to route water around the outer edge of the opencast pits, then concentrated volumes of water will be discharged at point locations on the hill slopes. Also, the soils most susceptible for erosion are those where sandy topsoil overlies more clayey, usually structured subsoil.

When considered together, this information suggests that the soils on the hill slopes are particularly prone to erosion. Hence rather than dispersing out over the surface, the concentrated flow at the canal discharge points would erode gulleys into the soil and carry silt into the major rivers, impacting on water quality.

6.2.4 Impact of pit dewatering

In general, the impact of pit dewatering would be to lower the surrounding water table. In the case of Chapudi Mine, the drawdown may be in the order of 100 m. This would reduce the contribution of groundwater to surface flow on the one hand and, on the other, directly reduce surface water flow by inducing a drawdown on surface water levels.

6.3 Impacts on quality

The philosophy supporting the following section of the report is that if all constituents in the cumulative discharge from the Project site are within the applicable target water quality ranges, then the Project activities will not contribute significantly to an unacceptable cumulative impact.

The converse of this statement is not necessarily true, as different activities within the catchment may discharge different pollutants at different concentrations, and the dilution effect may mean that a constituent that is out of the target water quality range in the cumulative discharge from the Project site is within the target water quality range when the discharge is combined with the major rivers flow itself.

However the Precautionary Principle requires that a conservative approach be taken, in this case to account for possible discharge of pollutants by future activities in the river catchment, and therefore the dilution effect of the major rivers cannot be relied upon.

6.3.1 Increased sediment load in the major rivers

In the natural state of the project site, vegetation cover causes friction to rainfall run-off, that reduces flow velocities and consequently shear forces between the water and the ground surface, resulting in the ground surface remaining intact and not being eroded away. If for any reason flow velocities are increased, there is potential for increased erosion to occur.

Increased erosion means that the run-off contains a higher silt or sediment load, which is discharged to the major rivers. A component of this sediment load is particles fine enough to remain in suspension, 'clouding' or 'muddying' the water.

The extent of this effect can be quantified by measuring a water quality parameter, viz. suspended solids. If there are too many suspended solids in the water this can negatively affect biological life.

In addition, a changed sediment load could have similar morphological effects to the river as changing peak flow rates, such as changes in channel character or dimensions and changes to bed roughness. All of these changes could potentially affect biological life.

The following activities are likely to cause an increase in flow velocities, or directly increase erosion:

- Stripping (vegetation clearance) of mining areas prior to excavation of pits;
- Construction of hard-standing areas that increase run-off volumes, including roads, buildings and paved areas;
- Canalisation of run-off, particularly if canals do not discharge directly into the major rivers; and
- Construction activities that loosen the ground surface.

Furthermore, if run-off from the stockpiles is uncontrolled, such run-off would likely contain a high sediment load due to the fine particles in the waste product resulting from the ore crushing process.

It can thus be stated that without any mitigation measures, the sediment load in the major rivers will increase as a result of mining activities associated with this Project.

6.3.2 Impaired water quality due to pollutants discharged from processing plant

Wastewater from the coal ore beneficiation process would contain pollutants in excess of the target water quality ranges for the water uses of the receiving water body and discharge of this would impact negatively on the surface water quality. A further consideration is the run-off of pollutants from the process plant area following rainfall, due to the activities within that area.

6.3.3 Impaired water quality due to pollutants run-off from stockpiles

It is likely that run-off from the stockpiles will have a different chemical composition to natural run- off. In this event it is best practice to keep 'dirty' water from stockpile run-off separate from 'clean' water from natural run-off.

6.3.4 Impaired water quality due to pollutants in water discharged from opencast pits

Overflow of water (decant), whether surface or ground, from the pits could release pollutants to the surface water environment if geochemical testing indicates a possible acid mine drainage or other water quality issue.

6.3.5 Impaired water quality due to petrochemical spills

Fuel or oil spills from vehicles could contaminate surface water resources. Leakages, spills or run-off from vehicle wash bays, workshop facilities, fuel depots or storage facilities of potentially polluting substances could contaminate surface water resources.

6.4 Generalized mitigation measures

- Diversion of streams and drainage lines: The water quality of re-routed streams should be maintained by preventing scour of bed material, therebyminimising turbidity during flood conditions. Lining of the canals and/or energy dissipating structures may be required at steep slopes.

- Impact of the proposed mining development on surface water runoff quantity: The area of the open pits should be kept as small as possible to minimize the reduction in runoff.

- Impact of the proposed mining development on surface water runoff quality: By adhering to the requirements of GN 704 and implementing a design along the guidelines provided in the Best Practice Guidelines, the water quality will not be polluted by mining activities. However, care should be taken in the mining development phase to restrict the clearing of land to the minimum required. In this phase, while erosion control measures are being implemented, the highest risk of erosion damage occurs. This will lead to high turbidity levels and increased sediment in the drainage lines and streams.

- In the event of major floods causing failure of the system, the dilution effect may minimise the impact.

- Other types of failures should be prevented by proper management and maintenance of the system.

- Impact of the dirty water areas on water quality: By adhering to the requirements of GN 704 and following the best practice guidelines, as would be required in the licensing application, dirty water is contained and water available after evaporation losses will be re-used.

- In case of accidental spillages, especially of hydro carbons and of coal, specialized equipment should be available on site to mop up the pollutants before irreversible damage is caused. Else, specialized contractors may be used to fulfill this function.

- Off-setting the loss of wetlands: The creation of small impoundments at the head of stream diversions, where appropriate, may be considered. These low structures (earth or gabion embankments) will lower the approach velocity and contain sediment, thereby delivering relatively clean water at acceptable velocities into the canal system. In time wetlands will be formed behind the embankments.

- Impact of surface water use: At this stage of the investigations, the large-scale development of a surface water source for use by the mine does not appear feasible. Therefore surface water use would be limited to the direct rainfall on open pits, increased evaporation loss and a small quantity to be stored for use in the dirty water area control dam.

- Limiting erosion at drainage structures, e.g. design and install appropriate outlet structures to retard the flow velocity.

7. PROPOSED MINING SITE STORMWATER DRAINAGE SYSTEMS

7.1 Background

A conceptual layout of the required system has been done, based on the requirements in the Best Practice Guideline G1: Stormwater Management, DWAF, August 2006, using the available mining layouts as at July 2013.

Note that the conceptual layouts do not take the timeline into account. Over the life of a pit, intermediate systems may be installed to shorten flow paths. We have assumed that no drainage structures may cross over rehabilitated zones and therefore long diversion structures around the continuous pits are required. Furthermore, we have indicated mostly the major systems required to contain dirty water and divert clean water around sensitive areas. In the operational phase, more nominal sized conduits and ponds may be required which are not indicated in the conceptual, small-scale layout.

The non-carbonaceous dumps all require paddocks (or a form of silt trap) at the toe to prevent the transport of sediment to streams and rivers. If feasible, the tops of the dumps should be dished and/or provided with a low berm on the edge to retain rainwater which should evaporate quickly in the hot, dry summers. In this climate where there may not always be enough water in dry spells to establish and/or maintain vegetation on the sides of the dumps, erosion down the slopes will occur and should be controlled. This can be achieved by providing relatively flat side slopes and back-slope terraces at carefully selected intervals.

The carbonaceous stockpiles should all be provided with impermeable liners and dirty water collector drains to discharge into the dirty water system leading to holding ponds.

The proposal locality of the carbonaceous, non-carbonaceous and topsoil stockpiles are generally not positioned to be hydraulically favourable, meaning that the current placement of the stockpiles would create numerous additional ponds, berms and canals. Therefore it is proposed that the footprints of the stockpiles be reshaped hydraulically so that the extent of the footprints acts as drainage basins that allow dirty stormwater runoff to converge to a single point at a lower elevation within the footprints and at the same time diverting clean stormwater runoff around the footprints back to its natural flow paths. **Figure 7.1** shows the current mining layout.

Chapudi Project

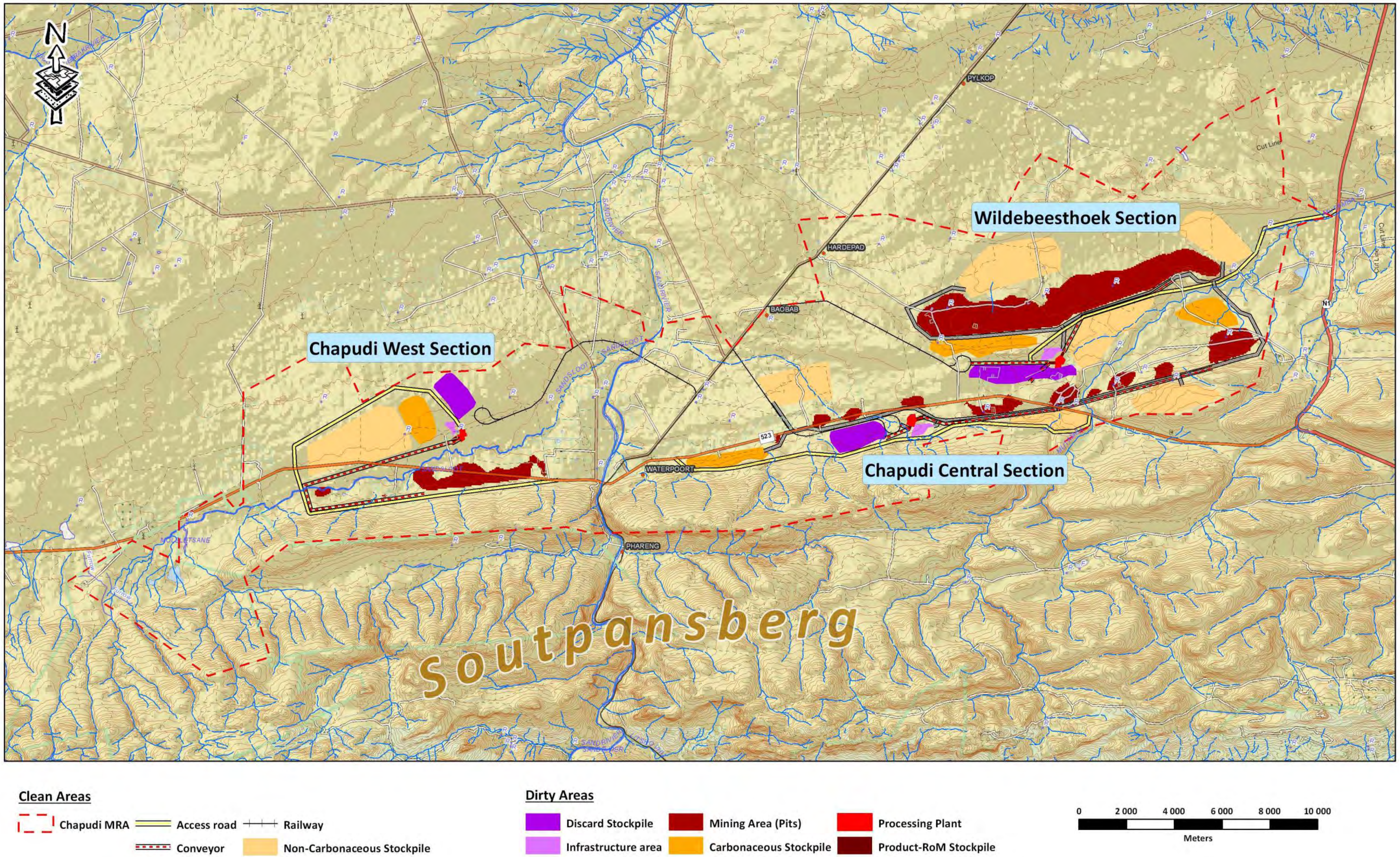

FIGURE 7.1: MINING LAYOUT

7.2 Drainage characteristics

The central section of the Chapudi project is located north of the Soutpansberg mountain range and east of the Sand River. The Mutamba River also meanders through the eastern part of the mining area. The mining area footprints extend across both of these two catchment areas and hence two drainage patterns exist within this mining section. The Sand River catchment section has a dendritic to parallel drainage pattern which drains north to westwards into the Sand River and the Mutamba River catchment section has a dendritic pattern that drains in a north-eastwards direction into the Mutamba River.

The western section of the Chapudi project is also located north of the Soutpansberg mountain range but west of the Sand River with the Sandsloot River meandering through the mining area. The Sandsloot River's catchment area has a sub-parallel drainage pattern with virtually no defined streams north of the Sandsloot River.

The Wildebeesthoek section of the Chapudi project is located just north of the proposed central mining section and borders the Mutamba River banks on its south-eastern boundary. Minimal drainage lines traverse the proposed mining area and this section would thus have the smallest effect on the stormwater system.

7.3 Localised stormwater impacts for the Chapudiproject

Apart from the two major impacts as identified in Section 6.1 above, it is commonly accepted that all the dirty areas of the proposed mining infrastructure will have a negative impact on the surface water quality, if no mitigation measures were to be implemented.

The impacts that may affect the surface water runoff due to mining activities are generic in nature and are thus classified as either a type A or a type B impact.

Impact A

According to GN 704 no mining activities may take place within 100m from a water course or within the 1:50 year floodline, whichever is the greatest. Furthermore, no facility such as ponds/reservoirs and residue deposit may be placed within the 1:100-year floodline. Note that due to the fact that the 50-year and 100-year floodlines are usually fairly close (i.e. it would reflect as a single line on small-scale drawings), only the 100-year floodlines are used to delineate the "no-go" zones.

Impact B

The proposed mining infrastructure layout may cause an obstruction to the natural drainage regime of a particular stream or river, which in turn could eliminate the contribution of that stream or river to the larger drainage system further downstream.

Figure7.2, Figure 7.3and **Figure7.4** below shows the position of possible impacts that were identified at the Chapudi Central section, Chapudi West section and the Wildebeesthoek Section respectively.

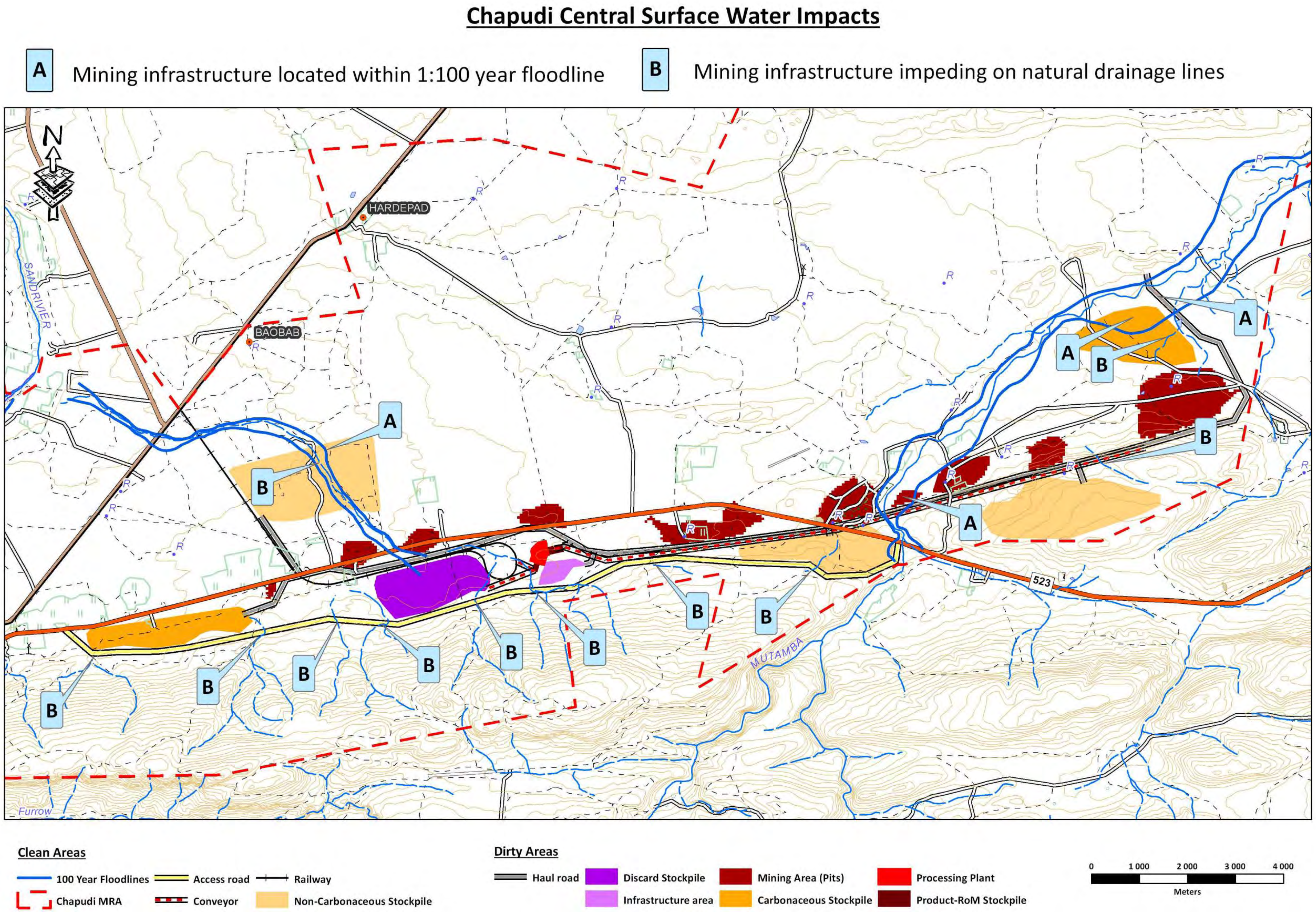

FIGURE 7.2: CHAPUDI CENTRAL : LOCALITIES OF POSSIBLE IMPACTS

Chapudi West Surface Water Impacts

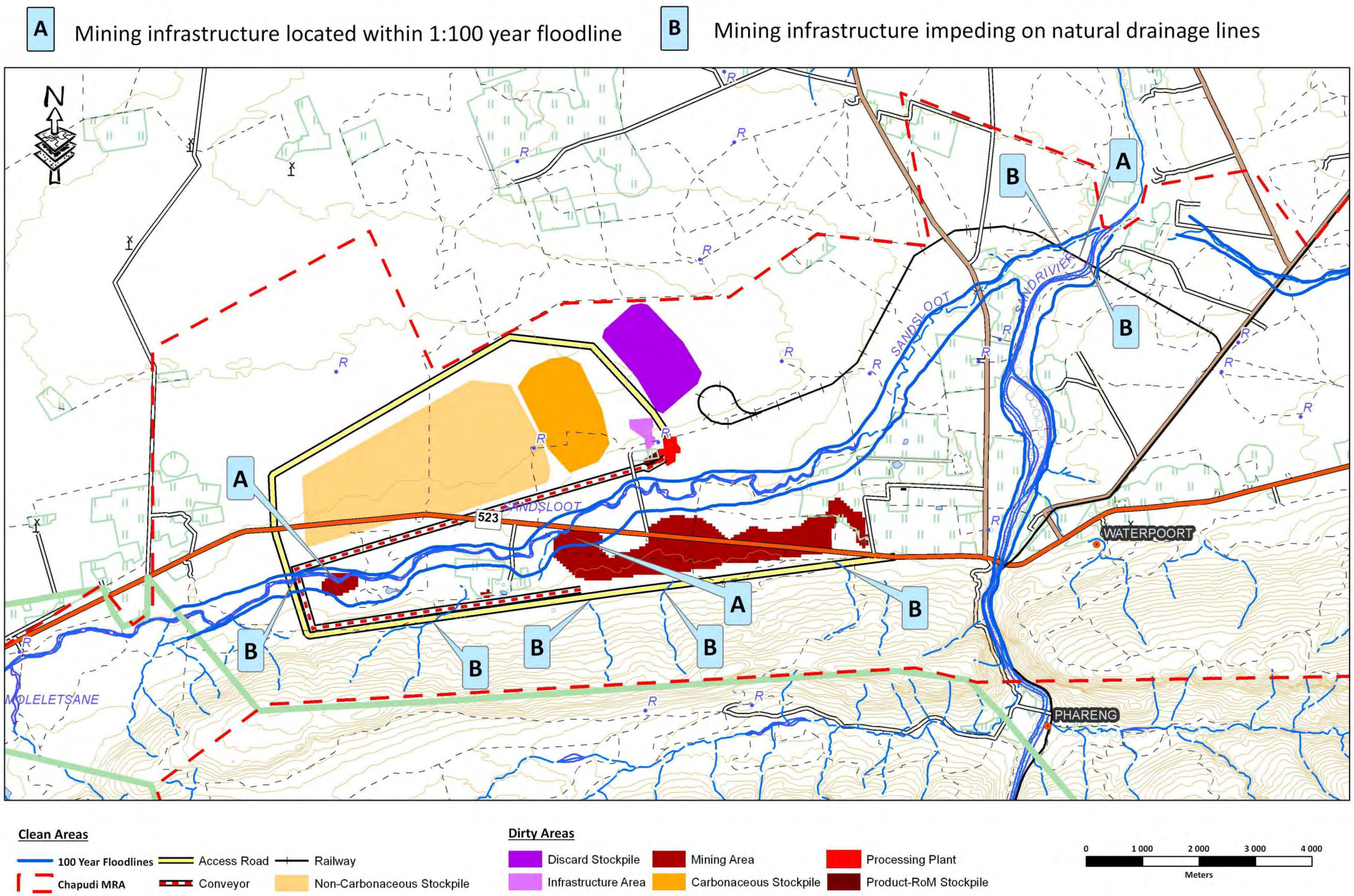

FIGURE 7.3: CHAPUDI WEST : LOCALITIES OF POSSIBLE IMPACTS

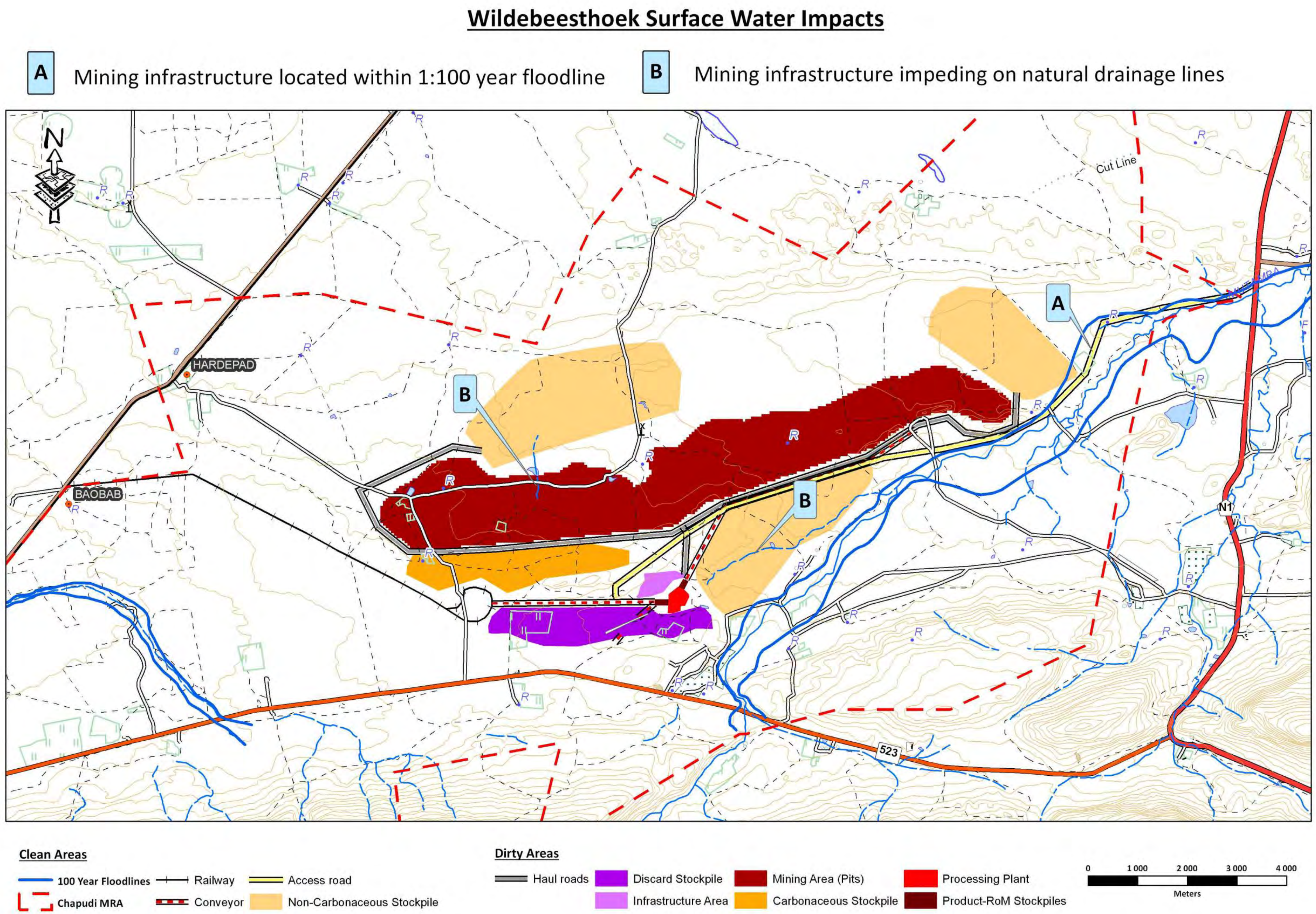

FIGURE 7.4: WILDEBEESTHOEK: LOCALITIES OF POSSIBLE IMPACTS

7.4 Localised stormwater mitigation measures for the Chapudi project

As a general mitigation measure, it is proposed that all access and haul roads be constructed so as to also act as diversion berms and canals.

It is also proposed that runoff at all dirty areas be contained by dirty water berms and excess water be drained by canals (if no access road or haul road can fulfill this function) to discharge dirty stormwater to the proposed dirty water ponds.

Table 30 below shows the various types of localised mitigation measures that are proposed.

TABLE 29: LOCALISED MITIGATION MEASURE TYPES

MITIGATION MEASURES	
I	Revise mining and/or stockpile footprints **to avoid the 1:100 year floodline**or the 100m buffer zone, whichever is applicable. The 100m Buffer Zone normally only applies where the 1:100 year floodline is not shown.
II	Design **bridge/culvert over drainage lines** and determine the change in normal flood levels. If an adverse impact occurs, the structure(s) should be enlarged.
III	Construct **clean water** cutoff berms and canals.
IV	Construct **dirty water** berms.
V	Construct **dirty water flood attenuation or storage ponds.**
VI	Relocate and/or hydraulically **reshape mining infrastructure.**

Figures 7.5, 7.6 and 7.7 below shows the localities of the mitigation measures that are proposed for the Chapudi Central Section, the Chapudi West Section and the Wildebeesthoek Section respectively, with reference to**Table 30** above.

Chapudi Central Mitigation Measures

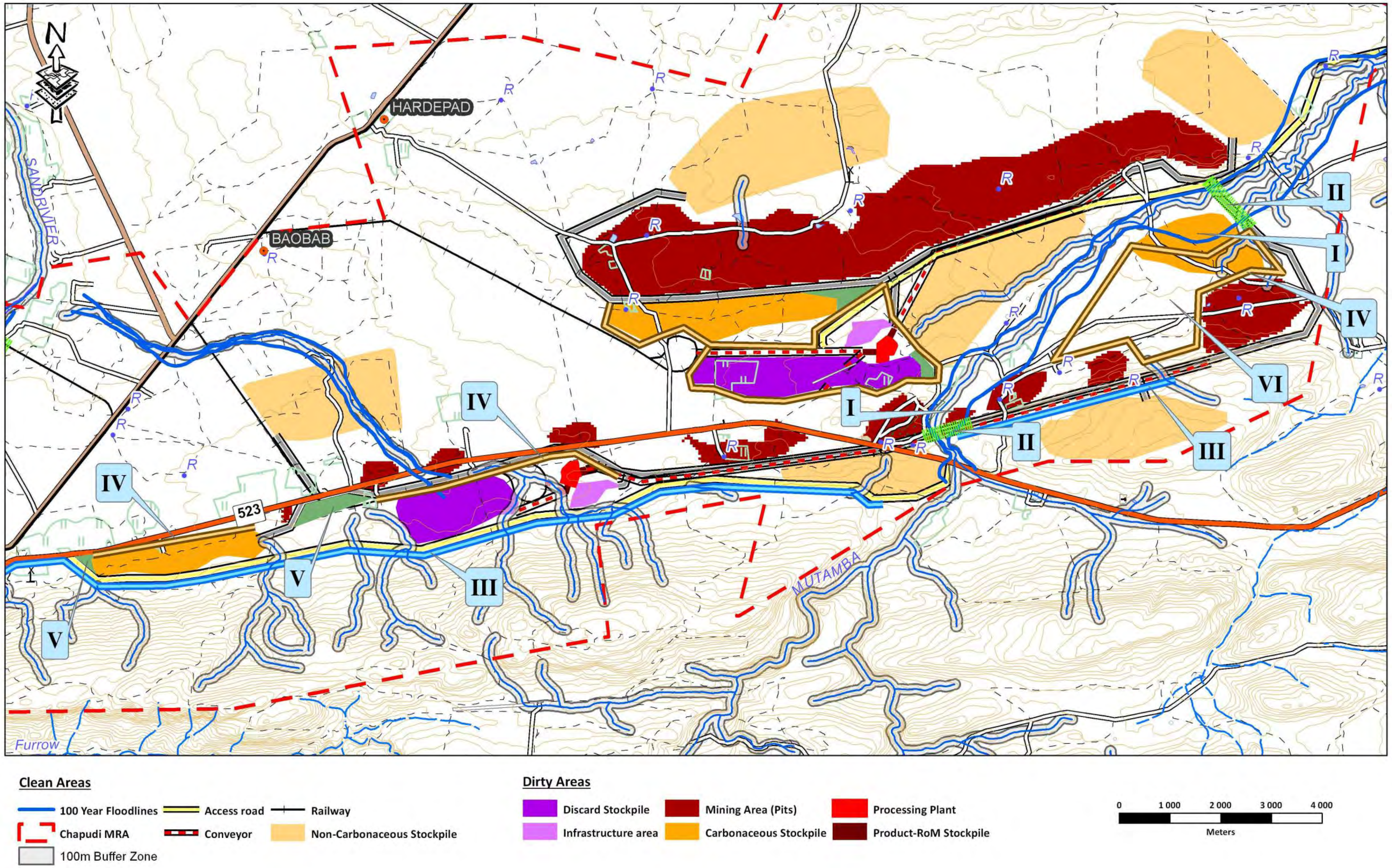

FIGURE 7.5: PROPOSED MITIGATION MEASURES: : CHAPUDI CENTRAL

Chapudi West Mitigation Measures

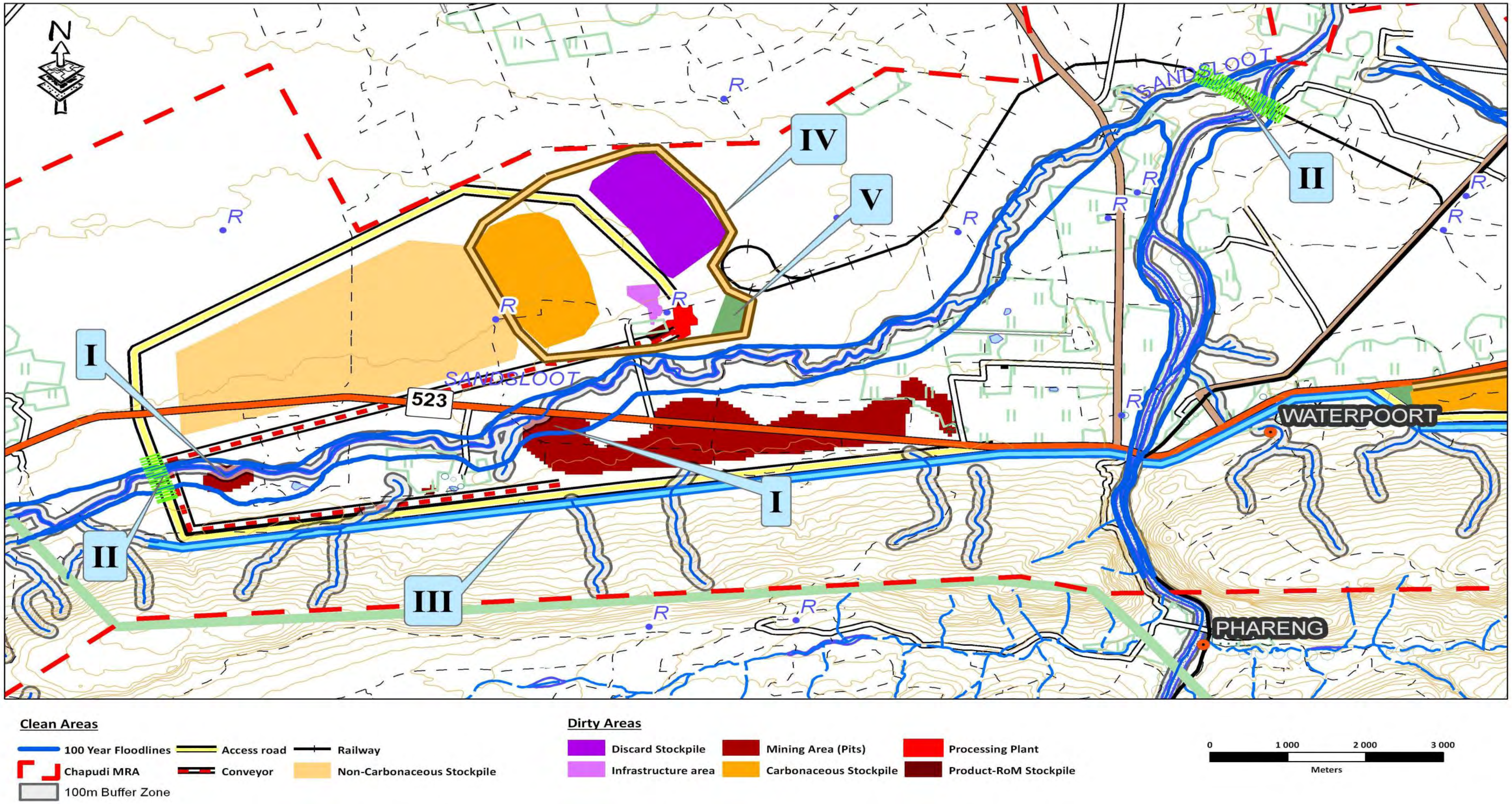

FIGURE 7.6: PROPOSED MITIGATION MEASURES :CHAPUDI WEST

Wildebeesthoek Mitigation Measures

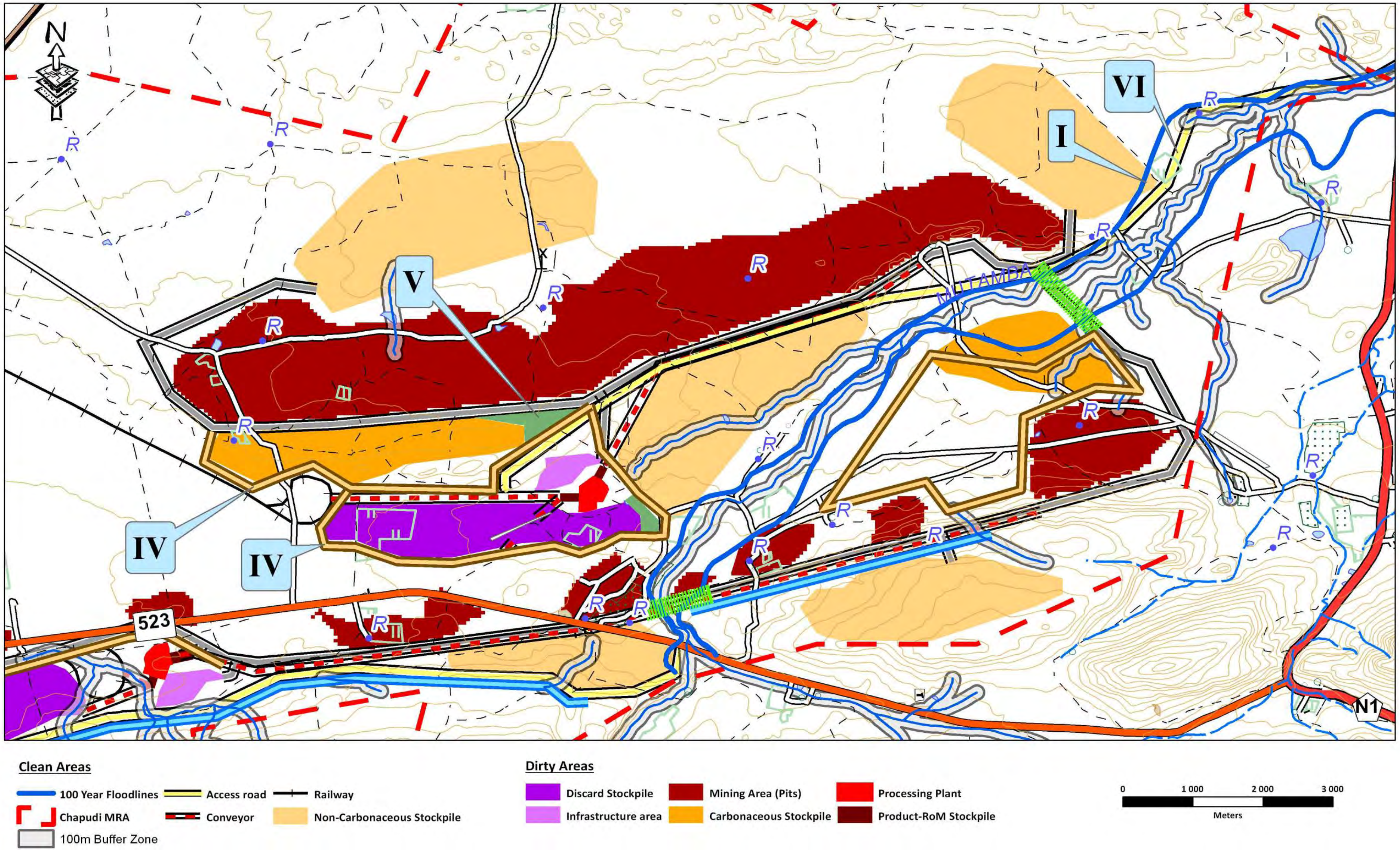

FIGURE 7.5: PROPOSED MITIGATION MEASURES: WILDEBEESTHOEK

8. IMPACT OF THE PROPOSED DEVELOPMENT ON SURFACE WATER

Section 6 above describes the generalized impacts and proposed mitigation measures at opencast coal mines, whereas **Section 7** describes the expected localized impacts and mitigation requirements at the Chapudi development.The impacts on the surface water systems within the Sand River Basin and Mutamba River (Nzhlele River Basin) are discussed in this section.

A vital part of the stormwater system is the prevention of pollution by separating dirty water areas from clean stormwater systems. Therefore polluted runoff from the plant areas and dumps has to be collected in dirty water systems for storage and re-use as prescribed by law. If the system is properly implemented and maintained, the impact of the "dirty water" areas will be limited to a reduction in runoff. Coal of Africa has a stated policy of striving for zero effluent discharge and if this is achieved and maintained over the life of the mine the impact on surface water quality will be minimal.

8.1 Impact of the proposed mining development on surface water runoff

Rainwater falling on the open portions of the pits will be collected as dirty water and be re-used. Likewise, seepage and surface water runoff from the carbonaceous dumps will be collected as dirty water.

The total reduction in runoff shown in **Table 30** and **Table 31** for the Sand River and Mutamba Rivers respectively is for the worst case scenario at the end of the life of the mine, assuming that <u>no rehabilitation</u> of the pits has been done and the carbonaceous dumps and plant areas retain polluted runoff.

For the Sand River Basin, the cumulated impact has a reduction in annual runoff of 318 427 m^3/annum, or 0.33% of the MAR of the downstream **quaternary catchment A71J**. The theoretical impact on runoff in the **Sand River** just downstreamof the mining activities, based on the *naturalized* runoff estimates amounts to 0.56%. With the actual cumulated runoff in the Sand River expected to be smaller than the naturalized runoff due to upstream water use, the actual impact would be a larger percentage

TABLE 30: ESTIMATED IMPACT* OF PROPOSED MINE ON SURFACE WATER RUNOFF IN QUATERNARY CATCHMENT AREA A71J

DESCRIPTION	AFFECTED AREA (ha)	% OF SITE AREA	RUNOFF INTERCEPTED** (m^3/a)	% OF MAR of A71J	% OF MAR IN SAND RIVER***
Opencast mining (all pits)	861	12.4	83 398	0.09	
Plant dirty water area, plus haul roads	2051	29.4	198 738	0.21	
Carbonaceous dump area	375	5.4	36 291	0.04	
TOTAL FOR SITE	3 286	47.2	318 427	0.33	0.56

* Based on worst case scenario with no rehabilitation in place

** Based on 9.69 mm runoff, the average for A71J

*** MAR = 57.13 million m^3/a

For the Mutamba River, the cumulated impact has a reduction in annual runoff of 283 530 m^3/annum, or 0.41% of the MAR of the downstream quaternary catchment A80F. The impact on the naturalized runoff in the Mutamba River is a low 0.41% and similar to the discussion above for the Sand River Basin, the actual impact in terms of percentage of the runoff may be higher. In the absence of flow gauges in the river, a more reliable estimate can not be made of this quantity.

TABLE 31: ESTIMATED IMPACT* OF PROPOSED MINE ON SURFACE WATER RUNOFF IN QUATERNARY CATCHMENT AREA A80F

DESCRIPTION	AFFECTED AREA (ha)	% OF SITE AREA	RUNOFF INTERCEPTED** (m^3/a)	% OF MAR of A80F
Opencast mining (all pits)	1187	17.0	81418	0.12
Plant dirty water area, plus haul roads	2525	36.2	173186	0.25
Carbonaceous dump area	422	6.1	28 925	0.04
TOTAL FOR SITE	4133	59.3	283530	0.41

* Based on worst case scenario with no rehabilitation in place

**Based on 6.86 mm runoff, the average for A80F

8.2 Potential impacts of utilizing or developing a surface water supply source

As described in **Section 3.5.4**, flow in both the Sand River and Mutamba River is highly ephemeral and in the absence of large dam sites, cannot be utilised as a surface water source. The water requirement for the Chapudi Project, at the peak production rate, is estimated to be 11 000 m^3/day. At this stage, the water supply will probably be from the following sources:

- Groundwater (boreholes and seepage into the pits)
- Stormwater runoff impounded on site
- An external source piped to site

It is recognised that stormwater is a seasonal event and its contribution to the demand will be small and inconsistent. It has therefore not been included as a source in the water-supply scheme and thus the impact on water quantity is limited to the estimated amounts shown in **Tables 30 and 31**.

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