Appendix I: Hydrology

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/
NEAS Reference Number:	DEAT/EIA/
Date Received:	13 May 2014

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED CONTINUOUS ASH DISPOSAL FACILITY FOR THE MATIMBAPOWER STATION IN LEPHALALE, LIMPOPO PROVINCE

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4.2 The specialist appointed in terms of the Regulations_

I, KAREN KING, declare that –

General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

GCS WATER AND ENVIRONMENTAL CONSULTANTS (PTY) LTD.
Name of company (if applicable):

13 MAY 2014
Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED CONTINUOUS ASH DISPOSAL FACILITY FOR THE MATIMBAPOWER STATION IN LEPHALALE, LIMPOPO PROVINCE

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4.2 The specialist appointed in terms of the Regulations_

I, Hassen Khan, declare that –

General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

[signature]

Signature of the specialist:

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Matimba Ash Disposal and Conveyor: Hydrological Assessment Report

Version - 4

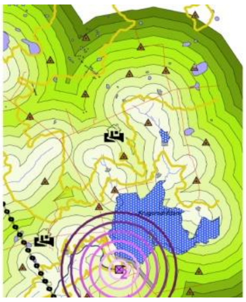
13 April 2015

Royal Haskoning DHV

GCS Project Number: 14-053

Client Reference: 14-053




Matimba Ash Disposal and Conveyor: Hydrological Assessment Report

Report: Version – 1

14-053

13 April 2015

DOCUMENT ISSUE STATUS

Report Issue	Draft		
GCS Reference Number	GCS Ref – 14-053		
Client Reference	14-053		
Title	**Matimba Ash Disposal and Conveyor: Hydrological Assessment Report**		
	Name	Signature	Date
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EXECUTIVE SUMMARY

GCS Water and Environment (Pty) Ltd. (GCS) has been appointed by Royal Haskoning DHV to conduct a hydrological assessment of the site, risk assessment on the risks to and from surface water as a result of the proposed infrastructure, Storm Water Management Plan (SWMP), water quality monitoring plan and a water and salt balance for the Matimba Continuous ash disposal facility project. The scoping phase of this study identified two potential sites (Alternative 1 and 2) for the ash disposal facility, within a radius of 8km of the Matimba Power Station which can be viewed in Figure 4.1. Royal Haskoning DHV further requested a SWMP for a linear infrastructures route to Alternative site 2. Both potential sites and associated linear infrastructures route to Alternative site 2 have thus been assessed within this report. The study area is situated near Lephalale in the Limpopo Province of South Africa. The project area consists of the Matimba Power Station as well as a Greenfields area largely comprising bushveld.

A baseline survey was conducted to identify any surface water elements that could potentially influence development and planning on site. A site visit was conducted in order to determine the normal flow rates, river health and potential factors that could influence hydrological modelling of flows. Generally-accepted methods and formulae such as the Rational Method, Alternative Rational Method and the Standard Design Flood (SDF) Method were used to determine design floods at various points within the area and to estimate flood levels, as elaborated-upon in Section 6. Runoff from the catchment area was assessed by downscaling quaternary catchment data. A review of a previous report undertaken by GCS in 2005, based on the hydrology of the area in question, was performed and has been elaborated-upon in Section 5.

The project area is drained by the non-perennial Sandloop River, running from north to south. The catchment area of site Alternative 2 contains branches of a tributary of the Sandloop River and the catchment area of Alternative 1 contains a very small tributary of the Sandloop River. An additional watercourse occurs to the west of site Alternative 1 which also drains toward the Sandloop River.

The study area was delineated into 3 catchments areas for flood calculations. All catchment areas were found to differ significantly from natural catchment areas derived solely from historical topographic maps. Local development has changed catchment boundaries and flow paths. Effective catchment areas that considered existing development were derived for each catchment area. In order to calculate the peak flows, the Rational, Alternative Rational and Standard Design Flood methods were utilised. The flows were determined for a 24-hour rainfall event. Peak Flows for the 1:50- and 1:100-year flood events calculated for Catchment 1, as seen in Figure 6.1, are 4.03m^3/s and 7.73m^3/s, respectively. For Catchment 2 these are 28.98m^3/s and 43.83m^3/s and for Catchment 3 these are 395.92m^3/s and 506.96m^3/s. A detailed explanation of these calculations can be viewed in Section 6.5. The area is not anticipated to have a large potential stream flow reduction impact on the runoff of the immediate and general areas.

Five water samples as well as two ash samples were taken at sites around the study site and assessed. The ash samples were taken from the existing Matimba Ash Disposal Site. The location of these sites can be seen in Figure 8.1. The dam/pan water samples indicated good water quality, yet fluoride and metals were elevated. The dams within the site boundary are utilised by wildlife in the area for drinking water and none of the parameters analysed exceeded the Livestock Watering Guidelines. Samples MASW1&2 at site MASW1, however, contained elevated aluminium levels and it is recommended that this is monitored at least biannually as livestock are likely to drink from this pan over time.

The ash samples primarily comprised of calcium, magnesium and potassium but an aqueous extraction test performed on the samples showed high concentrations of sulphate, calcium and magnesium in the leachate. The calcium and magnesium are not of concern, however, the elevated sulphate will have a negative impact on the receiving environment. The aqueous extraction analysis for both samples indicated that runoff from the Ash Disposal Facility would not be suitable for the environment, domestic use or livestock watering. The results from a once-off sampling event cannot be used to make a conclusive statement about the ash disposal facility but from this analysis the runoff from the disposal facility poses a pollution potential and should therefore be contained in a dirty water system as part of an overall SWMP.

In order to comply with best practice storm water management principles stipulated in General Notice 704 of the South African National Water Act (36 of 1998) (GN 704), areas of clean and dirty water need to be identified and managed accordingly. Runoff from clean water areas must be diverted around dirty water areas. A conceptual plan for each proposed site and the linear route infrastructure has been developed that indicates proposed storm water management measures that are required to ensure the separation of these dirty and clean water areas. Site Alternative 1 requires a Pollution Control Dam (PCD) with storage capacity of 203 600 m^3 and that spills on average only once in 50 years. Matimba Power Station has already commissioned an independent PCD design of approximately this capacity for this site. The GCS analysis confirms this dam's design capacity. For site Alternative 2 the entire ash disposal facility site should be regarded as a dirty water area. Runoff from the site can be captured in a down-slope drain system and diverted to a PCD. A PCD is recommended to the north of the ash disposal facility site and below all likely spoil heaps with a capacity of approximately 180 000 m^3. A reduced ash facility site area would lead to a reduced PCD size by approximately 23 600 m^3 capacity. The required toe drains would be long and would need to be designed to accommodate peak flow rates in the order of 0.75 m^3/s. Please see Figures 11.1 and 11.3 for the Storm Water Management Plans (SWMPs) for the respective sites.

The SWMP for the linear infrastructures route requires drains, berms and sumps to be placed along the route. The elevation profile was plotted for the route and sumps were recommended at the lowest point to collect the dirty water to be pumped into the nearest PCD, depending on which Alternative was chosen and the final design of the Matimba Power Station. Berms and drains would need to be placed around the linear route infrastructure. In accordance with the GN704 regulations of the South African National Water Act (36 of 1998), these measures must be able to accommodate a 1 in 50-year flood event. The 1 in 50-year flood volumes calculated for sump A, B and C are 1603, 1217 and 441 m^3 respectively.

A comprehensive water quality monitoring programme is recommended at the Matimba Power Station general area in terms of Best Practice Guidelines G3: Water Monitoring Systems (DWA, 2006c). The water quality monitoring programme will assist with overall water management at the Matimba Power Station. The monitoring programme should be amended according to on-site operations and future Environmental Impact Assessment and Water Use License requirements. The monitoring programme recommends quarterly sampling at identified sampling points and open water bodies, monthly sampling upstream and downstream of relevant rivers and pans close to the infrastructure and bi-annual sampling upstream and downstream of relevant rivers and pans further downstream from the plant.

Flood lines on river sections are analysed to evaluate risks associated with potential flooding of infrastructure and protection of natural resources. No infrastructure is allowed to be placed and constructed closer than 100m from a river or from the 1:100-year flood line; whichever of the 2 is farthest from the river I question. The 1:50- and 1:100-year flood lines of the 3 rivers analysed within this study mostly fall outside of the 100m buffer zone. These flood lines could be exaggerated owing to data inaccuracy (cross sections using 20 m contours). Mostly overland flow is expected and consequent flood lines are extremely difficult to determine. A conservative approach would be to accept a wider flood plain in order for protection of the resource and to allow water to flow freely over a protected zone. A floodplain has been delineated that is likely to include any probable flow path for the design flood and a 100m buffer zone around this flood plain has been drawn (see Figure 7.2).

An impact assessment was performed for the proposed development. This assessment involves identifying and describing risks associated with the proposed development on downstream users and suggesting mitigation strategies for each risk found. The assessment was conducted for the construction, operation and closure phase of the development. It was found that water users downstream of the development are predominantly mining, irrigated agriculture and urban industrial water users. Potential risks and mitigation measures were largely centred on pollution of surface water resources. The proposed ash disposal facility development is unlikely to pose significant risks to local surface water resources if appropriate measures are in place, as outlined in this document. Emphasis is placed on the monitoring programme and risk mitigation measures being implemented correctly. The main mitigation measure recommended is the implementation of the SWMP.

A water and salt balance was also performed on the existing ash disposal facility. Simulation modelling using the Goldsim Model showed that the required PCD of approximately 170 000m^3 capacity should be constructed to capture surface runoff and in order to not be exceeded more than once in 50 years, on average. Water quality sample MA SW 3&4 showed the highest elevated TDS concentration of 940 mg/l. MA SW 3&4 is an existing PCD at the Matimba Power Station and is further explained in Section 8. This elevated concentration is likely to have occurred because of high evaporation rates (+/- 1950mm/year) which causes salt deposits in the PCD. It is recommended that the salt balance be updated if more flow data and quality data become available. These can then be incorporated into the existing GoldSim Model of the site.

It is recommended that site Alternative 1 be considered over site Alternative 2. This is because Matimba Power Station has already commissioned an adequately-sized independent PCD design for Alternative 1, which requires a PCD storage capacity for a dam that spills on average only once in 50 years of 203 600 m^3. For site Alternative 2, however, the entire ash disposal facility site should be regarded as a dirty water area, thus a large PCD of approximately 180 000 m3 capacity would be required to the north of the disposal facility site and below all likely spoil heaps. Based on the available contour data and ash and water samples taken, neither site Alternative is more favourable from a flood line, water quality or water balance perspective. Developmental risks, mitigation measures and monitoring recommendations would also remain the same at both sites. There will be minimal stream flow reduction from development at either site.

LIST OF ABBREVIATIONS:

The following abbreviations are used throughout the document:

BPG; Best Practice Guideline.

DWA; Department of Water Affairs.

GN704; General Notice 704 of the South African National Water Act (36 of 1998) which describes regulations of the protection of natural water resources in South Africa with regard to development within flood lines, the separation of clean and dirty water systems, design criteria and interaction with Interested and Affected parties

MAE; Mean Annual Evaporation

MAP; Mean Annual Precipitation

MAR; Mean Annual Runoff

PCD; Pollution Control Dam

SWMP; Storm Water Management Plan

Tc; Time of Concentration, which represents the time it takes for a raindrop to runoff from the furthest end of a catchment to a discharge point

WR2005; Water Resources 2005 national database of hydrological information

WRC; Water Research Commission

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1 INTRODUCTION

GCS Water and Environment (Pty) Ltd. (GCS) has been appointed by Royal Haskoning DHV to conduct a hydrological assessment, SWMP, risk assessment, monitoring plan and a water and salt balance for the Matimba continuous ash disposal Facility for the Matimba Power Station, situated in Lephalale in the Limpopo Province of South Africa. The project area consists of current power station activities as well as a Greenfields area. Royal Haskoning DHV further requested an SWMP for a linear route infrastructure situated in the same facility. At Matimba Mine there exists currently a power station and an existing ash disposal facility. Eskom runs the Matimba coal-fired, direct dry-cooled power station in close proximity to the Grootegeluk Coal Mine, from which it draws coal.

Matimba Power Station is a 3 990 MW installed capacity base-load coal fired power station, consisting of 6 units. Ash is generated as a by-product, owing to the combustion of coal from the power station. This ash is currently being disposed by means of 'dry ashing' approximately 3 km (three kilometres) south of the power station, on Eskom-owned land.

Matimba Power Station thus envisages aligning the continuation of the ash disposal (dry ashing) processes for the remaining life of the power station with the current waste legislation, the National Environmental Management: Waste Act (NEMWA), Act 59 of 2008, and therefore requires the necessary licensing in terms of the Environmental Impact Assessment (EIA) Regulations (2010) promulgated under the National Environmental Management Act (NEMA) Act 107 of 1998 (as amended).

The proposed continuous ash disposal facility will be able to accommodate the ashing requirements of the power station for the next 44 years. The scoping phase of the Environmental Impact Assessment (EIA) study identified two potential sites for the facility, thus both have been assessed within this report (Please see Figure 4.2).

A detailed site visit report describing the physical environment on site can be seen in **Appendix A**. **Appendix B** contains the Hydrological Methodologies Input Data sheets, **Appendix C** contains the WARMS dataset used to analyse types of water users downstream of the mine and **Appendix D** contains the full Risk Assessment spreadsheet.

2 SCOPE OF WORK

The Scope of Work (SoW) can be summarised as follows:

Information sourcing / literature review
- Review of existing information

• Site Visit
- Site assessment
- Water quality sampling and
- Flood line assessment

• Hydrology
- Climate and rainfall evaluation
- Catchment delineation
- Analyses of laboratory results and quality data
- Mean Annual Runoff (MAR) and Normal Dry Weather Flow (NDWF) analyses
- Flood flow analyses
- Flood line analyses
- WARMS (register of water users) data evaluation
- Water Resources Evaluation

• Stochastic Water and Salt Balance modelling (W&SB)
- Flow simulation using GoldSim
- Salt load transport simulation using GoldSim
- The water and salt balance model will be provided in GoldSim Player format to the Client (free software)
- A one-day training session on the model will be provided to the Client
- A user manual for the model will be provided

• SWMP
- Delineation of clean and dirty catchments
- Determination of impacts of all infrastructure on the MAR
- Determination of the storm water flows and volumes (1:50 and 1:100 year events)
- Indication of the placement of berms, channels and PCDs
- Conceptual designs will be done for the proposed infrastructure

The dirty water storage required is calculated / modelled to prevent spillage not more than once, on average, in 50 years

- Water Monitoring Programme
  - Water sample parameter testing and evaluation
  - Monitoring Plan including location of monitoring points

- Environmental Risk and Potential Impact identification and proposed Mitigation Measures
  - Identification of sensitive receptors downstream of the mine
  - Evaluation of the impact on quantity and quality of water that reaches the downstream environment
  - Describe all surface water impacts and propose mitigation measures

- Reporting
  - Project close-out report

The hydrological investigation will form part of the environmental authorisation processes under the National Environmental Management Act (Act 107 of 1998), the National Water Act (Act 36 of 1998) and the National Environmental Management: Waste Act (Act 59 of 2008).

3 METHODOLOGY AND DATA SOURCES

A baseline survey was conducted to identify elements that could potentially influence development and planning on site. A site visit was conducted in order to get an indication of the normal flow rates, river health and potential factors that could influence hydrological modelling of flows.

A holistic approach was followed, thus local hydrological, water quality and environmental studies were linked to regional and national concerns, regulations and management strategies. This involved working primarily at the scale of the development site, but also looking at the hydrology at a catchment scale and at a Water Management Agency (WMA) scale. This further included ensuring that the outcomes of the studies comply with the legislation that governs the area. The relevant pieces of legislation are the National Environmental Management Act, 1998 (Act No 107 of 1998) (NEMA) and the National Water Act, 1998 (Act no. 36 of 1998) (NWA) (South Africa, 1998b) and the National Environmental Management: Waste Act (Act 59 of 2008).

Generally-accepted methods and formulae were used to determine design floods in the relevant catchments. Runoff from the streams was analysed using accepted techniques to downscale quaternary catchment data (SANRAL, 2007).

Software employed in this study includes:

- ArcView10.1 (ESRI, 2012) for Geographic Information Systems (GIS) work;
- Results of WRSM as published in WR2005 (WRC, 2005) were used for base-line runoff data;
- The Standard Design Flood Software (Alexander, 2002) for design flood calculations;
- HEC-RAS Modelling Software (US Army Corps of Engineers, 1995);
- The Daily Rainfall Data Extraction Utility (ICFR, 2012) for MAP calculations, and
- The Goldsim Water Balance Model (Goldsim Technology Group, 2013).

Climate data were obtained from the South African Weather Service as well as the WR2005 (WRC, 2005), Design Rainfall Estimation for South Africa (Smithers & Schulze, 2002), Daily Rainfall data extraction utility (ICFR, 2012), TR102 (Adamson, 1981) and RLMA SAWS (Smithers & Schulze, 2000) databases.

The SWMP was compiled in accordance with the Department of Water Affairs (DWA) BPG G1: Storm Water Management (DWA, 2006a). The Water and Salt Balance (W&SB) model was conducted in accordance to the DWA Best Practice Guidelines (BPG) G2: Water and Salt balances (DWA, 2006b). The water monitoring programme complies with the DWA BPG G3 (DWA, 2006c).

Please refer to Appendix B for the hydrological calculations performed, various methods used for peak flow calculations and hydrological data used.

4 LOCATION

The proposed Matimba ash disposal facility and linear route infrastructure is situated in Lephalale in the Limpopo Province of South Africa. The study area is located in Water Management Area 2: Limpopo and in quaternary catchment area A42J. The location of the project site can be seen in Figure 4.1 below. As mentioned, the scoping phase of this study identified two potential sites for the proposed ash disposal facility. Site Alternative 1 is located directly next to the existing ash disposal facility. This has been referred to within this document as Alternative 1. Site Alternative 2 is roughly 11km north of this proposed site and has been referred to in this study as Alternative 2. The linear route infrastructure links the power station to alternative 2 of the ash disposal facility. Please see Figure 4.1.

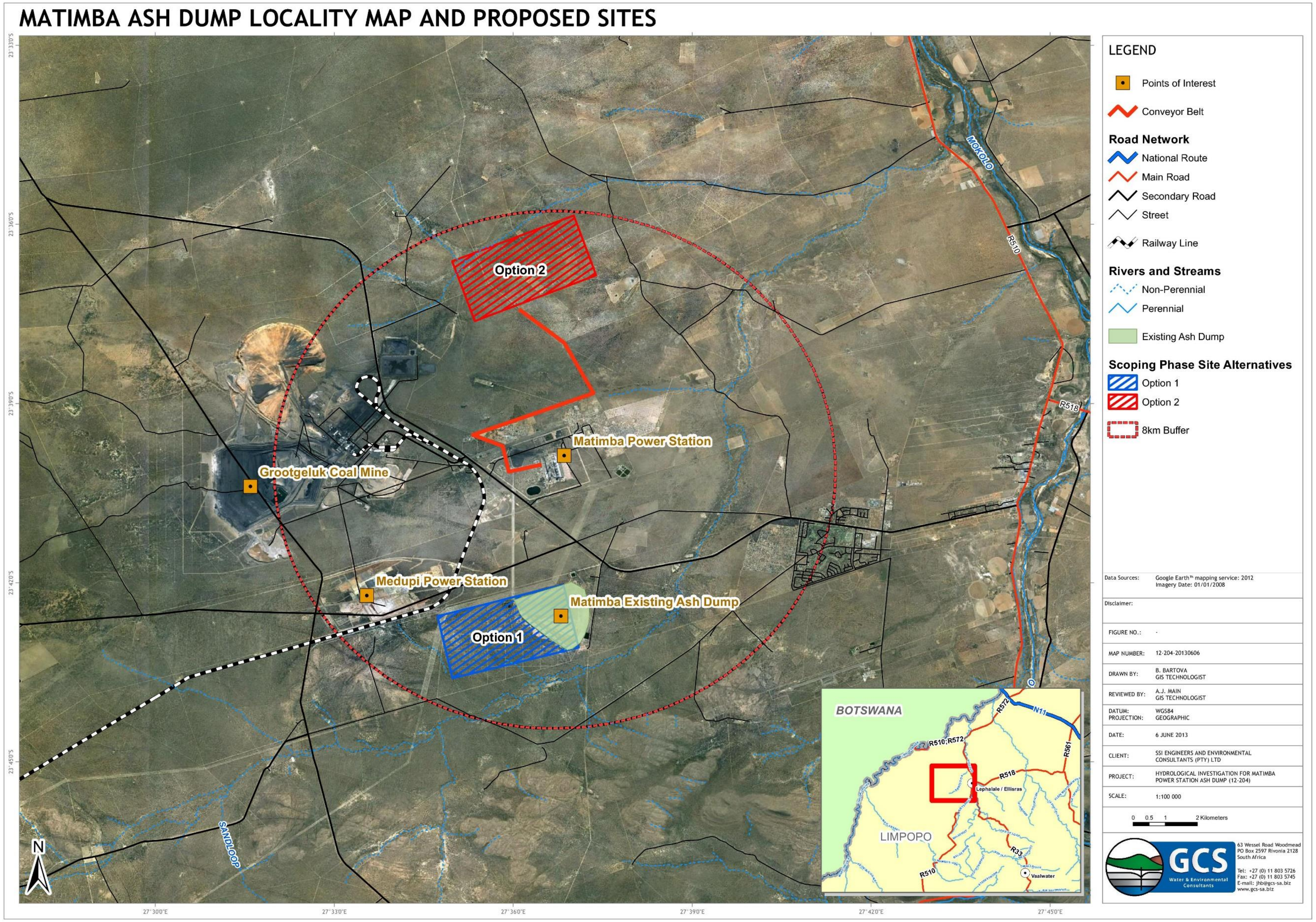


Figure 4.1: Locality Map with the Proposed Facilities

5 REVIEW OF PREVIOUS REPORTS

The report referenced below was found to be relevant within the context of this study. The Medupi Power Station, referred to in the underlying report précis, falls within the 8km radius that the scoping phase of this study identified, within which the two potential sites for the proposed ash disposal facility have been identified and assessed.

Matimba B Power Station Hydrogeological and Surface Water Report – Water Sections of EIA. May 2005. GCS (Pty) Ltd. (GCS, 2005) was reviewed.

The hydrology section of this report describes the topography of the general area into which both sites fall as flat and the general topographical drainage system as poorly developed, consisting primarily of dry, sandy gullies located south and east of Matimba (Medupi) Power Station. The poor drainage system can be attributed to the topography, sandy soils and low rainfall of the area. As a result of the lack of well-defined drainage courses the report concludes that proposed infrastructure is unlikely to have a direct impact on surface water.

The Sandloop River drains the south-western part of the area and that the Sand and Grootspruit Rivers, tributaries of the Sandloop River, originate in the Waterberg mountain range and flow into the Sandloop River upstream of the Sandloop Dam. The availability of water from this dam has resulted in extensive irrigation activities. The Sandloop Dam was developed to support mining and thermal power generation activities.

The regional water supply scheme comprises water from the Sandloop Dam that is pumped to Lephalale via a balancing dam at Wolwefontein. Some of the water is treated before being sent to Lephalale. Eskom treats water for its own use and delivers potable water to Marapong. Farmers situated in a riparian zone of a water course abstract water from the Sandloop River.

In 2005, the potential surface water resources within the area were nearly fully developed, however, it is possible to increase the water availability from the catchment by further water resources development. The report lists water resources development options as the raising of Sandloop Dam, the construction of a dam in the upper reaches of the Sandloop River and diverting surplus water from the river to demand centres.

The report concludes that surface water resources are available and that future water resource developments will ensure sustainable water supply to proposed new developments if water requirements are investigated adequately.

6 HYDROLOGY

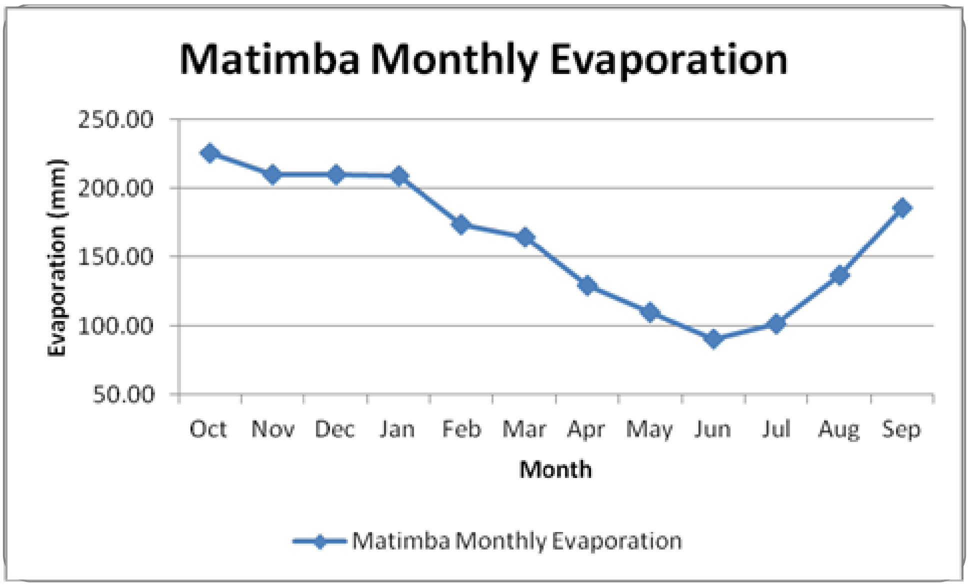
6.1 Climate

Lephalale normally receives about 400mm of rain per year, with most rainfall occurring during mid-summer. It receives the lowest rainfall in June and the highest in January. The average midday temperatures for Lephalale range from 22.3°C in June to 31.9°C in January. The region is the coldest during July when temperatures drop to 3.7°C on average during the night.

Monthly evaporation for the area is calculated by multiplying the Mean Annual Evaporation (MAE) of the region, as derived from the WR2005 spread sheets (Middleton & Bailey, 2009), by the proportion of evaporation that occurs in that region, monthly (please see table and graph below).

Table 6.1: Mean Annual Evaporation for the Matimba Area

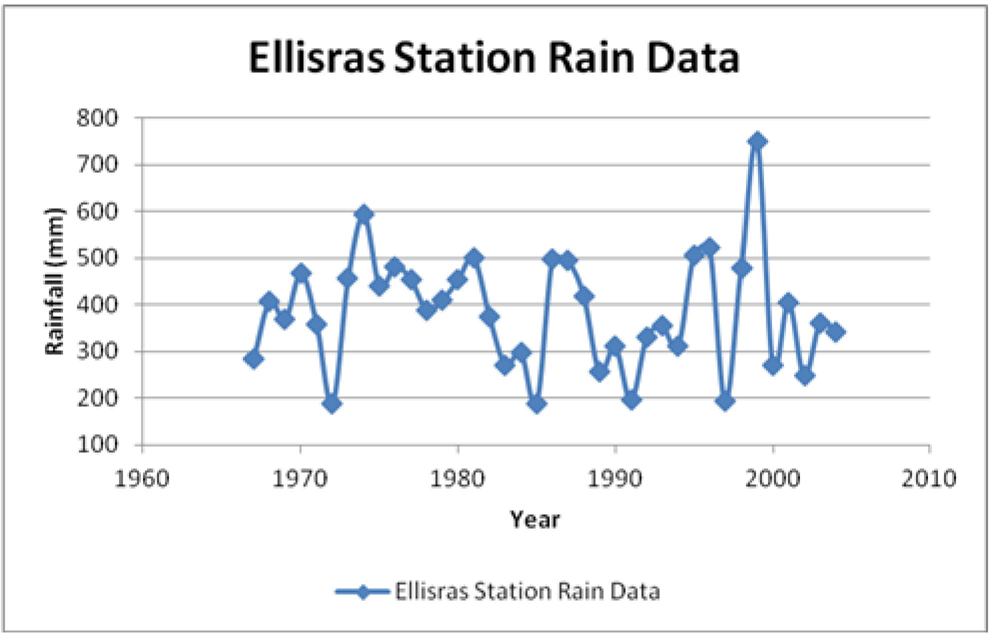
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Ave.	MAE (mm)
Evaporation Zone 4A monthly distribution	12	11	11	11	9	8	7	6	5	5	7	10	100	8	
Actual Evaporation	226	210	210	209	174	165	129	110	91	102	137	186	1949	162	1949



Graph 1: Matimba General Mine Area Monthly Evaporation

The Mean Annual Precipitation (MAP) of the Limpopo Water Management Area (WMA), into which the project site falls, is 471mm and the quaternary catchment (A42J) into which the site falls has an MAP of 428mm (Middleton & Bailey, 2009). The design rainfall estimation for South Africa software (Alexander, 2002) calculated an MAP for the site of 465mm and the Daily Rainfall Data Extraction Utility (ICFR, 2012) data series indicated an MAP for the site of 534mm. The nearest rainfall station with good quality rain data is Ellisras Police Station (0674400W) (TR102 data) (Adamson, 1981). This station had data from 1967 to 2004 and showed an MAP of 385mm. The Design Rainfall Estimation Utility results were chosen for use within this study as they falls within the general range calculated using the other sources and are made up of the data from all the stations in the vicinity. Furthermore, they most accurately represent the general rainfall in the sub-catchment and the programme is widely used and accepted within the hydrology profession.

To give an indication of past rainfall trends variation in the area, a summary of the total annual rainfall over the entire record period of the nearby Ellisras Police Station rainfall data are shown in the graph 2.



Graph 2: Ellisras Police Station Total Annual Rainfall Graph

6.2 Site visit

A two day site visit in Lephalale was undertaken on the 23rd and 24th of May 2013. A follow up site visit was done in March 2014 to compare the change of water quality over this time period. During this site visit, the two alternatives sites for the proposed Matimba ash disposal facility were assessed for the following purposes:

- General site assessment;
- Water quality sampling; and
- Flood line assessment.

The site Alternative 1 consists of current ash disposal activities as well as bushveld. The area of the existing Matimba Ash disposal facility consists of two existing, lined storm water dams/PCDs and one large, lined PCD under construction. Site Alternative 2 is a Greenfields area largely comprising bushveld.

Water features identified during the site visit include the following:

Site Alternative 1

- Two existing, lined PCDs and one lined PCD under construction;
- Storm Water Channels and Berms; and
- An artificial pan used by local wildlife for drinking water.

Site Alternative 2

- An artificial pan used by local wildlife for drinking water.

The natural environment of both site alternatives comprises bushveld and grassland. The environment is generally dry and flat. No water or clear drainage paths were visible flowing towards the Sandloop River. Please see photographs of the sites below.

Photo 6.1: Undefined Drainage Path toward the Sandloop River

Photo 6.2: An Artificial Pan from which Livestock Drink

The full site visit report can be seen in **Appendix A**.

6.3 Catchment delineation, characterization, properties and land use

The general area is drained by the non-perennial Sandloop River, running from north to south. The catchment area of Alternative 2 contains branches of a tributary of the Sandloop River and the catchment area of Alternative 1 contains a very small tributary of the Sandloop River. An additional watercourse occurs to the west of Alternative 1 which also drains toward the Sandloop River.

Catchment areas used for flood calculations were found to differ significantly from natural catchment areas derived solely from historical topographic maps. Local development has changed catchment boundaries and flow paths. Effective catchment areas that accounted for existing development were thus derived for each catchment. The table below shows a summary of the catchment areas.

Table 6.2: Summary of catchment sizes

Sub-catchment	River	Site Area *(km^2)*
Natural Catchment 1	Tributary of the Sandloop	5.1
Natural Catchment 2	Tributary of the Sandloop	12.57
Natural Catchment 3	Tributary of the Sandloop	54.58
Effective catchment 1	Tributary of the Sandloop	0.83
Effective catchment 2	Tributary of the Sandloop	7.1
Effective catchment 3	Tributary of the Sandloop	52.51

The catchments can be seen in the figure below.

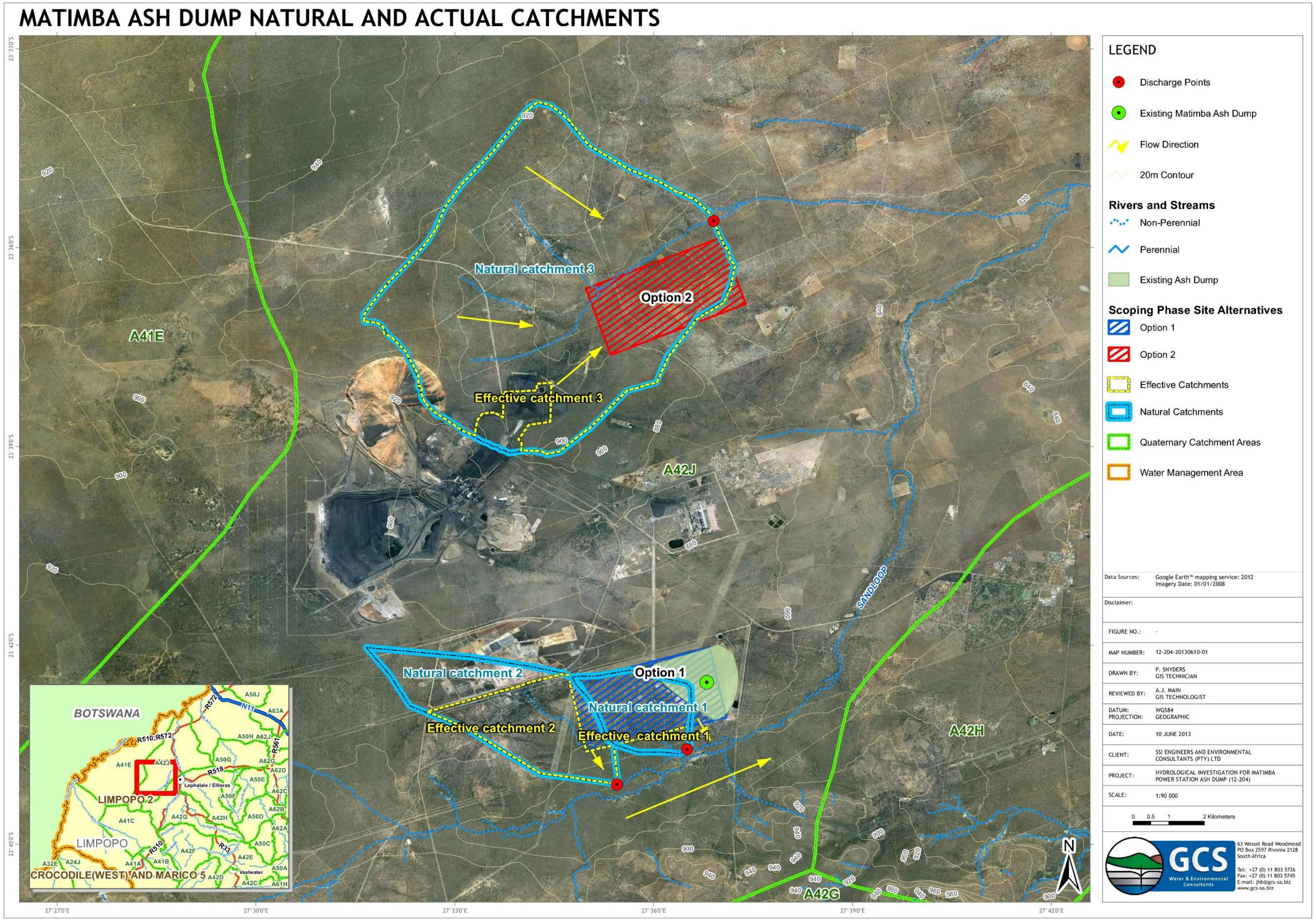


Figure 6.1: Catchment areas for Alternatives 1 and 2

The catchment is rural and flat and comprises semi-permeable soils. The vegetation that makes up the area is mainly light bushveld with a combination of light grass and bare areas. Please see **Appendix B** for a more detailed breakdown of the land uses.

6.4 Mean Annual Runoff (MAR)

WR2005 quaternary runoff data (Middleton and Bailey, 2009) was downscaled in order to obtain representative site runoff. Mean Annual Runoff was calculated using two methods:

- Initially this was calculated using the simple equation; Site runoff = (site area * quaternary catchment runoff) / quaternary catchment area.
- MAR was also calculated by multiplying monthly runoff values obtained from the WR2005 database (Middleton & Bailey, 2009) by a correction factor. This factor was calculated by multiplying the quotient of the site area and the quaternary catchment area, raised to the power of 2.6, by the quotient of the site rainfall and the quaternary catchment rainfall. The MAR results calculated using the correction factor method were chosen as this method is more thorough.

The resulting MAR values are tabulated below. Table 6.3 also shows the percentages of MAR from the site boundary that make up the relevant quaternary catchment and Water Management Area. As the figures are small, the area will not have a large potential stream flow reduction impact on the runoff of the immediate and general areas. This means that the runoff of the Quaternary Catchment and Water Management Areas into which the proposed development sites fall will not be significantly decreased by the proposed development.

Table 6.3: Mean Annual Runoff for the Matimba Ash Disposal facilities

Natural Catchment	Correction Factor MAR	Basic MAR	% Quat. Catchment Area	% Water Management Area
Alternative 1	0.58	0.47	8	0.1562
Alternative 2	0.40	0.32	5.52	0.1076

6.5 Peak flows

Peak flows have been calculated based on the results of three methods, the background to which are presented in the information box below:

Rational Method

The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km^2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow.

Alternative Rational Method

The alternative rational method is based on the rational method with the point precipitation being adjusted to take into account local South African conditions.

Standard Design Flood Method

The standard design flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities.

Daily design rainfall depths which are summarized below were obtained from The Design Rainfall estimation for South Africa programme (Smithers & Schulze, 2000). The design depths are representative of a 24hour rainfall event over the catchments. These data were used within the Rational and SDF methodologies used to calculate peak flows for the catchments.

Table 6.4: Design rainfall depths for the study area catchments

Return Period (year)	Design rainfall estimation for South Africa (mm)
1:50	148.5
1:100	168.3

The three methodologies detailed above were utilised to calculate and compare the peak flows for the 3 effective catchments for the 1:50 and 1:100 year return periods. The results of these calculations are tabulated below.

Table 6.5: Peak Flows as Calculated Using Three Methods

Catchment Name	Method					
	Rational		Alternative Rational		SDF	
	1:50	1:100	1:50	1:100	1:50	1:100
	(m^3/s)					
Catchment 1	4.03	7.73	5.13	7.12	8.51	7.12
Catchment 2	28.98	43.83	58.21	80.81	36.82	80.81
Catchment 3	336.83	524.76	249.79	346.77	395.92	506.96

Of the methodologies used here, the results obtained from the SDF method were chosen to represent the peak flows for catchment 3. This is because the SDF method is:

- The most conservative of these methods;
- Specifically set up for South African conditions; and
- Widely used and accepted within the hydrology industry.

The results using the Rational method were chosen for catchments 1 and 2, as this method is more appropriate to catchment areas of a smaller size. The following peak flows for each catchment were adopted for flood line analyses:

Table 6.6: Adopted peak flows

Catchment Name	1:50 (m^3/s)	1:100 (m^3/s)	Method
Catchment 1	4.03	7.73	Rational
Catchment 2	28.98	43.83	Rational
Catchment 3	395.92	506.96	SDF

7 FLOOD LINES

Flood lines on river sections are analysed to evaluate risks associated with potential flooding of infrastructure and protection of natural water resources. Legislation guides the planning team with regards to minimum requirements of placement of infrastructure in relation to a natural watercourse. Flood line assessments on the proposed Matimba ash disposal facility sites were conducted in accordance with GN704 and Best Practice Guidelines. The main purpose of this flood line assessment is to identify areas around natural water courses that need to be protected.

As defined watercourses could not be clearly identified on site and contour data were limited to 20m intervals, two approaches to the calculation of these flood lines was taken:

- A standard approach was taken initially, for which river cross-sections were identified, relevant height and width values were entered into the HEC-RAS hydraulic modelling programme and flood heights were calculated for the 1:100- and 1:50-year peak flood events, as calculated in the previous section. The problem with this approach was that the river's coverage and the drainage lines understood within HEC-RAS were not in agreement, owing in part to the contour data available and to the flatness of the area (Please see Figure 7.1). The 100m buffers based on these results are thus not reliable.

- The second approach was based on Google Earth imagery, information gathered on site and previous experience. A poorly-delineated floodplain was identified visually. Please see Figure 7.3.

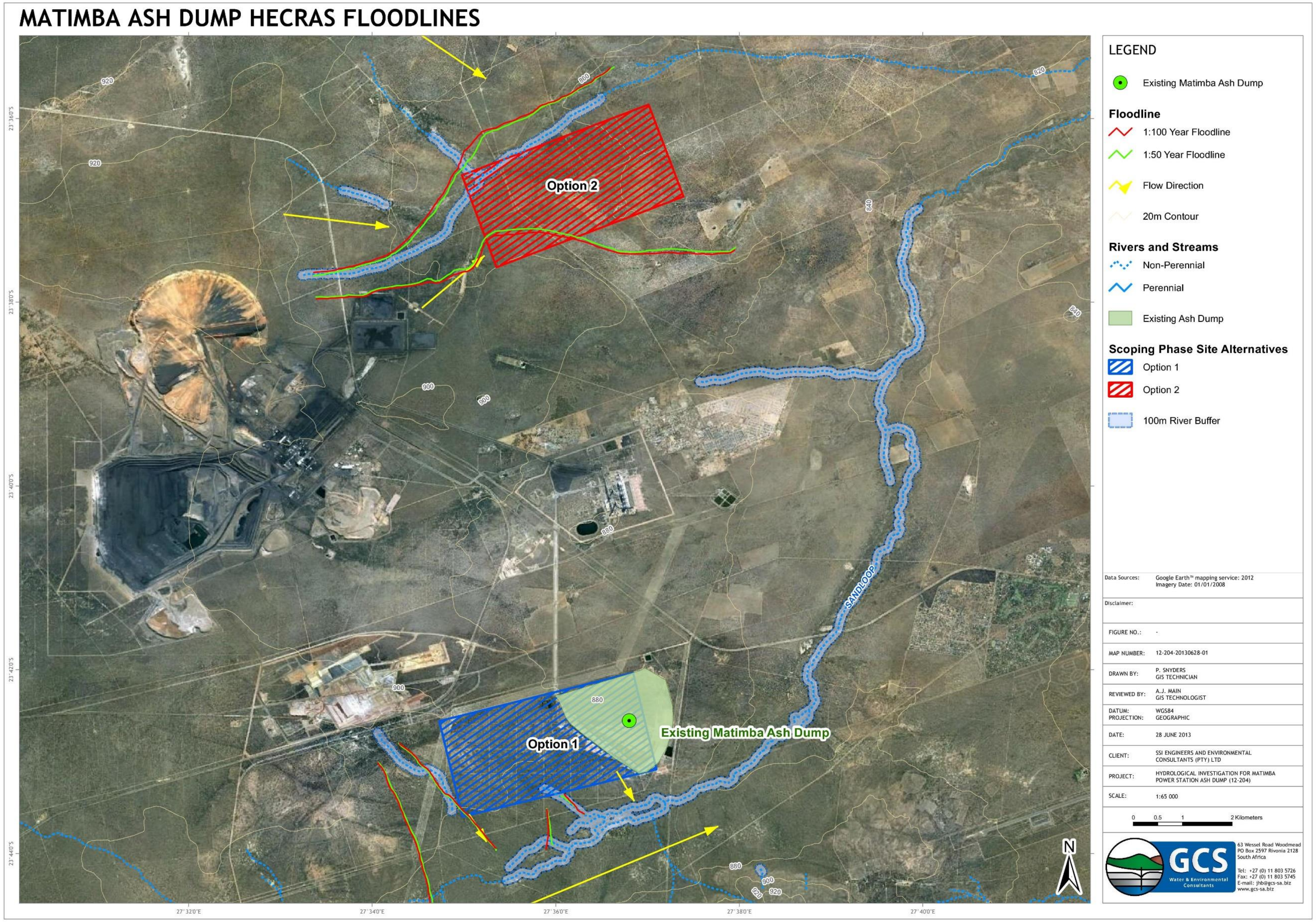


Figure 7.1: Hec-Ras Flood lines

7.1 Methodology & Data sources:

The following data and data sources were used in the assessment:

- 1:50 000 topographical data;
    - Watercourses;
    - 20m interval contour lines;
- Google Earth imagery; and
- TR102 rainfall data.

Two watercourses were identified at site Alternative 1 and were labelled Rivers 1 & 2. These watercourses are tributaries of the Sandloop River. These watercourses were found to cross the site boundary, or pass within 100 m of the site, and are likely to influence development. For the Sandloop River itself, floods would tend to flow randomly across a wide, poorly defined floodplain. The 1:100 year floods would be contained within this flood plain and a buffer zone was drawn that extended 100 m from the apparent edges of this floodplain. More detailed flood-line analysis was not considered necessary. One watercourse was identified at site Alternative 2 and was labelled River 3. This watercourse is also a tributary of the Sandloop River and it intersects the site boundary. A flood line analysis was thus required for this tributary.

Rivers 1 and 2 were analysed from their most downstream positions (before confluence with the Sandloop River) backwards to their origins. These watercourses are very short and thus only 2 cross sections on each watercourse were considered. River 3 was analysed from a point parallel to the most downstream location of the site boundary backwards to its origin. Three cross sections were considered for this watercourse.

As highlighted in the previous section, design floods for each catchment were calculated (making use of the standard calculation spreadsheets described in the SANRAL Drainage Manual) using the following methods:

- The Rational method;
- The Alternative Rational method; and
- The SDF method.

River and catchment characteristics and properties were derived from 1:50 000 topographical data, Google Earth imagery and a site inspection. Flood levels for each watercourse were modelled in HEC-RAS. Flood lines were then derived and mapped using ArcView10.1.

Flood characteristics are influenced by soils and by vegetation. For both site alternatives, the vast majority of the catchment area was dominated by sparse bush-veld with well-established and hardy grass undergrowth. The local topography is flat and no defined watercourses were seen during the site visit. It seems likely that with each flood event that occurs, new and temporary flow-paths will develop that will be guided more by roads, fences, pathways and existing vegetation than by dominating topographical features.

Flood calculations were based on homogeneous bushveld vegetation and on a poorly-defined river bed 2 m wide that was modelled in HEC-RAS. Additional flood plain estimations were derived based on likely preferred flow paths owed to natural slopes. A summary of the catchment properties assumed are shown in the table below:

Table 7.1: Catchment details

Catchment Name	Area (km^2)	Slope	Tc (hours)
Effective catchment 1	0.83	0.002	0.677
Effective catchment 2	7.1	0.05	0.564
Effective catchment 3	52.51	0.11	0.748

Owing to the small catchment sizes, the Time of Concentration (Tc) values are small and all less than 1 hour (as expected).

7.2 HEC-RAS model setup:

When the 1:50 000 topographical data of the area were overlaid on Google Earth imagery, the paths of watercourses did not agree. Deriving cross sections from 20 m contours also produced some discrepancies in data accuracy (as expected). The resulting cross sections do not all follow expected patterns and this posed modelling challenges.

A provisional HEC-RAS model assumed an added river bed with a constant channel width of 2m. Manning's "n" values of 0.030 and 0.070 were assigned to the channel and flood plains respectively (according to the look-up table contained within the HEC-RAS model). For Rivers 1 & 2, only 2 cross sections at the most upstream and the most downstream locations were considered (the rivers are very short; between 1 and 3 km). The cross sections were labelled with an "R" (River) and "CS" (Cross Section) prefix followed by chronological numbering 1 (downstream) and 2 (upstream). Three cross sections were considered for River 3 with the same labelling structure. The figure below shows the geographic locations of each cross section calculated.

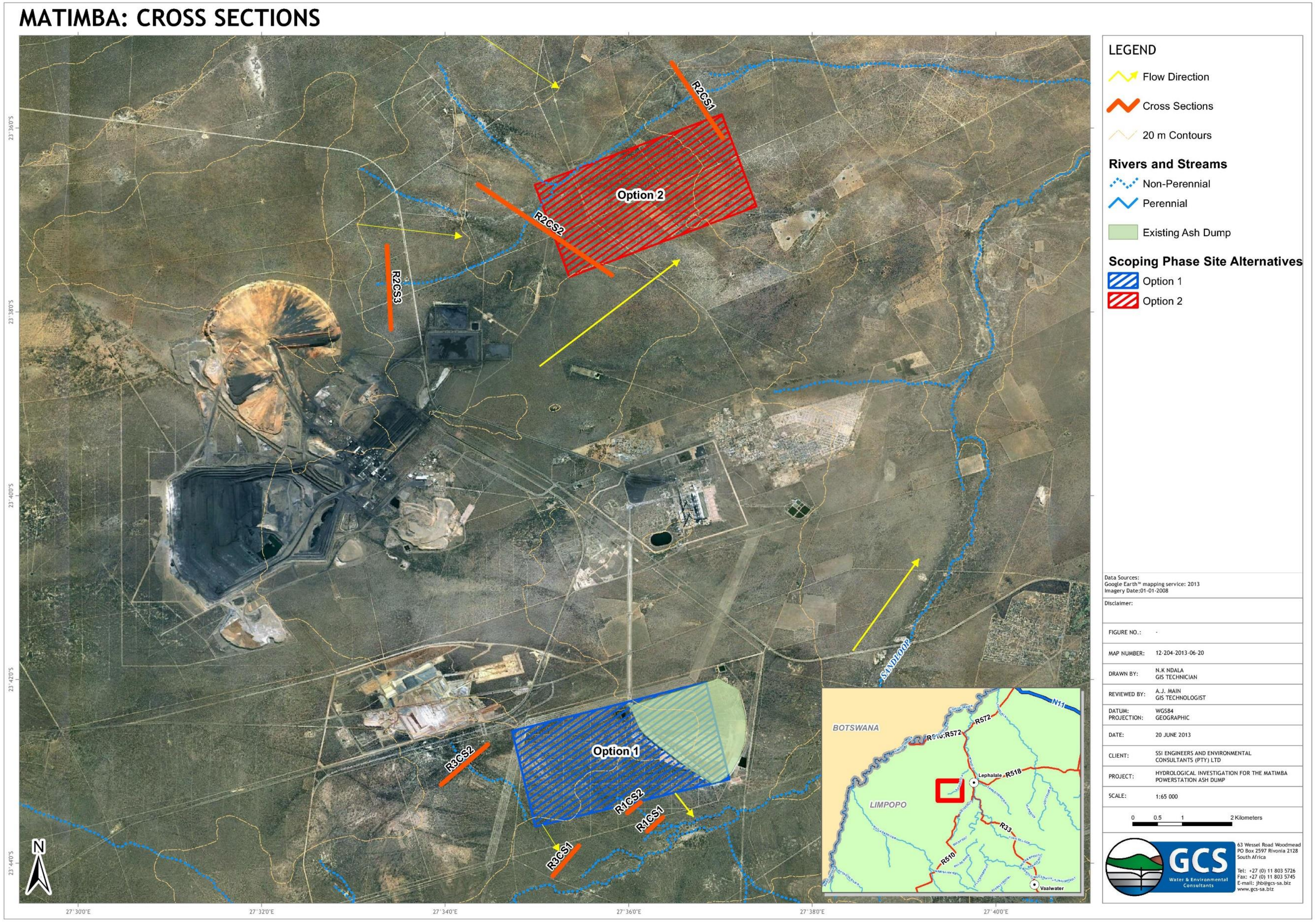


Figure 7.2: Flood line Cross Sections

7.3 HEC-RAS model results:

The following table describes the elevations of water levels that could potentially be reached during 1:50 and 1:100 year floods at each cross section (Please see Figure 7.3).

Table 7.2: Flood heights

Cross section	Height above sea level (m)	
	1:50	1:100
R1CS1	868.58	868.65
R1CS2	873.09	873.15
R2CS1	859.04	859.13
R2CS2	877.63	877.83
R2CS3	891.96	892.01
R3CS1	873.78	873.83
R3CS2	895.31	895.38

Maximum flood depths for Rivers 1 and 2 do not exceed 0.5 m; this flood level is very low (as expected). This depth represents the maximum vertical height from the lowest ground level point in the middle of the river to the surface water level. Maximum flood levels that are reached for River 3 do not exceed 1.5m.

Froude numbers and flow velocities for Rivers 1 & 2 are low and regular. These results are realistic and represent typical values of Froude numbers less than 1 and velocities below 3 m/s. Froude numbers and flow velocities for River 3 are high. The discrepancies could be ascribed to limited cross section data and poor cross-section accuracy.

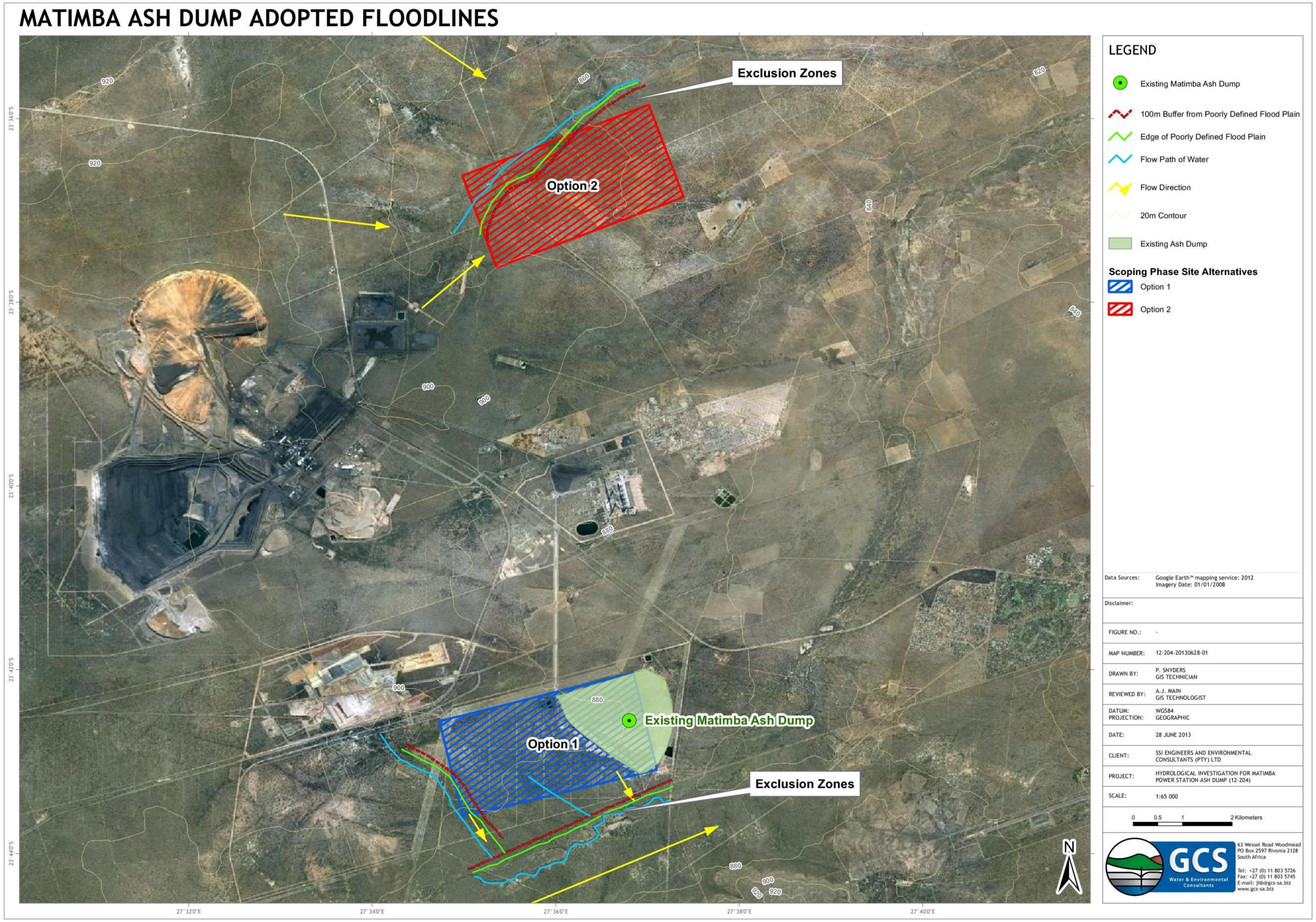


Figure 7.3: Adopted Flood Lines and Exclusion Zones

7.4 Interpretation of results:

The 1:50- and 1:100-year flood lines of the 3 analysed rivers mostly fall outside of the 100m buffer zone. These flood lines could be exaggerated owing to data inaccuracy (cross sections using 20 m contours). Mostly overland flow is expected and consequent flood lines are extremely difficult to determine. A conservative approach would be to accept a wider flood plain for protection of the resource and to allow water to flow freely over a protected zone. A floodplain has been delineated that is likely to include any probable flow path for the design flood and a 100 m buffer zone around this flood plain has been drawn.

A 100m buffer zone from the edge of this poorly-defined flood plain was drawn and accepted as the ultimate exclusion zone. Neither a flood plain, nor a flow path could be identified on the small headwater tributary on the northern side of the Alternative 1 site. 100m buffer lines were thus drawn around the area in which the standard rivers coverage has identified this headwater tributary. Delineated and estimated areas are limited to areas where flooding could potentially impact on development, thus flood lines were not calculated over the whole extent of the rivers.

8 WATER QUALITY ASSESSMENT

Water quality evaluations were performed on 5 sampling points in the site area. Sampling was done during a winter period (May 2013) and serves as a baseline description of the quality of surface water on site. A second site visit was done in March 2014 to determine the effect of the power station on the water resources and to serve as a baseline assessment for the linear route infrastructure study. The samples were collected from man-made dams/pans and two PCDs. Please see Figure 8.1 for the sample site locations. These are once-off samples and do not necessarily indicate average quality at the site.

The water samples were submitted to SANS-accredited laboratory M&L Laboratory Services for analysis in accordance with methods prescribed by the South African Bureau of Standards (SABS), in terms of the Standards Act (Act 30 of 1982). The chemistry results were compared to four different guidelines, namely:

- Department of Water Affairs (DWA) South African Water Quality Guidelines Volume 1 for Domestic Use (1996a);
- DWA South African Water Quality Guidelines Volume 5 for Livestock Watering (1996b); and
- DWA South African Water Quality Guidelines Volume 7 for Aquatic Ecosystems (1996c).
- South African Bureau of Standards (SABS) SANS 241-1:2011 Drinking Water Standards;

The drinking water guidelines were used as they are the most comprehensive set of standards and provide for a worst case scenario where the water is unintentionally used for consumption by humans. Both the DWA and the SABS standards for drinking water were referred to in this report. The water sampled was mostly from dams/pans and as such Aquatic Ecosystem guidelines were included even though it is not a very comprehensive list of standards. The dams/pans that were sampled were primarily being used by local game in the area for drinking water, thus the DWA water quality guidelines for Livestock Watering were also referred to.

8.1 Results and Discussions

The chemistry results compared to the aforementioned standards are presented in Table 8.1 and 8.2, below.

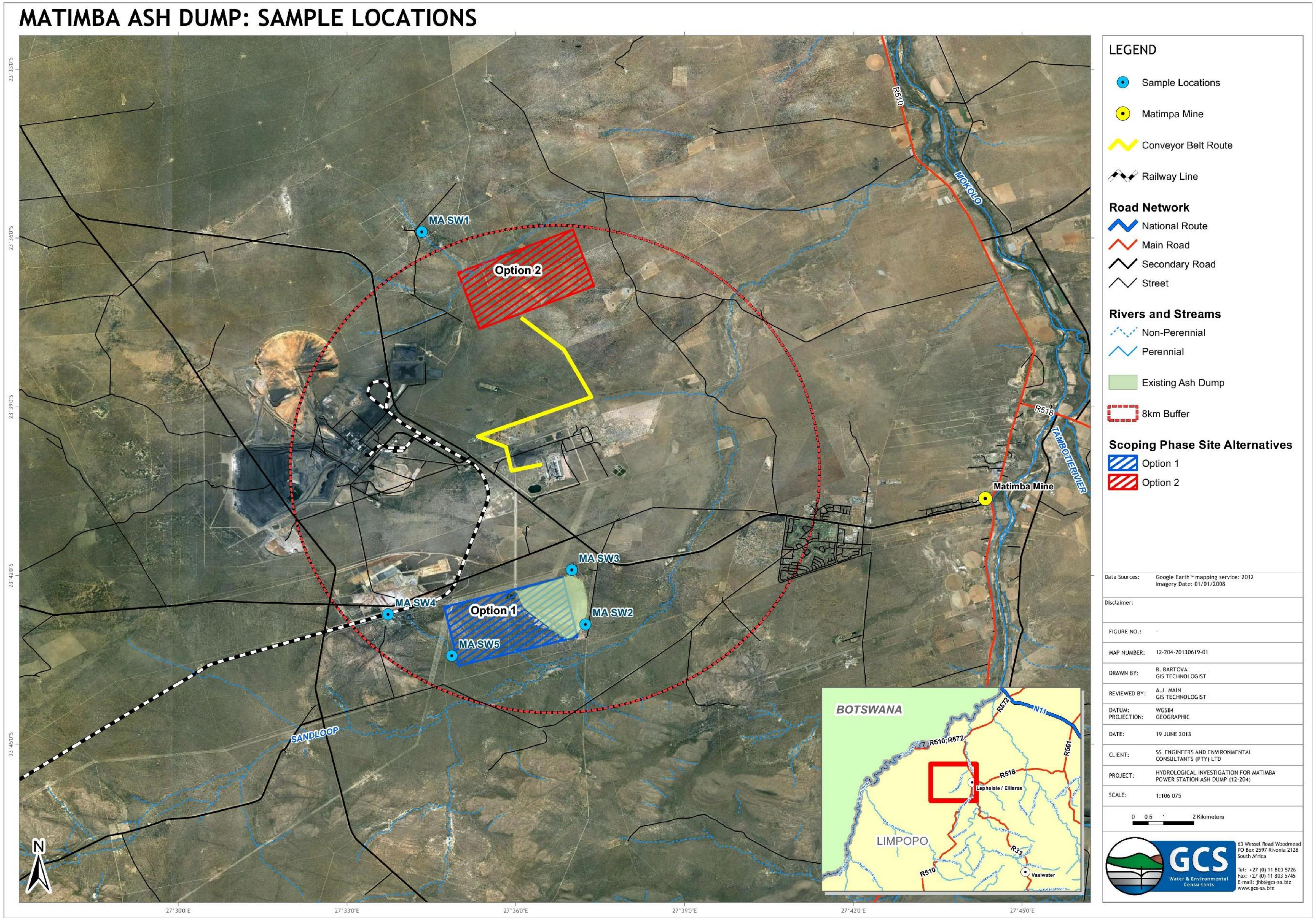


Figure 8.1: Matimba Sample Site Locations

Table 8.1: Water Quality Results for May 2013

Parameter (mg/l) TV = Target Value	DWA TV Domestic Use	SANS 241-1: 2011 Drinking Water	DWA TV Aquatic Ecosystem	DWA TV Livestock Watering	MA SW 1&2 (MASW1)	MA SW 3&4 (MASW2)	MA SW 5&6 (MASW3)	MA SW 7&8 (MASW4)	MA SW 9&10 (MASW5)
pH at 22°C	6-9	5-9.7	NS	NS	6.8	7.7	7.7	8.2	8.1
Conductivity (mS/m)	<70	<170	NS	NS	24.9	101	43.2	22.6	24.4
Total Dissolved Solids	<450	<1200	NS	<1000	320	940	332	180	170
Calcium, Ca	<32	NS	NS	<1000	17.7	62	39	17.2	12.5
Magnesium, Mg	<30	NS	NS	<500	7.3	16.9	2.6	4.1	5.4
Sodium, Na	<100	<200	NS	<2000	16.1	102	49	11.1	17.6
Potassium, K	<50	NS	NS	NS	9.6	14.4	4	6.3	9.6
Calcium Hardness as $CaCO_3$	NS	NS	NS	NS	44	155	97	43	31
Magnesium Hardness as $CaCO_3$	NS	NS	NS	NS	30	70	10.7	16.9	22
Total Alkalinity as $CaCO_3$	NS	NS	NS	NS	62	27	37	62	82
Acidity as $CaCO_3$ to pH 8.3	NS	NS	NS	NS	10	<1.0	<1.0	<1.0	3
Bicarbonate, HCO_3	NS	NS	NS	NS	76	33	45	76	100
Carbonate, CO_3	NS	NS	NS	NS	0	0	0	0	0
Chloride, Cl	<100	<300	NS	<1500	26	74	12.8	6	9
Sulphate, SO_4	<200	<500	NS	<1000	5	306	146	26	10.8
Nitrate, NO_3	<26.6	<48.7	NS	<100	9.6	<0.1	0.9	1.2	0.1
Nitrate, N	<6	<11	NS	NS	2.2	<0.1	0.2	0.3	<0.1
Fluoride, F	<1	<1.5	<0.75	<2	0.2	1	2	1.5	1.9
Aluminium, Al	<0.15	<0.3	<0.005	<5	4.5	0.003	0.32	0.31	0.07
Manganese, Mn	<0.05	<0.5	<0.18	<10	0.35	0.004	0.004	0.002	<0.001
Iron, Fe	<0.1	<2	NS	<10	2.8	0.02	0.04	0.18	0.06

Table 8.2: Water Quality Results for March 2014

Parameter (mg/l) TV = Target Value	DWA TV Domestic Use	SANS 241-1: 2011 Drinking Water	DWA TV Aquatic Ecosystem	DWA TV Livestock Watering	MA SW 1&2 (MASW1)	MA SW 3&4 (MASW2)	MA SW 5&6 (MASW3)	MA SW 7&8 (MASW4)	MA SW 9&10 (MASW5)
pH at 22°C	6-9	5-9.7	NS	NS	7.1	8.1	3.4	8.1	-
Conductivity (mS/m)	<70	<170	NS	NS	9.4	137	121.6	137	-
Total Dissolved Solids	<450	<1200	NS	<1000	74	1156	888	1156	-
Calcium, Ca	<32	NS	NS	<1000	3.8	115	81	115	-
Magnesium, Mg	<30	NS	NS	<500	9.5	287	202	287	-
Sodium, Na	<100	<200	NS	<2000	0.86	15.4	66	15.4	-
Potassium, K	<50	NS	NS	NS	4.6	8.8	4.7	8.8	-
Calcium Hardness as $CaCO_3$	NS	NS	NS	NS	9.5	287	202	287	-
Magnesium Hardness as $CaCO_3$	NS	NS	NS	NS	6.6	276	63	276	-
Total Alkalinity as $CaCO_3$	NS	NS	NS	NS	26	102	BDL	102	-
Acidity as $CaCO_3$ to pH 8.3	NS	NS	NS	NS	4	BDL	202	BDL	-
Bicarbonate, HCO_3	NS	NS	NS	NS	32	124	0	124	-
Carbonate, CO_3	NS	NS	NS	NS	0	0	0	0	-
Chloride, Cl	<100	<300	NS	<1500	0.5	7.6	8.5	7.6	-
Sulphate, SO_4	<200	<500	NS	<1000	0.3	454	383	454	-
Nitrate, NO_3	<26.6	<48.7	NS	<100	BDL	0.7	2.2	0.7	-
Nitrate, N	<6	<11	NS	NS	BDL	0.2	0.5	0.2	-
Fluoride, F	<1	<1.5	<0.75	<2	0.2	1.7	BDL	1.7	-
Aluminium, Al	<0.15	<0.3	<0.005	<5	1.4	0.05	29	0.05	-
Manganese, Mn	<0.05	<0.5	<0.18	<10	0.006	0.21	0.89	0.21	-
Iron, Fe	<0.1	<2	NS	<10	0.86	0.008	2	0.008	-

From Table 8.2 it can be seen that sample MA SW3&4 contained relatively more non-compliant parameters when compared to the other samples. The samples are compared in terms of a few primary parameters, as seen below;

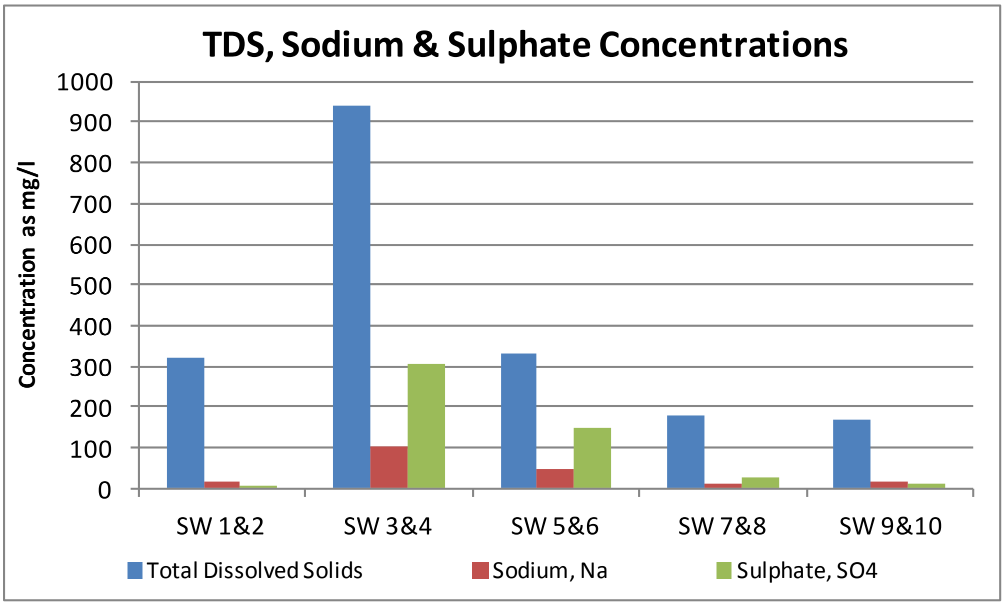


Figure 8.2: TDS, sodium and sulphate concentrations of the May 2013 site visit

The water chemistry results per sample site are further discussed below in terms of the samples taken from pans/dams and PCDs.

8.1.1 MA SW 1&2

May 2013

This sample was taken from a man-made pan or small dam at sampling point MA SW 1. The pan is used by local wildlife for drinking water. The chemistry results indicated elevated metals at this site, namely:

- aluminium (exceeded both the drinking water standards and the Aquatic Ecosystem standards);
- manganese (exceeded the DWA Domestic Use and Aquatic Ecosystem standards); and
- iron (exceeded both the drinking water standards and the Aquatic Ecosystem standards).

None of the concentrations of these parameters exceeded the Livestock Watering standard. According to the DWA standards for Domestic Use, there can be certain health effects associated with these elevated parameters, as seen below:

Table 8.3: Health effects associated with parameters of concern (MA SW 1&2)

Parameter of concern	Health effect at concentration noted (DWA, 1996a)
Aluminium (4.5 mg/ℓ)	No acute health effects are expected except at very high concentrations although there may be long-term neurotoxic effects. This relationship has not been conclusively demonstrated. Severe aesthetic effects (discolouration) occur in the presence of iron or manganese.
Manganese (0.35 mg/ℓ)	Increasingly severe staining and taste problems. No health effects.
Iron (2.8 mg/ℓ)	Pronounced aesthetic effects (taste). Slight health effects expected in young children, and sensitive individuals.

Samples MASW1&2 at sampling point MASW1 contained elevated aluminium levels and it is recommended that sample site MASW1 is monitored at least bi-annually as livestock are likely to continue to drink from this pan over time.

March 2014

The water quality at the site was generally good. Only aluminium (Al) and iron (Fe) exceeded the DWA target values for domestic use, as stated previously. Manganese levels have dropped and are now in the acceptable range.

8.1.2 MA SW 3&4

May 2013

This sample was taken from PCD 1 at sampling point MA SW 3&4 and as such is expected to be contaminated and not comply with the standards provided.

The chemistry results indicated the following parameters exceeded the DWA Domestic Use limits: conductivity, total dissolved solids, calcium, sodium, sulphate, and fluoride. Furthermore, the fluoride concentration also exceeded the DWA Aquatic Ecosystem limit. However, all of the parameters analysed were compliant with SANS 241-1:2011 drinking water and DWA Livestock Watering standards. As this is a PCD, this water is unlikely to be used for drinking by either animals or humans.

March 2014

This sample correlated to the sample taken in May 2013. The following was noted:

- Calcium (Ca), aluminium (Al) and manganese (Mn) exceeded the DWA SAWQG target values for domestic use;
- Fluoride (F) exceeded the DWA SAWQG target value for livestock; and

- Sulphate (SO4) exceeded the SANS 241:2011 limit, indicating potential contamination from mining-related activities.

8.1.3 MA SW 5&6

May 2013

This sample was taken from PCD 2 at sampling point MA SW576 and as such is expected to be contaminated and not comply with the standards provided.

The chemistry results indicated elevated:

- calcium (exceeded the DWA Domestic Use standard);
- fluoride (exceeded all standards except DWA Livestock Water); and
- aluminium (exceeded all standards except DWA Livestock Water).

The water quality of this sample is relatively more polluted when compared to the other samples but as this is a PCD, this is not unexpected. Additionally, as this is a PCD, this water is unlikely to be used for drinking by either animals or humans.

March 2014

The following was noted for this sample:

- The water quality was generally poor, with a pH of 3.4 (acidic);
- pH, sulphate (SO4) and manganese (Mn) exceeded the SANS 241:2011 limit, which is indicative of contamination from mining-related activities; and
- Electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca), aluminium (Al) and iron (Fe) all exceeded the DWA SAWQG target values for domestic use.

8.1.4 MA SW 7&8

May 2013

This sample was taken from a dam between Matimba Power Station and the proposed Medupi Power Station at sampling point MA SW 7&8. The dam is possibly used by local wildlife for drinking water. The chemistry results indicated elevated:

- fluoride (exceeded the DWA Domestic Use and Aquatic Ecosystem standards);
- aluminium (exceeded all standards except DWA Livestock Water); and

- iron (exceeded the DWA Domestic Use standard only).

None of the concentrations of these parameters exceeded the Livestock Watering standard. According to the DWA standards for Domestic Use there can be certain health effects associated with these elevated parameters, as shown in Table 8.2 below:

Table 8.4: Health effects associated with parameters of concern (MA SW 7&8)

Parameter of concern	Health effect at concentration noted (DWA, 1996a)
Fluoride (1.5 mg/ ℓ)	Slight mottling of dental enamel may occur in sensitive individuals. No other health effects are expected.
Aluminium (0.31 mg/ℓ)	No effects on health are expected. Noticeable adverse aesthetic effects (colour) occur when aluminium is present in association with iron or manganese.
Iron (0.18 mg/ℓ)	Very slight effects on taste and marginal other aesthetic effects. No health effects are expected.

March 2014

- The water quality at the site was poor;
- Electrical conductivity (EC), calcium (Ca), magnesium (Mg) and manganese (Mn) exceeded the DWA SAWQG target values for domestic use;
- Total dissolved solids (TDS) exceeded the DWA SAWQG target values for livestock;
- Sulphate (SO4) and fluoride (F) exceeded the SANS 241:2011 limit; and
- The elevated constituents noted at the point indicate potential contamination from the Power Station activities and infrastructure (e.g. ash disposal facility runoff can result in elevated EC, TDS and SO4).

8.1.5 MA SW 9&10

May 2013

This sample was taken from sampling point MA SW 9&10; a pan at the ash disposal site at the Matimba Power Station. The pan is used by local wildlife for drinking water. The chemistry results indicated elevated:

- fluoride (exceeded all standards except DWA Livestock Water); and
- aluminium (exceeded the DWA Aquatic Ecosystems standards only).

None of the concentrations of these parameters exceeded the Livestock Watering standard. According to the DWA standards for Domestic Use there can be certain health effects associated with these elevated parameters see Table 8.5.

Table 8.5: Health effects associated with parameters of concern (MA SW 9&10)

Parameter of concern	Health effect at concentration noted (DWA, 1996a)
Fluoride (1.9 mg/ ℓ)	Mottling and tooth damage will probably be noticeable in most continuous users of the water. No other health effects occur.
Aluminium (0.31 mg/ℓ)	No effects on health are expected. Noticeable adverse aesthetic effects (colour) occur when aluminium is present in association with iron or manganese.

March 2014

Samples could not be taken due to inaccessibility to the site.

8.2 Geochemical Diagrams

The water chemistry results were plotted in a geochemical diagram in order to determine the type of water and the major chemical characteristics. The geochemical graph used is the Piper diagram. Piper diagrams are useful graphical presentations of the various percentages of the major anion and cation constituents of water. The cation and anion percentages are illustrated in two triangular fields and extrapolated onto a central diamond-shaped field as a combination of both anions and cations. Piper plots are a useful way of revealing differences and similarities between waters. In addition, their actual positions on the diagram allow for classification based on the major cations and anions present.

The Piper diagram for the surface water sample is presented in **Figure 8.3** and **Figure 8.4** below. Figure 8.3 shows that the samples plot in two distinct groups. Samples MA SW 3&4 and MA SW 5&6 plot in the top right-hand side of the Piper diagram and indicate a relativity higher proportion of sulphate compared to the other samples. These waters can be classified as sodium- sulphate water types. This is expected since these samples are from the two PCDs. The remaining samples from the pans/dams plotted towards the centre and slightly to the left of the Piper diagram. These samples indicated less impacted waters with calcium/magnesium-water types.

Figure 8.4 shows that all of the samples plotted within the calcium sulphate water type sector of the diagram and showed impacts due to mining activities, with the exception of MA SW1 which plotted in the sodium chloride water type sector of the diagram and showed signs of being brackish.

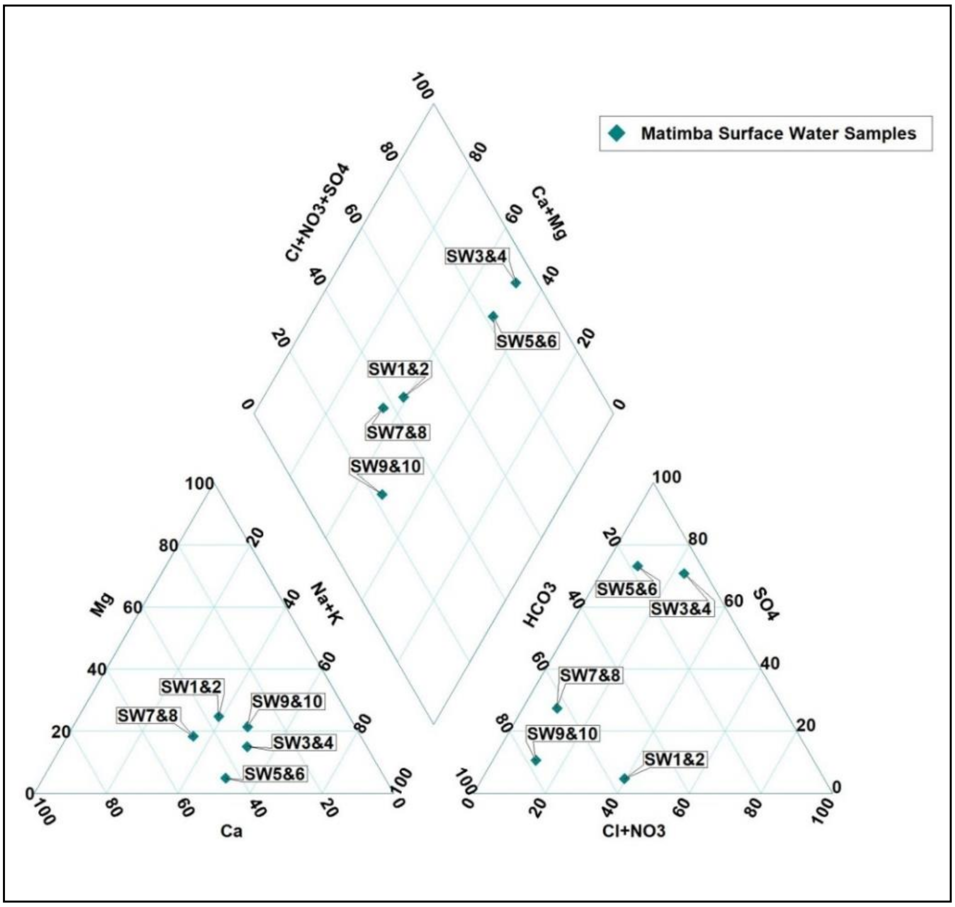


Figure 8.3: Piper diagram for the May 2013 site visit

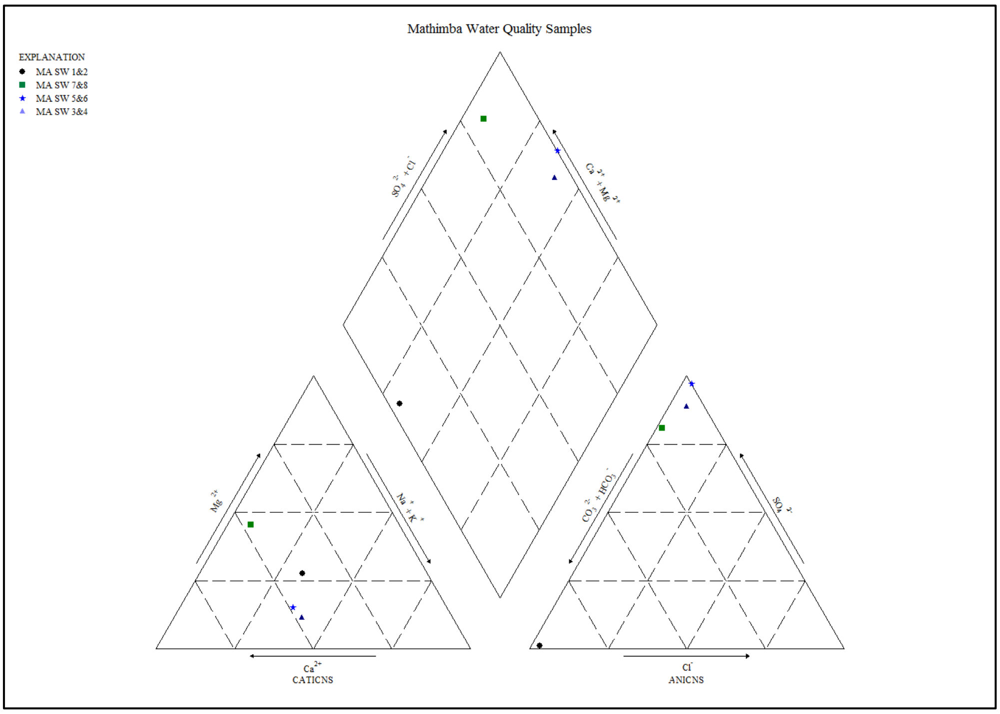


Figure 8.4: Piper diagram for the March 2013 site visit

8.3 Concluding Remarks

The dam/pan water samples highlighted that fluoride and metal levels were elevated. These dams are utilised by wildlife in the area for drinking water and none of the parameters analysed exceeded the Livestock Watering guidelines. Samples MASW1&2 at site MASW1, however, contained elevated aluminium levels and it is recommended that this is addressed as this may be dangerous for the livestock that drink from the pan over time.

In terms of the PCD samples, PCD 1 was more contaminated than PCD 2, however, these dams are not expected to be compliant with drinking water or Livestock Watering standards. These PCDs should be contained and access controlled. It is recommended that the PCDs be in line with all Water Use License (WUL) requirements in terms of size, free-board levels, water quality and monitoring requirements, including but not limited to groundwater and toxicity testing. PCDs should meet the minimum conditions of the Best Practice Guidelines A4: PCDs (Department of Water Affairs, 2007) and Government Notice 704 of The National Water Act (36 of 1998). The results from a once-off sampling event cannot be used to make a conclusive statement about the water quality. However, from this analysis, the water sampled from the dams/pans is fit for livestock watering and the PCD water should be contained.

9 ASH QUALITY ASSESSMENT

9.1 Sample Description

Two ash samples were taken from the existing Matimba Ash disposal site (please see Figure 8.1 for the location of the existing ash disposal facility) by GCS personnel in May 2013; samples MA1 and MA2. The samples were submitted to Eco Analytica (at North-West University) for analysis and the results are discussed below. The aim of the ash sample analysis was to provide a general idea of the pollution potential of the disposal facility should run-off from the ash piles be released into the environment. This investigation does not represent a waste characterisation study and cannot be used for long-term predictions as the results are from a once-off sampling event with a limited sample size (only two samples were collected).

9.2 Analysis Methodology

The samples underwent an ammonium acetate extraction, which provides an indication of the total elemental concentrations in the sample. This is presented in the nutrient status and gives an understanding of the total composition of the samples.

Additionally, the ash samples were submitted to an aqueous extraction. These results provide an indication of the elemental concentrations soluble in water and which, therefore, are available for absorption by plants and can potentially leach into the groundwater. The results of this test show the concentrations of certain parameters that would make up the run-off, should the ash piles be exposed to rainfall.

9.3 Chemistry Results

a) Nutrient Status

The nutrient status results are presented in Table 9.1, below, which shows the total composition of the ash samples.

Table 9.1: Nutrient Status of the Ash Samples

Parameter	MA Soil 1	MA Soil 2
Calcium, Ca (mg/l)	4491.9	3953.9
Magnesium, Mg (mg/l)	398.8	202.7
Potassium, K (mg/l)	64.3	110.6
Sodium, Na (mg/l)	9.9	45.1
Phosphate, P (mg/l)	18.1	13.9
pH (KCl)	8.70	8.50
EC (mS/m)	205	258
Organic (%C)	1.41	0.92
Zinc, Zn (mg/kg)	0.13	2.72
Aluminium, Al Saturation (%)	0.11	0.00

As can be seen from the results above, both samples are primarily comprised of calcium, magnesium and potassium in terms of mg/l.

b) Aqueous Extraction

The results of the aqueous extraction are presented in **Table 9.2** below. The aqueous extraction results were compared to the same sample standards used for the surface water samples, namely:

- Department of Water Affairs (DWA) South African Water Quality Guidelines Volume 1 for Domestic Use (1996a);
- DWA South African Water Quality Guidelines Volume 5 for Livestock Watering (1996b); and
- DWA South African Water Quality Guidelines Volume 7 for Aquatic Ecosystems (1996c).
- South African Bureau of Standards (SABS) SANS 241-1:2011 Drinking Water Standards;

Table 9.2: Aqueous extraction results of ash samples compared to standards

Parameter	DWA TV Domestic Use	SANS 241-1: 2011 Drinking Water	DWA TV Aquatic Ecosystem	DWA TV Livestock Watering	MA Soil 1	MA Soil 2
pH at 22°C (pH unit)	6-9	5-9.7	NS	NS	7.89	7.57
Conductivity (mS/m)	<70	<170	NS	NS	187	253
Calcium, Ca	<32	NS	NS	<1000	235.66	419.62
Magnesium, Mg	<30	NS	NS	<500	79.48	35.97
Sodium, Na	<100	<200	NS	<2000	4.60	21.84
Potassium, K	<50	NS	NS	NS	5.86	20.72
Bicarbonate, HCO_3	NS	NS	NS	NS	45.76	33.56
Chloride, Cl	<100	<300	NS	<1500	3.44	6.29
Sulphate, SO_4	<200	<500	NS	<1000	830.94	1148.90
Nitrate, NO_3	<26.6	<48.7	NS	<100	4.34	8.53
Manganese, Mn	<0.05	<0.5	<0.18	<10	0.02	0.02
Iron, Fe	<0.1	<2	NS	<10	0.01	0.00
Copper, Cu	<1	<2	<0.0003	<0.5	0.01	0.02
Zinc, Zn	<3	<5	<0.002	<20	0.001	0.01
Boron, B	NS	NS	NS	<5	5	6
Sodium Absorption ration (SAR)	NS	NS	NS	NS	0.22	1.71
Phosphate, PO_4	NS	NS	NS	NS	0.48	0.00
Ammonium, NH_4	NS	NS	NS	NS	0.36	0.45

The results indicate that the samples show high concentrations of sulphate, calcium and magnesium. Calcium and magnesium are not of concern; however the elevated sulphate will have a negative impact on the receiving environment. The results for each sample are discussed in more detail below.

Sample MA1

This sample had elevated concentrations of conductivity (both drinking water standards), calcium (DWA Domestic Use standards only), magnesium (DWA Domestic Use standards only), sulphate (both drinking water standards) and copper (Aquatic Ecosystem standard only) in the aqueous extraction. This analysis indicated that run-off from this sample would not be suitable for the environment, domestic use or livestock watering.

Sample MA2

This sample had elevated concentrations of conductivity (both drinking water standards), calcium (DWA Domestic Use standards only), magnesium (DWA Domestic Use standards only), sulphate (both drinking water and livestock watering standards), copper (Aquatic Ecosystem standard only), zinc (Aquatic Ecosystem standard only) and boron (livestock watering standards) in the aqueous extraction. This analysis indicated that run-off from this sample would not be suitable for the environment, domestic use or livestock watering.

9.4 Concluding Remarks

The nutrient status results indicate that both samples primarily comprised of calcium, magnesium and potassium in terms of mg/l.

The aqueous extraction results show that the samples indicated high concentrations of sulphate, calcium and magnesium in the leachate. Calcium and magnesium are not of concern; however the elevated sulphate will have a negative impact on the receiving environment. The aqueous extraction analysis for both samples indicated that runoff from these samples would not be suitable for the environment, domestic use or livestock watering.

The results from a once-off sampling event cannot be used to make a conclusive statement about the ash disposal facility. However, from this analysis, the runoff from the ash pile poses a potential pollution threat and should therefore be contained in a dirty water system as part of an overall SWMP.

10 CONCEPTUAL SWMP (SWMP)

Any SWMP in South Africa must comply with GN704, Regulation 77 and other relevant legislation. The measures taken to develop this plan must also conform to the following Best Management Guidelines published by the Department of Water Affairs:

i. G1 Storm Water Management

ii. A4 PCDs

iii. A5 Water Management for Surface Mines

iv. A6 Water Management for Underground Mines

In order to comply with best practice Storm Water principles, areas of clean and dirty water need to be identified and managed accordingly. This involves separating the clean water areas from the dirty water areas using a series of berms and channels and diverting dirty water around clean areas and finally into a PCD. Typical areas of dirty water would be any areas where activities pose a pollution risk to surface water resources. Typical areas of clean water include the natural environment, such as areas around streams and rivers (CSIR, 1995). Runoff from clean water areas must be diverted around dirty water areas.

Runoff from dirty water areas must be collected and contained, and may not spill from the dirty water area more than once, on average, in 50 years. Dirty water areas should be managed as a closed separate system regulated by a collection point or PCD. All dirty water should be directed to this collection point and then be managed accordingly, either by re-use in the dirty system, evaporation, or treatment and discharge downstream.

A conceptual plan is required that indicates all areas of clean and dirty water as well as proposed storm water management measures (infrastructure) that are required to ensure the separation of these different water areas. A mine plan is required to finalize this conceptual SWMP.

The conceptual SWMP was produced for the Matimba ash disposal facility and the linear route infrastructure. The Matimba ash disposal differs slightly from normal processes, in that GCS was requested to develop full plans for two potential sites.

10.1 Matimba Ash Disposal facility

10.1.1 Site Alternative 1

Separation of Clean and Dirty Water Systems

The proposed ash disposal facility is located at some distance from the Matimba Power Station and straddles a catchment divide. The site also constitutes an extension of the existing ash disposal facility. With the exception of the extreme south-west corner of the proposed site, there are no upstream catchments that could contribute clean water flows to the site. Water tends to drain naturally away from the site. Toe drains of spoil-heaps constructed on the site will allow collection of all runoff from the site (which must be considered dirty water).

In the extreme south-west corner of the proposed site, overland flood flow from an upstream catchment area is likely to occur. There is no defined watercourse in this area. This water must, however, be diverted away from the proposed ash disposal area. The ideal diversion would likely include laser levelling of a 50 m wide waterway that follows the 1:500 slope along the western boundary of the proposed disposal facility area, back to the Sandloop River. Upstream slopes are, however, so flat that a 1m high earth berm along this western boundary would effectively divert flood water. It is unlikely that this simplified diversion would result in any local erosion of soils. As expected, flow depths and velocities will be low.

The entire ash disposal facility site should be regarded as a dirty water area. Runoff from the site could, however, be easily captured in a down-slope drain system and removed to a PCD. A single, large PCD is recommended to the south of the ash disposal site and below all likely spoil heaps. The layout of recommended storm water management measures is detailed in **Figure 10.1**, below:

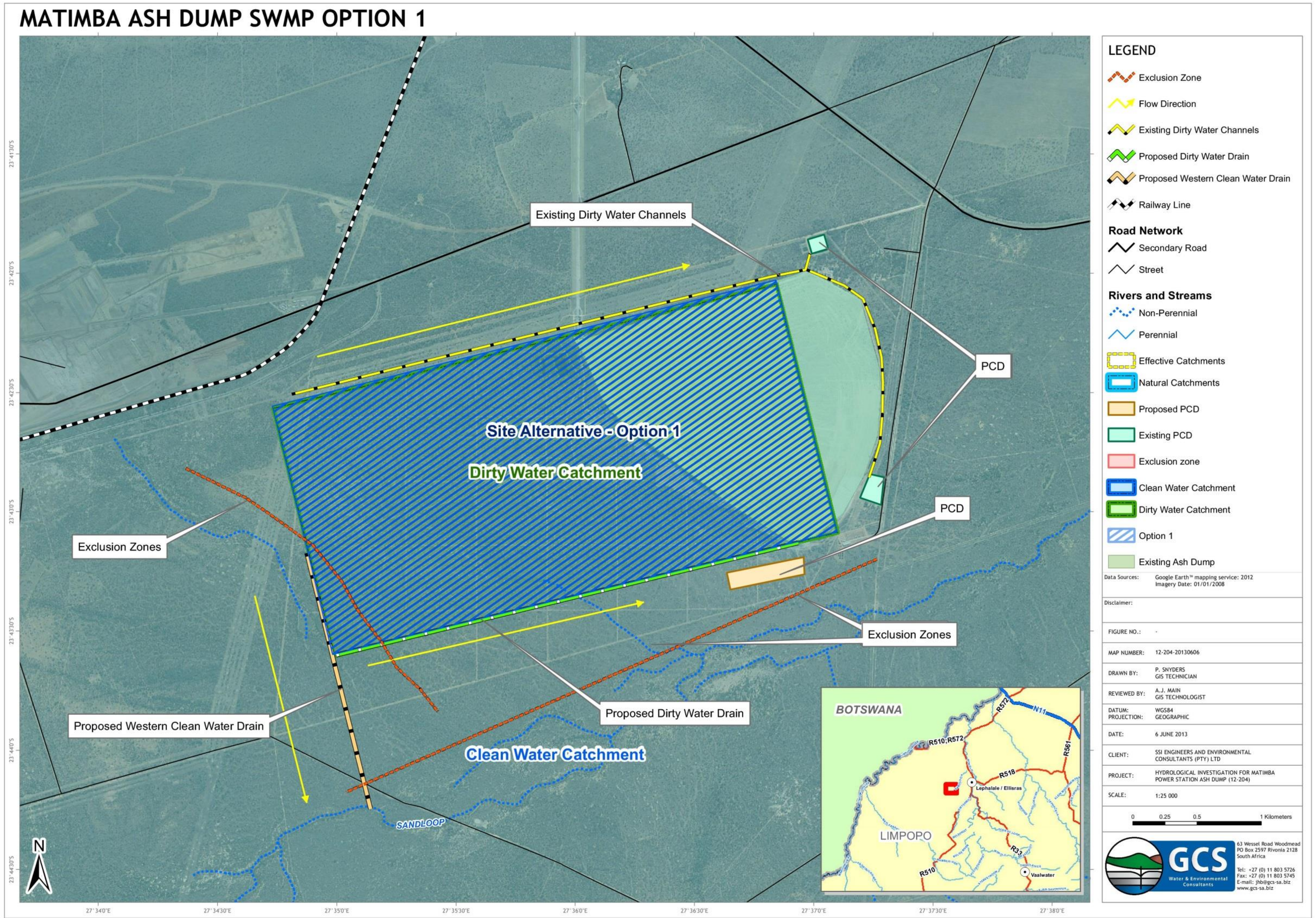


Figure 10.1: Site 1 Conceptual Storm Water Management Measures

Containment of Dirty Water

Runoff and drainage from spoil heaps will be considered dirty water and, as such, this water must be captured on site and contained in a PCD. The entire proposed ash disposal facility site is approximately 720 hectares in extent.

Assuming that the entire site was covered by a layer of fly-ash between 20 and 30 m deep, it is likely that 50% of the expected 430 mm per annum rainfall would penetrate the spoil heaps and report to toe drains (approximately 1.5 million cubic meters per annum). Some seepage water is, however, likely to enter the groundwater. In practice, ash spoil heaps are covered with top-soil and rehabilitated on an on-going basis. As spoil heaps extend to new areas, older areas need to be covered and rehabilitated.

Under the arid local climatic conditions, water falling on rehabilitated surfaces will largely be lost to evaporation and transpiration and very little rain water is likely to infiltrate into the disposal facility. If one assumes 60 hectare of active ash pile, 60 hectare in the process of being rehabilitated (and being actively irrigated) and the remainder of the site as rehabilitated ash pile, provisional simulations indicate that total annual drainage and runoff from the site is unlikely to exceed 360 000 m^3 per annum (on average) and that this quantity of water could readily be captured on site and lost to evaporation. It is, however, estimated that 50% of this outflow (some 25 mm per annum over the site area) will seep into the groundwater and not report to toe drains.

Assuming an average surface area of 8 ha, PCD storages are simulated in **Figure 10.2**. This equates to a required PCD storage capacity, for a dam that spills on average only once in 50 years, of 203 600 m^3. Matimba Power Station has already commissioned an independent PCD design of approximately this capacity for this site. The GCS analysis confirms this dam's design capacity. It is suggested that the main toe drain indicated on the figure above should be capable of conveying a peak flow rate of 0.88 m^3/sec.

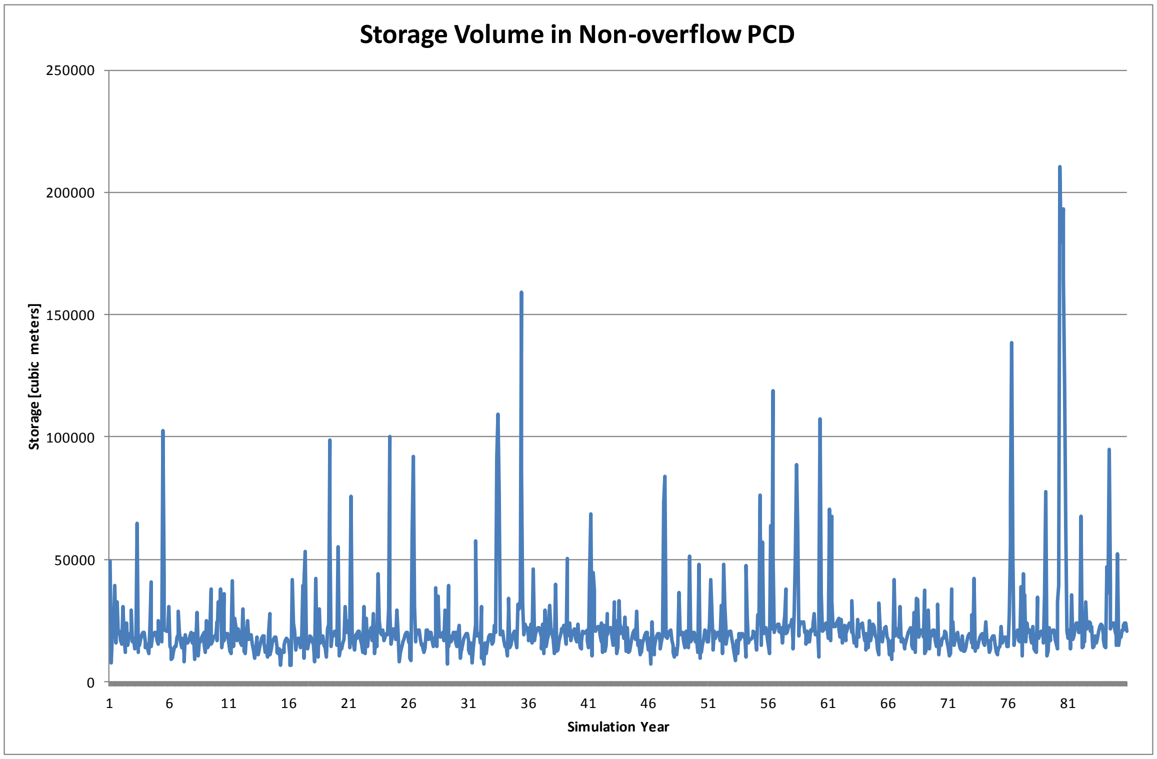


Figure 10.2: PCD Storage

10.1.2 Site Alternative 2

Separating Clean and Dirty Water Systems

This site alternative lies more on a hill-slope with runoff from above the site that would need to be diverted away. A long clean-water drain can be constructed that captures this runoff and conveys clean water runoff to a south-eastern discharge point.

A particular problem at this site is that the flow path of the river is poorly defined. It would seem that with each flood event a new stream-line is established in a wide, poorly defined, flood plain. The area is so flat that vegetation, roads, fence-lines and other transient features may have more impact on the flow path than topographical features. While it is possible to model probable flood lines in HEC-RAS or a similar hydraulic model, actual flow paths are likely to be less definable.

For the purpose of this study, the larger flood plain was delineated using Google Earth imagery, and a 100 m buffer zone was drawn above this line to indicate areas that seem to be safe from flooding. This exercise excludes large sections of the proposed site towards the northern and western boundaries of the site. A down-slope toe-drain would be required to collect dirty water runoff and convey this to a PCD.

The entire ash disposal facility site should be regarded as a dirty water area. Runoff from the site could, however, be easily captured in a down-slope drain system and removed to a PCD. A single, large PCD is recommended to the north of the disposal facility and below all likely spoil heaps. The layout of recommended storm water management measures is detailed in **Figure 10.3** below:

Containment of Dirty Water

The ash-disposal facility area should be considered as a dirty water area, and is treated in much the same way as the site Option 1, described above. A reduced ash disposal site area would lead to a reduced PCD of approximately 180 000 m^3 capacity. Toe drains would be long and would be designed to accommodate peak flow rates in the order of 0.75 m^3/sec.

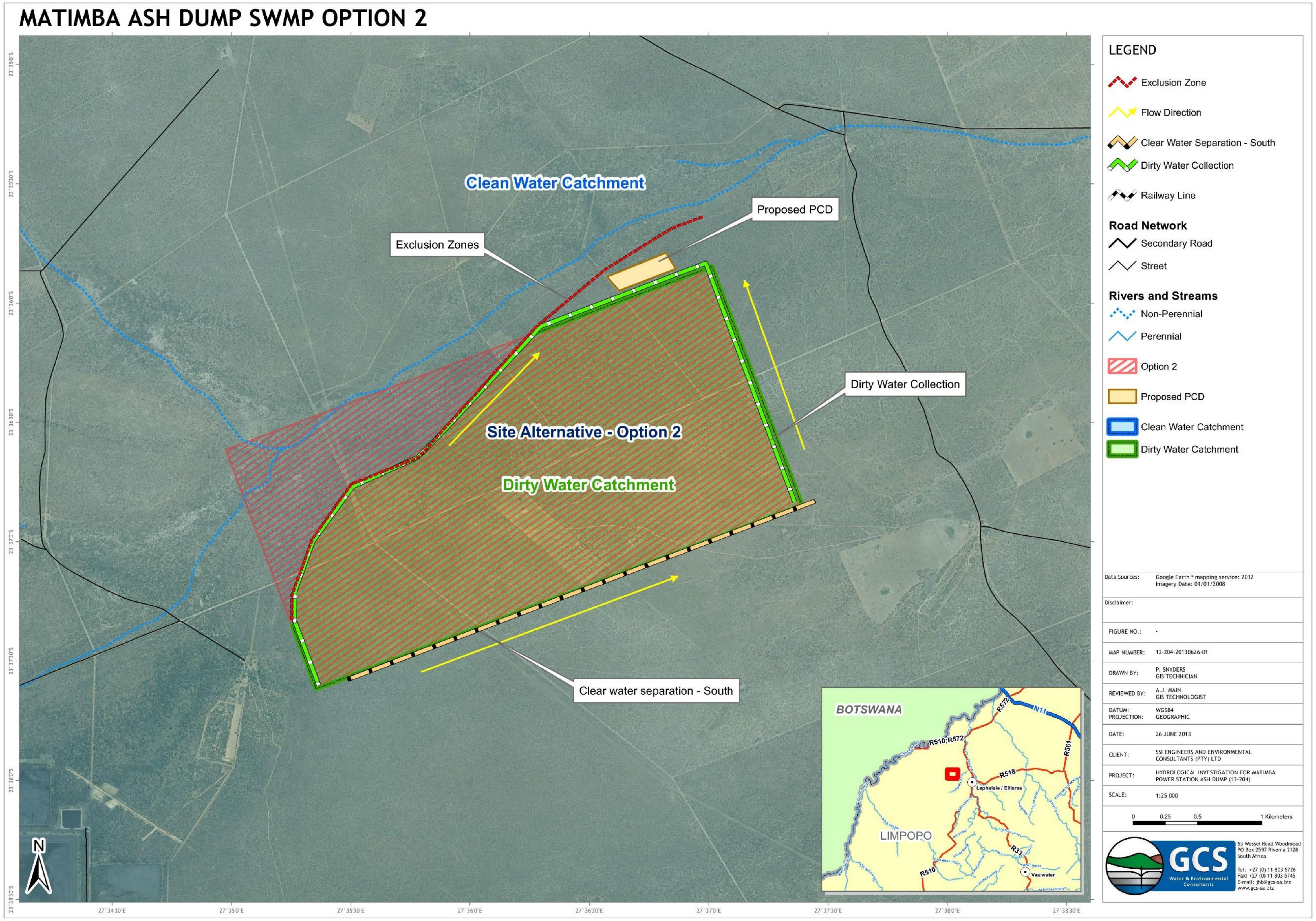


Figure 10.3: Site 2 Conceptual Storm Water Management Measure

10.2 Matimba Linear Infrastructures Route

The entire linear route infrastructure area was defined as a dirty catchment. During the operation of the belt, dust will be generated and therefore this area can be considered dirty. The width of the belt was assumed to be 5 meters with a length of approximately 10km, as agreed-upon with the Client. The total area of the belt is 0.0464km^2.

The Client stated that there will be a road situated next to the belt with the length, width and area the same as the linear route infrastructure. The road was considered to be a clean area as it would be used to maintain the linear route infrastructure. If this road is used to transport material or waste then it should be considered dirty and the proposed storm water management measures of the linear route infrastructure should be implemented on the road.

10.2.1 Proposed Storm Water Management Measures

The storm water management measures suggested for the linear route infrastructure are a berm and a drain located next to the belt as shown in Figure 10.4.

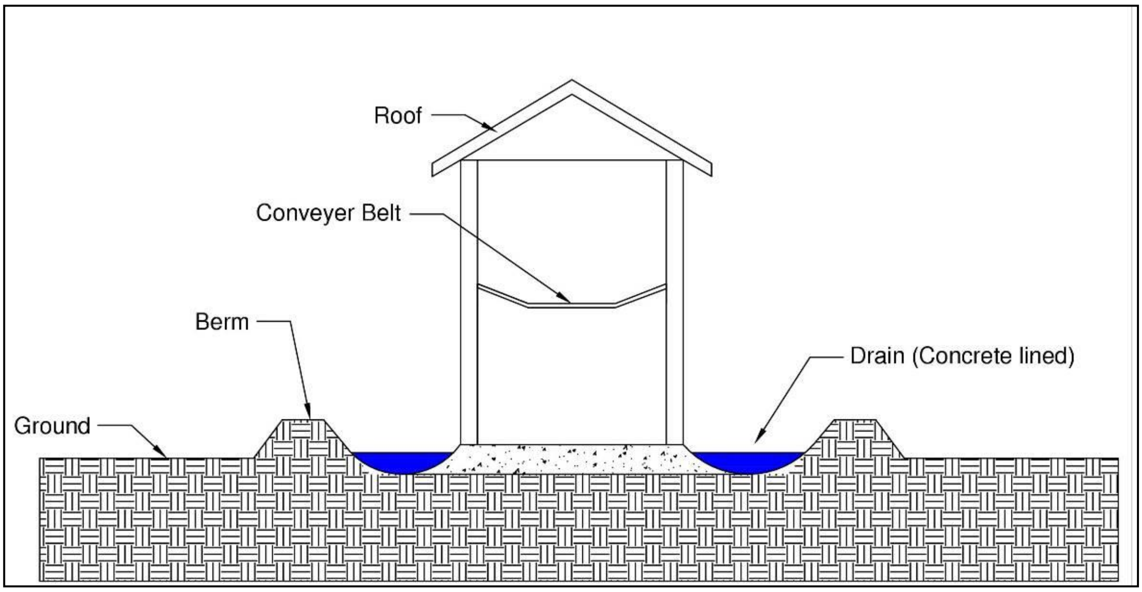


Figure 10.4: Storm Water Measurements for the Conveyor Belt

The drains are placed to stop clean water from entering the dirty water system and vice versa. Rainfall that falls on the roof will mix with the dust generated by the linear route infrastructure and this water will be contained by the berms and transported to the sumps placed along the route. Sumps A, B and C were placed at the lowest elevation point of the route. The areas contributing runoff to these sumps can be seen in Table 10.1. Water that accumulates in these sumps must be pumped to the nearest PCD. The topography of the area was determined using 20m contours. For an accurate placement of sumps, a detailed topography survey of up to 1m should be done on the route. A culvert is suggested under Sump B to navigate clean water from the above catchment under the belt and back into the environment. This will ensure that clean water does not mix with the dirty water.

Table 10.1 Area contributing runoff to the sumps

Sump	Area (km^2)
A	0.012
B	0.030
C	0.0044

The conceptual SWMP and location of the storm water management measures can be seen in Figure 10.5. The elevation profile of the belt can be seen in the left hand side top corner of Figure 10.5.

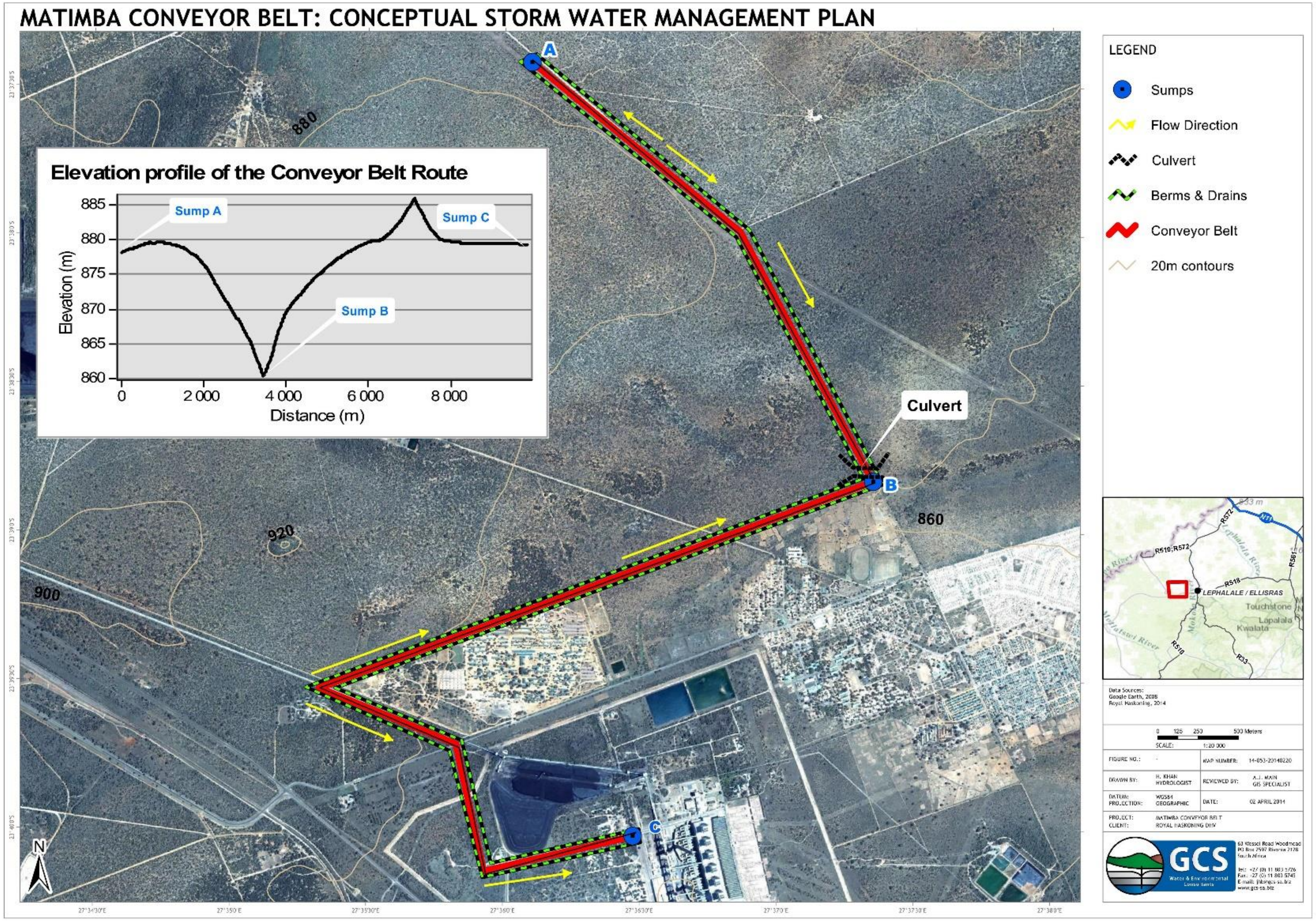


Figure 10.5: Conceptual Storm Water Management Plan for the Matimba Conveyor Belt

10.2.2 Design Flood peaks

Rational Method

The rational method was developed in the mid-19th century and is one of the most widely used methods for the calculation of peak flows for small catchments (< 15 km2). The formula indicates that Q = CIA, where I is the rainfall intensity, A is the upstream runoff area and C is the runoff coefficient. Q is the peak flow.

Alternative Rational Method

The alternative rational method is based on the rational method with the point precipitation being adjusted to take into account local South African conditions.

Standard Design Flood Method

The standard design flood (SDF) method was developed specifically to address the uncertainty in flood prediction under South African conditions (Alexander, 2002). The runoff coefficient (C) is replaced by a calibrated value based on the subdivision of the country into 26 regions or Water Management Areas (WMAs). The design methodology is slightly different and looks at the probability of a peak flood event occurring at any one of a series of similarly sized catchments in a wider region, while other methods focus on point probabilities.

The design flood peaks were calculated for the area of the belt flowing into sumps A, B and C shown in Table 10.2. Catchment A is the area flowing into sump A and so on. According to the GN704, the capacity for the drains and sumps has to be able to accommodate the 1 in 50-year design flood event.

The three methods used for to determine the design floods were the Rational, Alternative Rational and the SDF method. The SWMP is based on future land cover conditions that will have an increase in impervious areas and steep slopes, therefore the best flood peak determination methods would be the Rational or Alternative Rational method. This is because these two methods incorporate a runoff factor that is based on surface slope, perviousness of the site and vegetation. These factors can be adjusted for the future land cover conditions. The alternative rational method is based on the rational method with the point precipitation being adjusted to take into account local South African conditions. As shown in Table 10.2, the Alterative Rational method had the highest flood peaks. These values were then chosen as the best method to base our conceptual designs on because this method is specific to South African conditions and because these are the most conservative values.

Table 10.2: Design Flood peaks

Catchment	Method					
	Rational		Alternative Rational		SDF	
	1:50	1:100	1:50	1:100	1:50	1:100
	(m^3/s)					
A	0.126	0.162	**0.214**	**0.246**	0.067	0.086
B	0.360	0.463	**0.600**	**0.692**	0.186	0.238
C	0.081	0.105	**0.104**	**0.119**	0.037	0.048

10.2.3 Design Flood Volumes

The design flood volumes were calculated using a triangular hydrograph with the time of the rising limb of the hydrograph equal to the Time of Concentration (Tc) and the descending limb equal to twice the Tc. The volume is equal to the area under the hydrograph. The design flood volumes can be seen in Table 10.3, below.

Table 10.3: Design Flood Volumes

Catchment	Tc	Peak Volume	
		Alternative Rational	
	1:50	1:50	1:100
	(hours)	*(m^3)*	
A	1.39	1603	1847
B	1.21	1217	1559
C	0.79	441	508

11 WATER AND SALT BALANCE

This chapter describes the proposed Matimba ash disposal facility Water Balance and Salt Balance Model of the two proposed site alternatives. The proposed infrastructure on both sites must meet GN704 design criteria. To ensure that the proposed PCD in the project area will not spill over more than once one average in 50 years, a daily water balance model has been created in the software package Goldsim (Goldsim, 2013). Please see the information box below.

GoldSim allows the user to create realistic models of mine water systems in order to carry out risk analyses, evaluate potential environmental impacts, support strategic planning, and optimise operations. GoldSim combines the flexibility of a general-purpose and highly-graphical probabilistic simulation framework with specialised modules to support mass transport modelling, reliability engineering, financial modelling and optimization. The user is thus able to predict future behaviour, identify influential system factors, answer 'What-if?' questions, and evaluate alternatives. GoldSim is not only powerful and flexible, thereby enabling the user to accurately represent a mine system, but also facilitates construction of graphical and highly transparent models that can be easily explained to decision-makers and stakeholders.

(http://www.goldsim.com/Web/Solutions/EnvironmentalSystems/)

Within this water balance study it was assumed that all necessary infrastructure and processes on the Matimba Ash disposal facility Sites for Alternatives 1 and 2, which influence the size of the PCD, were incorporated in the Goldsim Model. A Goldsim Dashboard Model and user manual have been provided as an accompaniment to this report. This model can be run using free Goldsim Player software downloaded from www.goldsim.com. Values within this model can be altered by the user, thus this model can be used by the client to see the effects of changes to various input variables.

11.1 Water Balance

A process flow diagram was set up to create linked flows within the Matimba Ash disposal facility sites. The final process flow diagram is shown in Figure 11.1. ESKOM provided flow data (running from April to June 2013) between the Recovery Dam at the Matimba Power Station and the existing Matimba Ash disposal facility. Average daily flow to the Ash disposal facility is ~500m^3/day. No other flow meters were available or installed on the site of the Matimba Ash disposal facility. Thus, all water volumes and water flow directions in the project area were calculated in a daily water balance model over 85 years using WR2005 data. Please see Figure 11.2 for the schematic ash pile water balance upon which the water balance model referred to above was based.

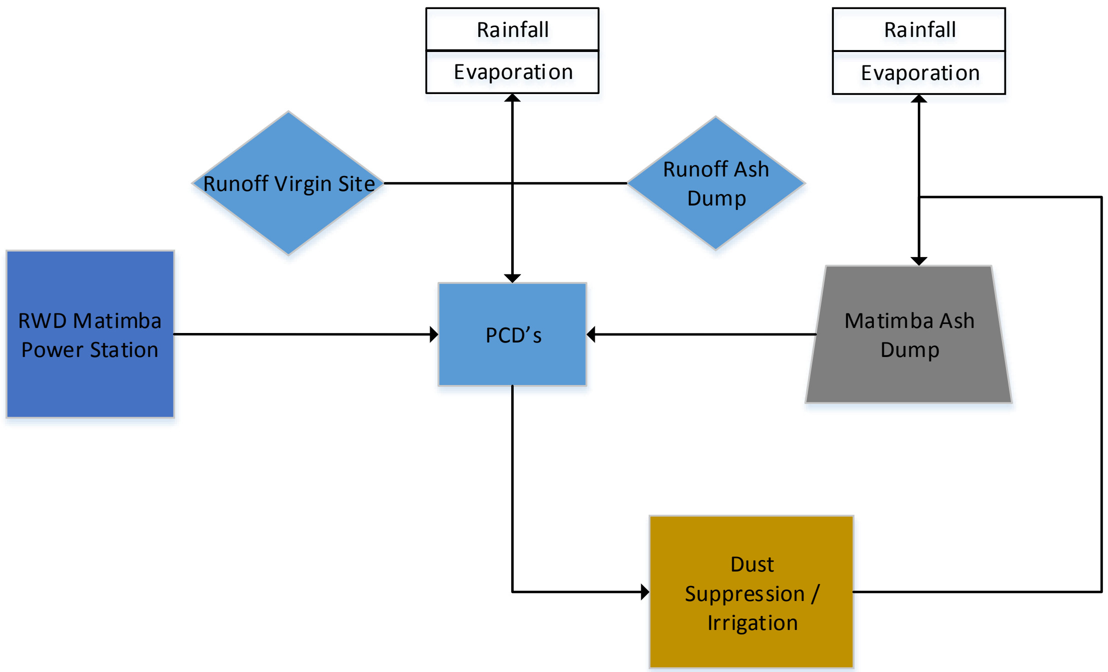


Figure 11.1: Process water flow diagram of the existing Matimba Ash disposal facility

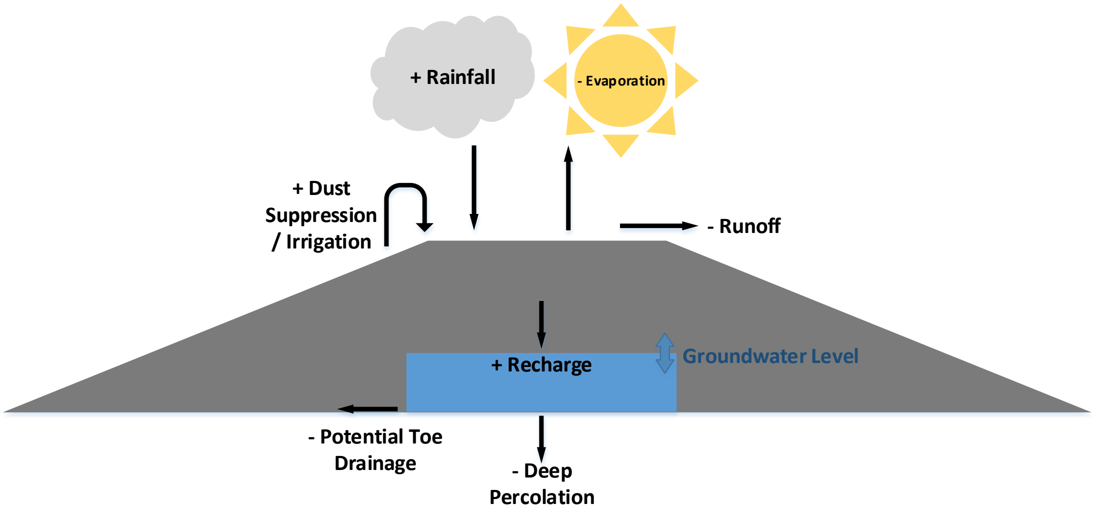


Figure 11.2: Schematic Ash Pile Water Balance

Methodology & Assumptions

Owing to a lack of measured flow data, a simplified water balance model was built to represent the current and proposed infrastructure at the two alternative sites of the Matimba Ash disposal facility. The water balance model was developed in such a way that the GoldSim Model can be changed depending on the stage and the size of the ash pile / entire facility. The choice of the final site alternative will be irrelevant for this water balance model.

It was assumed that the water balance model of the ash pile is a simple 1D- bucket model with vertical in- and outflows (as seen in Figure 11.2). The in- and outflows of each time-step form a new water level in the bucket. This new water level is the starting water level of the next time step.

The following assumptions and operational philosophies were made to develop the water balance model in GoldSim and to calculate the water volumes for the Matimba Ash disposal facility operations:

Table 11.1: Assumptions and operational philosophies Matimba Ash Pile

Water Balance Component	Element	Details
PCD Calculations		
Monthly Rainfall and Evaporation on the PCD	PCD_Rain, PCD_Evaporation	As detailed in hydrology section 6 (WR2005)
Runoff from existing Discard Dump	PCD_Virgin_Runoff	As detailed in hydrology section 6 (WR2005)
Runoff from Ash Pile	PCD_Ash_Disposal facility_Runoff	As detailed in hydrology section 6 (WR2005)
Ash Pile Runoff Factor	PCD_Ash_Disposal facility_Runoff_Factor	Assumed factor from rainfall that will runoff in drains and trenches on the ash disposal facility. This factor makes runoff a bit higher than runoff from WR2005. This is due to the effect of rehabilitation and stormwater infrastructure. Assumed factor: 0.05
PCD	PCD and PCD_Volume	Estimated volume from data from client: 365 000 m^3 (Eskom, 2013)
Ash Pile		
Recharge into Ash Pile	Ash_pile_Recharge	Runoff and losses are subtracted from the sum of rainfall and dust suppression on the ash pile. The recharge was subsequently transformed into a groundwater level in the ash pile by dividing the recharge rate by porosity.
Porosity of the ash on Ash Pile	Ash_Porosity	Assumed value: 0.05 (Gerswin, 2011)

Water Balance Component	Element	Details
Dust suppression or irrigation on Ash Pile	Ash_pile_Dust_Suppression_Rate	Default rate: 5mm/month
Surface Water losses on Ash pile	Ash_pile_SW_Losses	The sum of rainfall and dust suppression must be higher than a assumed percentage of the fixed average monthly evaporation. Default assumption: 0.33
Groundwater losses from Ash pile	Ash_pile_GW_Losses	If water is recharged in the ash pile, it is subject to two types of losses: deep percolation and/or toe drainage. The sum of these two processes forms the total of groundwater losses.
Deep Percolation from Ash pile into deeper groundwater	Ash_pile_Percolation	A fixed seepage factor into deeper groundwater is assumed at a hydraulic conductivity of coal ash. Default value from literature: 0.01m/d (Gerswin, 2011).
Toe Drainage	Ash_pile_Toe_Drainage	For this study no toe drainage was assumed, because current ash disposal facility has no groundwater trenches or drains and for the future ash ash disposal facility it is unknown. In case groundwater drains are required, a drainage factor can be given which will be a factor of the total water volume in the ash pile. Consequently, this will be subtracted from the groundwater level in the ash pile. A dispersion factor can be added to lag and smooth drainage curves from the ash pile.
Groundwater level Ash Pile	Ash_pile_GW_Level	Recharge minus deep percolation minus toe drainage gives new groundwater level in ash pile for the next time step.
Dimensions Ash Disposal Site		

Water Balance Component	Element	Details
Total Ash Disposal facility Surface	Total_Site_Surface	Assumed Value: 7.2km^2
Undisturbed Site Surface	Ash_Disposal facility_Bottom_Surface	+/- Current surface area Matimba Ash Disposal facility: 2.4km^2
Undisturbed Site Surface	Undisturbed_Site_Surface	This is the ash ash disposal facility surface subtracted from the total site surface: 4 .8km^2`
Elevation of the Ash Disposal facility	Ash_Disposal facility_Elevation	Assumed maximum ash pile elevation: 40m.

Results

An example daily water balance model simulation was conducted assuming no groundwater drainage from the ash pile. The model simulation was performed with the approximate size of the current Matimba ash pile (Table 11.1).

For this water balance model simulation the PCD is only subject to:

- Rain and evaporation on the PCD;
- Runoff from the undisturbed portion of the ash disposal facility site and from the ash pile;
- Dust Suppression and irrigation on the Ash pile

The example results of the water balance simulation described above are shown in Figure 11.3 and Figure 11.4. Figure 11.3 shows a graph of the volume of water in the PCD over 85 years. In this simulation the largest fill over 85 years of the PDC is ~174 000m^3. The second largest fill over 85 years is 170 000m^3. This implies, with regards to GN704, that the PCD volume should be at least ~170 000m^3 in order to not be exceeded more than once in 50 years, on average.

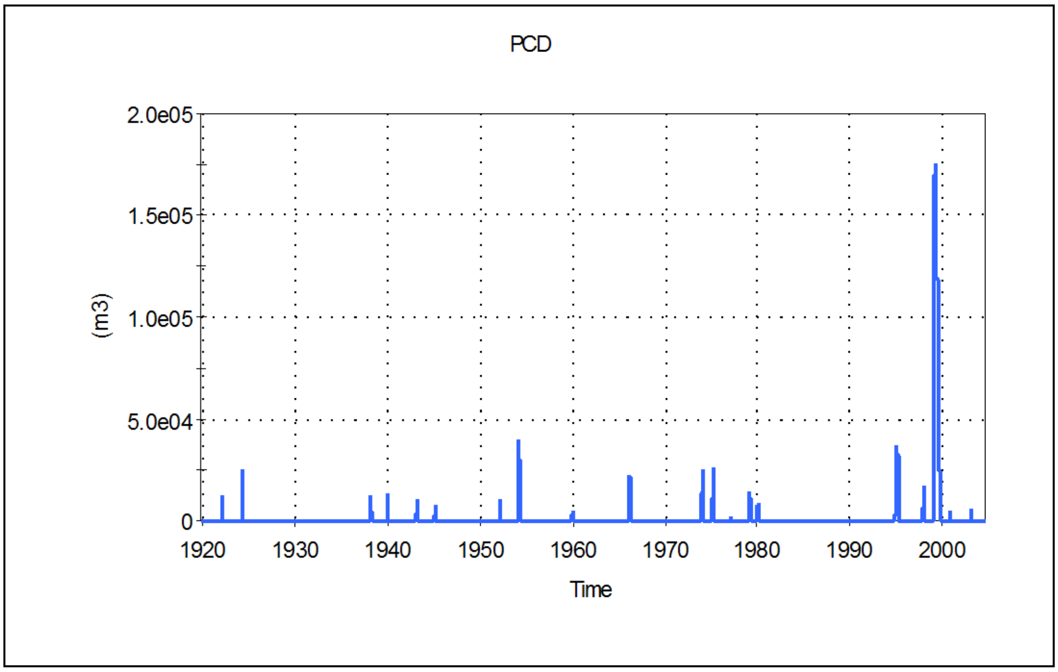


Figure 11.3: Example model simulation of the PCD

Figure 11.4 shows a graph of a water level simulation of the ash pile. In this situation, where a 1D-bucket model is assumed, an increase or decrease in the hydraulic gradient can be seen. This water level determines the potential for deep percolation and/or toe drainage. In the water balance model, parameters can be adjusted to change the water level over time and thus the hydraulic gradient.

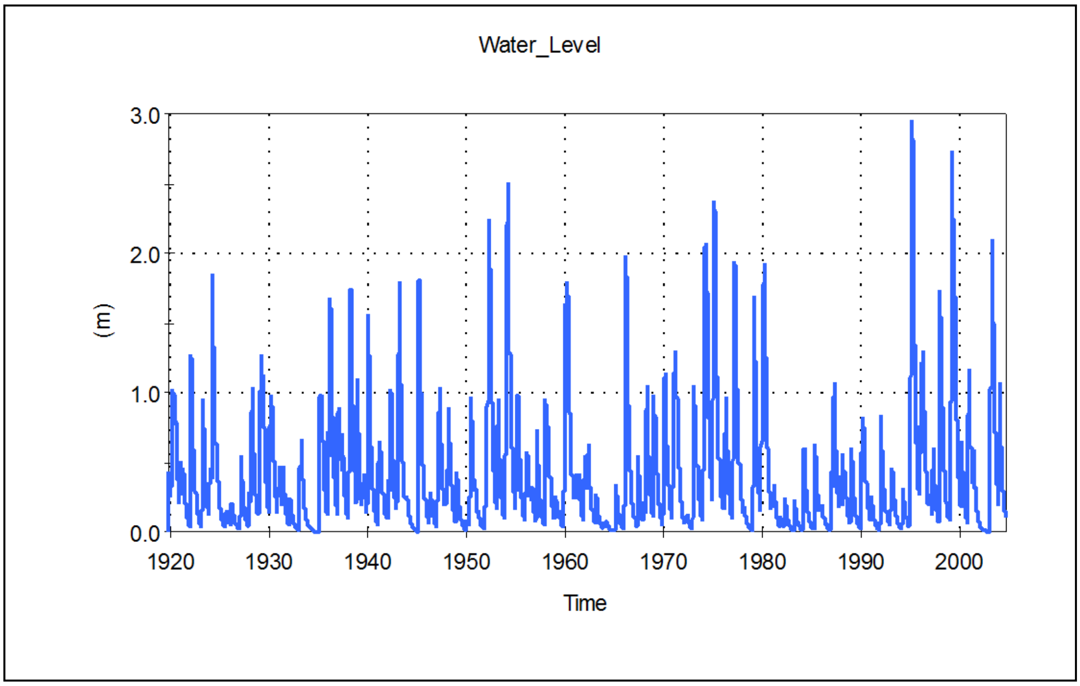


Figure 11.4: Simulated water level in the ash disposal facility

11.2 Salt Balance

Owing to insufficient water flow and quality data of the surrounding infrastructure of the proposed Matimba ash disposal facility, a basic salt balance assessment was conducted based on water quality sample results outlined in Section 8. In this study TDS concentrations were considered because they are representative of general salt concentrations. This brief assessment will be valid for both site alternatives.

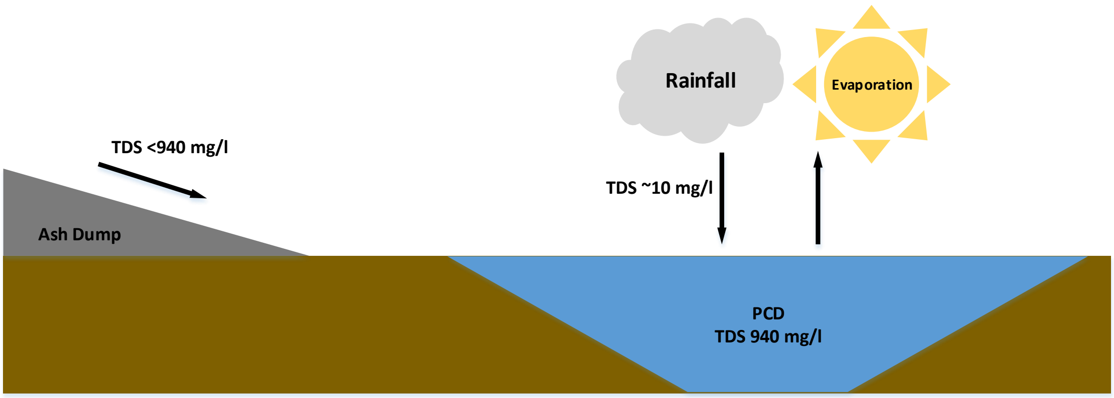


Figure 11.5: Schematic overview of a PCD Salt Balance

Water quality sample MA SW 3&4 showed the highest elevated TDS concentration of 940 mg/l (Section 8). This elevated concentration is likely to have occurred because of high evaporation rates (+/- 1950mm/year) which causes salt deposits in the PCD.

It can be assumed that rainfall contains approximately ~10mg/l of TDS concentrations. TDS concentrations in runoff from an ash pile are expected to be lower than the TDS concentrations in the PCD. This is because ash functions as a water filter.

It is recommended that the salt balance be updated when more flow data and quality data become available. This could then be incorporated in the GoldSim Model.

12 MONITORING

A comprehensive monitoring programme is recommended at the Matimba Ash disposal facility in terms of Best Practice Guidelines G3: Water Monitoring Systems (DWAF, 2006). The monitoring programme will assist with overall water management at the site, including but not limited to:

- Preventing pollution and thereby protecting the receiving water environment;
- Developing an understanding of the current pollution on the mine and monitor how it changes over time; and
- Assessing performance of pollution prevention measures, i.e.: compliance with license conditions and catchment objectives.

The parameters for water quality analysis should be the same as analysed for in this study unless further parameters are required by the relevant authorities. The recommended monitoring programme is in line with Best Practice Guidelines (DWAF, 2006). The monitoring programme should be amended according to on-site operations and future Environmental Impact Assessment and Water Use License requirements. A proposed outline for the monitoring programme is detailed in the table below.

Table 12.1: Proposed surface water monitoring programme outline

Details	Monitoring Frequency
Pre-Construction Phase	
Sample points should remain as they were in this study, and include any open water bodies in the immediate area.	Quarterly Water Samples
Construction and Operation Phase	
Up- and down-gradient samples of all rivers in the vicinity of the power station operations, as well as any springs, pans and natural dams.	Monthly Water Samples
Closure and Post-Closure Phase	
Up- and down-gradient samples of all rivers in the vicinity of the power station operations, as well as any springs, pans and natural dams	Bi-annual water samples

Furthermore it is recommended that sample site MASW1 is monitored at least bi-annually as high aluminium levels were detected here and livestock are likely to continue to drink from this pan over time.

13 IMPACT ASSESMENT

This exercise in risk identification and mitigation involves identification of the types of water users found in the area, as well as a description of the identified risks the mine may incur during the various phases of the project.

Using the WARMS Database (DWA, 2002), downstream users in catchment A42J were identified. Water in this catchment is used for irrigated agriculture, non-urban industrial use and water supply services, as seen in the WARMS data below.

Table 13.1: WARMS Data Water Uses Table

WARMS SUMMARY _ PARTICULAR TO A42J			
Drainage Region Code	**902 AGRICULTURE: IRRIGATION**	**909 INDUSTRY (NON-URBAN)**	**920 WATER SUPPLY SERVICE**
A42J	YES		YES
A42J		YES	

Please see Appendix C for the full dataset.

Table 13.2 shows identified potential risks and associated mitigation measures with regard to the project's potential impacts on surface water resources. These are the same for site alternatives 1 and 2. Please see Appendix D for an alternative Risk Assessment table. Again, the surface water risks will be the same for each site.

Table 13.2: Surface Water Impact Assessment Table

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Issues related to SURFACE WATER																
Separation of clean and dirty water areas: Clean water runoff from areas outside the dirty water footprint area could flow into this area and potentially become polluted.	SWMP	6	4	3	4	52	-	M	Identify dirty water footprint area, separate clean and dirty water using a system of berms and drains.	4	2	2	2	16	-	L
Vegetation and topsoil cleared from building sites and roadways could obstruct natural drainage, divert clean water into dirty water areas, cause waterlogging of adjacent areas or pollute water resources	SWMP	4	4	2	3	30	-	M	Overburden that is removed should be spread at a suitable location and immediately rehabilitated, taking into account natural drainage paths - All works should have appropriate drainage plans.	4	2	2	2	16	-	L
Soil disturbance could cause siltation of the surface water resource during soil turning activities.	Siltation	10	4	3	5	85	-	H	Ensuring that clean and dirty water separation infrastructure is in place prior to the commencement of the construction activities. Compaction of the area during base preparation.	4	4	1	2	18	-	L
Sizing of polution control dams	SWMP	10	4	2	5	80	-	H	Allowing within the design criteria for the 1:50 year storm event to be contained and re-used within the process. Management of the water balance is essential.	6	1	1	3	24	-	L
Slope could significantly contibute to erosion and siltation during the construction phase.	Erosion	6	4	2	5	60	-	M	Sloping of the areas so as to allow for free runoff - either towards a pollution control structure or away from the site, depending on whether the water is clean or dirty. Management of runoff velocity so as to prevent erosion gullies from forming. Inspections and maintenance will be required.	2	4	1	2	14	-	L
Builders rubble, packaging and other waste generated in the construction process could become a source of pollution for water resources.	Construction	2	2	2	5	30	-	M	Builders' contracts should stipulate the appropriate storage and removal of builders' waste	2	2	1	2	10	-	L
Fuels and/or toxic materials could be spilled and pollute local water resources	SWMP	6	3	3	3	36	-	M	Measures should be in place to contain any spills and allow safe collection and disposal of waste	4	3	2	2	18	-	L
Seepage to surface water (and groundwater) resources from the ash dump.	SWMP	10	4	2	5	80	-	H	Waste classification is required in order to influence design parameters and make recommendations with regards to design, liner and monitoring requirements. These must be adhered to in order to prevent or minimise seepage from waste disposal areas.	6	4	1	2	22	-	L
Runoff from workshops and washbays could be contaminated with hydrocarbons	SWMP	4	4	3	3	33	-	M	Suitable oil traps are provided to trap and store hydrocarbons for safe disposal.	4	4	1	1	9	-	L
Wash water contains heavy silt loads which could settle in pollution control dams and reduce storage capacity	SWMP	4	4	1	4	36	-	M	Suitable silt traps are provided to trap and remove silt from wash water	4	4	1	1	9	-	L
Runoff and drainage from coal stockpiles continue to yield acidic water	EMP	6	5	3	4	56	-	M	Stockpiles are spread and surfaces rehabilitated, the surfaces of TSFs are rehabilitated drains and return water dams are maintained and water transferred to a pollution control dam	6	5	1	2	24	-	L

14 CONCLUSIONS AND RECOMMENDATIONS

The study area is dry and warm and the catchment is rural, flat and impermeable. For both site alternatives the proposed development will not have a significant impact on the runoff in the immediate or greater areas if the recommendations, as stipulated below, are adopted.

Catchment areas used for flood calculations were found to differ significantly from natural catchment areas derived solely from historical topographic maps. Local development has changed catchment boundaries and flow paths. Peak flows for the 1:50- and 1:100-year flood events calculated for Catchment 1, as seen in Figure 6.1, are $4.03m^3/s$ and $7.73m^3/s$, respectively. For Catchment 2 these are $28.98m^3/s$ and $43.83m^3/s$ and for Catchment 3 these are $395.92m^3/s$ and $506.96m^3/s$, respectively. Development on either site is not anticipated to have a large potential stream flow reduction impact on the runoff of the immediate and general area.

The dam/pan water samples indicated elevated fluoride and metal levels. The dams within the site boundary are utilised by wildlife in the area for drinking water and none of the parameters analysed exceeded the Livestock Watering guidelines. Samples MASW1&2 at site MASW1, however, contained elevated aluminium levels and it is recommended that this is monitored as livestock is likely to continue to drink from this pan. The aqueous extraction analysis for both samples indicated that runoff from these samples would not be suitable for the environment, domestic use or livestock watering. It is further recommended that the PCD be in line with all WUL requirements in terms of size, free-board levels, water quality and monitoring requirements, including but not limited to groundwater and toxicity testing. Should the WUL not specify specific requirements, the PCDs should meet the minimum conditions of the Best Practice Guidelines A4: PCDs (Department of Water Affairs, 2007) and Government Notice 704. The results from a once-off sampling event cannot be used to make a conclusive statement about the water quality, but, from this analysis it can be concluded that the water sampled from the dams/pans is fit for Livestock Watering and the PCD water should be contained in a dirty water system as part of an overall SWMP.

A conceptual plan for each proposed alternative site has been developed that indicates proposed storm water management measures. Site Alternative 1 requires a PCD storage capacity for a dam that spills on average only once in 50 years of 203 600 m^3. Matimba Power Station has already commissioned an independent PCD Design for this site and a dam of approximately this capacity is already planned for this site. The GCS analysis confirms this dam's design capacity. For site Alternative 2 the entire ash disposal facility site should be regarded as a dirty water area. A single, large PCD is recommended to the north of the disposal facility and below all likely spoil heaps. A reduced ash disposal site area would lead to a reduced PCD of approximately 180 000 m^3 capacity. Toe drains would be long and would be designed to accommodate peak flow rates in the order of 0.75 m^3/sec.

For the linear route infrastructure SWMP, sumps are recommended at the lowest point to collect the dirty water and for it to be pumped into the nearest PCD. In accordance with GN704 regulations, these sumps must be able to accommodate a 1 in 50-year flood event. The 1 in 50-year flood volumes calculated for sump A, B and C are 1603, 1217 and 441 m^3 respectively. It is recommended that a detailed topography survey be done to determine the elevation profile of the belt and hence determine a more accurate SWMP.

A comprehensive monitoring programme is recommended at the Matimba ash disposal facility in terms of Best Practice Guidelines G3: Water Monitoring Systems (DWA, 2006c), in order to detect any potential contamination as early as possible. The monitoring programme will assist with overall water management at the site and should be amended according to on-site operations and future Environmental Impact Assessment and WUL requirements. The monitoring programme recommends quarterly sampling at identified sampling points and open water bodies, monthly sampling up- and down-stream of relevant rivers and pans within the study site and bi-annual sampling up- and down-stream of relevant rivers and pans in the greater area. As mentioned, it is further recommended that sample site MASW1 is monitored at least biannually as livestock are likely to continue to drink from this pan.

The 1:50- and 1:100-year flood lines of the 3 rivers analysed within this study mostly fall outside of the 100m buffer zone. These flood lines could be exaggerated owing to data inaccuracy (cross sections using 20 m contours). Mostly overland flow is expected and consequently flood lines are extremely difficult to determine. A conservative approach was adopted, in which a wider flood plain was accepted in order for protection of the resource and to allow water to flow freely over a protected zone. A floodplain has thus been delineated that is likely to include any probable flow path for the design flood and a 100m buffer zone around this flood plain has been drawn (Please see Figure 7.3). It is recommended that these flood lines are recalculated once 1m contour data become available.

An impact assessment was performed for the proposed development. It was found that downstream water uses are predominantly mining, irrigated agriculture and urban industrial water users. Potential risks and mitigation measures were largely centred on pollution of surface water resources. The proposed mine development is unlikely to pose significant risks to local surface water resources if appropriate measures are in place, as outlined in this document. Emphasis is placed on the monitoring programme and risk mitigation measures being implemented correctly. The main mitigation measure recommended is the implementation of the SWMP.

A water and salt balance was also performed on the existing ash disposal facility. Simulation modelling using the Goldsim Model showed that the required PCD volume should be at least ~170 000m^3 in order to not be exceeded more than once in 50 years, on average. Some volume estimations were made within this water balance. It is recommended that the water balances be updated when better information becomes available. Water quality sample MA SW 3&4 showed the highest elevated TDS concentration of 940 mg/l. This elevated concentration is likely to have occurred because of high evaporation rates (+/- 1950mm/year) which causes salt deposits in the PCD. It is recommended that the salt balance be updated if more flow data and quality data become available. These can then be incorporated into the existing GoldSim Model of the site.

The proposed ash disposal facility development (as planned) is unlikely to pose significant risks to local surface water resources when appropriate measures, as discussed in this specialist report, are implemented. The most important recommendation is to ensure that the proposed SWMP is implemented and that the associated infrastructure is properly designed by a registered Engineer and maintained.

The operational philosophy as described in this report should be followed, or if changed, the SWMP should be re-assessed to ensure that adequate protection is afforded to local surface water resources and that the SWMP remains compliant with relevant legislation and best practice guidelines.

Based on the abovementioned conclusions it is recommended that site Alternative 1 is selected over site Alternative 2. This is because Matimba Power Station has already commissioned an adequately-sized independent PCD Design for Site Alternative 1, which requires a PCD storage capacity for a dam that spills on average only once in 50 years of 203 600 m^3. For site Alternative 2, however, the entire ash disposal facility site should be regarded as a dirty water area, thus a large PCD of approximately 180 000 m3 capacity would be required to the north of the disposal facility and below all likely spoil heaps. Based on the available contour data and ash and water samples taken, neither site Alternative is more favourable from a flood line, water quality or water balance perspective. Developmental risks, mitigation measures and monitoring recommendations would also remain the same at both sites. There will be minimal stream flow reduction from development at either site.

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APPENDIX A: SITE VISIT REPORT

Hydrological Investigation Matimba Ash Disposal facility

Report

Version - 1

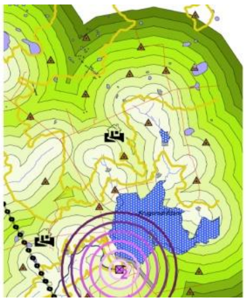
29 May 2013

Royal Haskoning DHV

GCS Project Number: 12-204

Client Reference: 12-204




Report
Version – 1

29 May 2013

Royal Haskoning DHV

12-204

DOCUMENT ISSUE STATUS

Report Issue	Draft		
GCS Reference Number	GCS Ref - 12-204		
Client Reference	12-204		
Title	Hydrological Investigation Matimba Ash Disposal facility		
	Name	**Signature**	**Date**
Author	Robert Verger		29 May 2013
Document Reviewer	Karen King		29 May 2013
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SITE VISIT

A two day site visit was undertaken on the 23rd and 24th of May to Lephalale. During this site visit, the two candidate site s for the proposed Matimba Ash disposal facility were assessed for the following purposes:

- General site assessment;
- Water quality sampling; and
- Flood line assessment.

Site Alternative 1 consists of current power station activities as well as bushveld. The area partly consists of the existing Matimba Ash disposal facility with two existing, lined storm water dams/PCDs and one large, lined PCD under construction.

Site alternative 2 is a Greenfield area largely comprising bushveld.

Water features identified on the sites during the site visit includes the following:

Site Alternative 1

- Two existing, lined PCDs and one lined PCD under construction;
- Storm Water Channels and Berms; and
- An artificial pan used by local wildlife for drinking water;

Site Alternative 2

- Artificial Pan used by local wildlife for drinking water;

The natural environment of both site alternatives comprises bushveld and grassland and the environment is generally dry and flat. No water or clear drain path was visible flowing towards the Sandloop River.

Figure 1.1 shows a map of the project areas with the geographic locations of each point sampled during the site visit. The general site areas are illustrated in the pictures below with water sample numbers, where taken. Five water samples were taken.

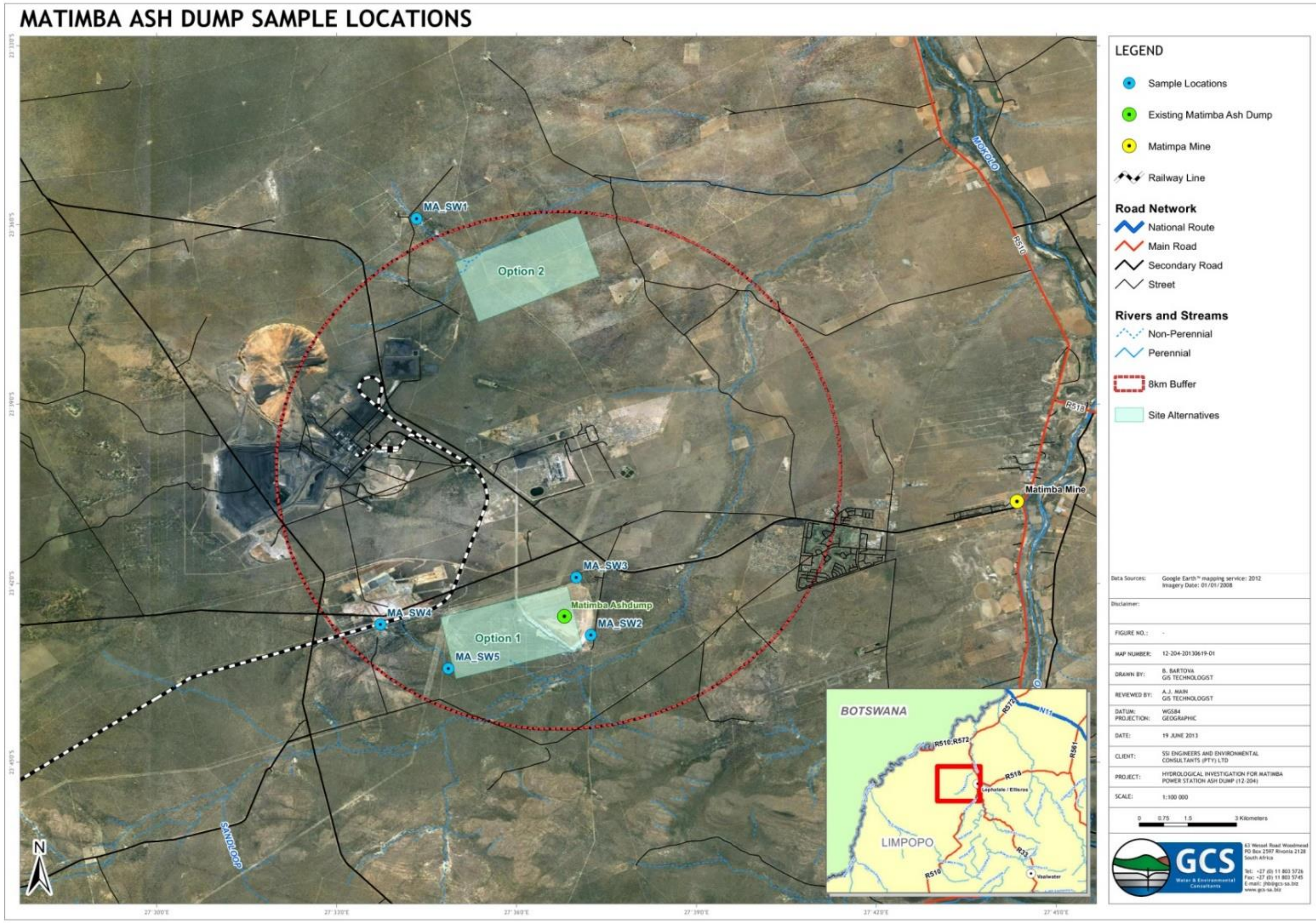


Figure 15.1: Matimba Ash Disposal facility Sample Locations

Photo 15.1: Site Alternative 1 - Lined PCD under construction taken from the existing Matimba Ash disposal facility

Photo 15.2: Site Alternative 1 - Lined PCD (Sample Point MA SW 3&4)

Photo 15.3: Site Alternative 1 - Lined PCD (Sample point MA SW 5&6)

Photo 15.4: Site Alternative 1 - Storm water trench next to rehabilitated Matimba Ash disposal site

Photo 15.5: Undefined pan upstream of site Alternative 1

Photo 15.6: Site Alternative 1 - Artificial Pan used by wildlife (Sample point MA SW 9&10)

Photo 15.7: Site Alternative 2 - Artificial Pan used by wildlife (Sample point MA SW 1&2)

Photo 15.8: Site Alternative 2 - Undefined drainage path towards the Sandloop River

Photo 15.9: Site Alternative 2: Dirt/sand road

15.1 Sample Point MA SW 1&2

The first point visited was an artificial pan used for drinking water by wildlife on the Manketti Game Reserve Properties (**Photo 15.7**). There was lots of water present and a buck was seen drinking there. The pan was surrounded by bushveld vegetation and grassland. The Research Manager of the Game Reserve (Marius Fuls) mentioned that clean water is pumped from the Exxaro Coal Mine into this pan. Sample MA SW 1&2 was collected here. Nitric acid was used to preserve the sample.

15.2 Sample Point MA SW 3&4

The second sample was taken at the lined PCD southeast of the existing Matimba Ash disposal facility (**Photo 15.2**). This PCD is connected to storm water trenches at the sides of the rehabilitated part of the ash disposal facility (

Photo 15.4). Before surface water enters the PCD, silt and other deposits are trapped by a silt trap. The surrounding site and the rehabilitated part of the ash disposal area are highly vegetated. The site was easily accessible.

15.3 Sample Point MA SW 5&6

The third sample was taken at the lined PCD north of the existing Matimba Ash disposal facility (

Photo 15.3). This PCD is also connected to storm water trenches at the sides of the rehabilitated part of the ash disposal area. No silt trap was observed here. On the opposite side of the road, a small dam was observed with a pump station. This dam is connected to the Matimba Power Station and receives water from the power station for dust suppression and/or irrigation. The surrounding site and the rehabilitated part of the ash disposal area are highly vegetated. The site was easily accessible as it is close to the entrance of the Matimba Ash Disposal facility.

15.4 Sample Point MA SW 7&8

The fourth sample point was an artificial pan next to the Medupi Power Station (currently under construction) upstream from site alternative 1 (

Photo 15.5). It was unclear where the water comes from. The banks were vegetated with grassland. The site was located on a bend and was easily accessible as it is next to the public road.

15.5 Sample Point MA SW 9&10

The fifth sample point visited was a pan used by wildlife for drinking water (many sets of animal footprints were observed). The pan was about 150 m long and 75 m wide. This sample point was bordering site alternative 1. (

Photo 15.6). Nitric acid was again used to preserve the sample.

APPENDIX B: HYDROLOGICAL METHODOLOGIES INPUT DATA SHEETS

Catchment Characteristics:

Catchment	Site Area	WMA	WMA Abbreviation	Area	MAP	MAE	MAR
	(km^2)			*(km^2)*	*(mm)*	*(mm)*	*(Mm^3)*
Natural Catchment 1	82.21	Limpopo	WMA 1	52 643	471	1 854	931
Natural Catchment 2	56.64	Limpopo	WMA 1				
Natural Catchment 3	5.69						
Actual catchment 1	0.77						
Actual catchment 2	54.61						
Actual catchment 3	4.69						

Quat catch	Quaternary Catchment Area	MAP	MAP from rainfall zone	MAE	MAR	MAR from runoff file	Rainfall zone	Evaporation zone	Description
	(km^2)	*(mm)*	*(mm)*	*(mm)*	*(Mm^3)*	*(Mm^3)*			
A42J	1 027	428	99.3	1 949	5.81	5.81	A4E	1D	Waterburg Bushveld
A42J	1 027	428	99.3	1 949	5.81	5.81	A4E	1D	Waterburg Bushveld

Sub - catchment:	Actual catchment 1	**Sub - catchment:**	Actual catchment 2	**Sub - catchment:**	Actual catchment 3
Area (km^2):	0.77	**Area (km^2):**	54.61	**Area (km^2):**	4.69
Physical characteristics as a % of the area of		**Physical characteristics as a % of the area of th**		**Physical characteristics as a % of the area of th**	
Area distribution		***Area distribution***		***Area distribution (% of total)***	
Rural	1	Rural	1	Rural	100
Rural area		***Rural area***		***Rural area***	
Surface slope		**Surface slope**		**Surface slope**	
Lakes & pans	0	Lakes & pans	0	Lakes & pans	0
Flat area	100	Flat area	100	Flat area	100
Hilly	0	Hilly	0	Hilly	0
Steep	0	Steep	0	Steep	0
Permeability (% of total rural area)		**Permeability (% of total rural area)**		**Permeability (% of total rural area)**	
Very permeable	0	Very permeable	0	Very permeable	0
Permeable	0	Permeable	25	Permeable	
Semi-permeable	100	Semi-permeable	75	Semi-permeable	100
Impermeable	0	Impermeable	0	Impermeable	0
Vegetation		**Vegetation**		**Vegetation**	
Thick bush & forests	10	Thick bush & forests	0	Thick bush & forests	0
Light bush & cultivated land	35	Light bush & cultivated land	87	Light bush & cultivated land	30
Grasslands	30	Grasslands	10	Grasslands	40
Bare	25	Bare	3	Bare	30

Sub-catchment	River	Site Area (m^2)	Site Area (km^2)	Site Area (Ha)	Slope for HEC-RAS (m/m) [dimention less]	Average catchment slope (10-85 slope) (m/m) [dimention less]
Current conditions						
Actual catchment 1	River 1	770 000.00	0.77	77.00	0.0032	0.002
Actual catchment 2	River 2	54 610 000.00	54.61	5 461.00	0.0025	0.11
Actual catchment 3	River 3	4 690 000.00	4.69	469.00	0.0051	0.05

Ave Channel Slope (%) (Y/X).100 (%)	Channel slope (use for flow) (m/m) [dimention less]	Catchment slope (use for height (%)) (%)	Length of longest watercourse (km)	Length of longest watercourse (m)	10-85 lenth of longest watercourse (m)	Height difference along 10-85 slope (m)
0.43	0.00	0.74	0.94	940.00	705.00	3
0.33	0.00	0.72	7.71	7 710.00	5 782.50	19
0.68	0.01	0.80	3.70	3 700.00	2 775.00	19

H0.85 (horizontal) (distance from start-hydro (end-HECRAS)) (km)	H0.85 (horizontal) (distance from start-hydro (end-HECRAS)) (m)	H0.85L (vertical) [higher] (elevation height at 85% of l of l w) (m)	H0.10 (horizontal) (distance from end-hydro (start-HECRAS)) (km)	H0.10 (horizontal) (distance from end-hydro (start-HECRAS)) (m)	H0.10L (vertical) [lower] (elevation height at 10% of l of l w) (m)
0.14	141.00	875	0.09	94.00	872
1.16	1156.50	887	0.77	771.00	868
0.56	555.00	898	0.37	370.00	879

Start Altitude of catchment (top, high) (m)	End Altitude of catchment (bottom, low) (m)	Mean Altitude of catchment (m)	Total lenth of catchment (km)	Total lenth of catchment (m)	Rainfall station position (most upstream position in catchment where possible) Longitude	Latitude	Number
877	870	874	0.94	940	27° 43.765'E	23°40.287'S	0674400W
931	863	897	9.50	9500	27° 43.765'E	23°40.287'S	0674400W
907	878	893	3.63	3630	27° 43.765'E	23°40.287'S	0674400W

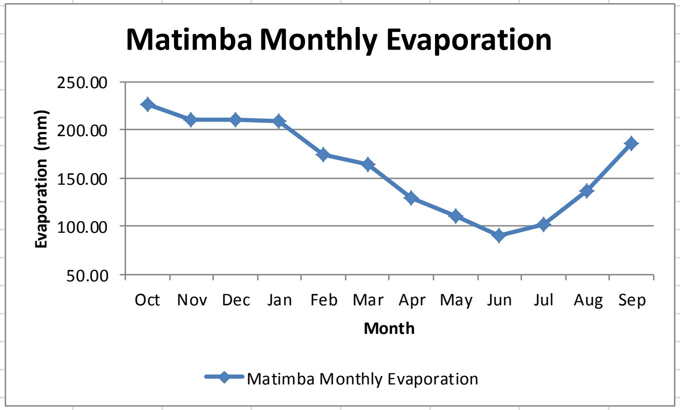
Rainfall Summary:

Rainfall data summary:		**(mm)**						
Project name:		**Matimba Ash Dump**						
Project number:		**12-204SW**						
1. MAPs:						**Lat**	**Long**	
Source:		**WR2005 quat spread sheets**						
WMA 1 (Limpopo)		471						
quat catch area	A42J	428						
Source:		**Design rainfall estimation for South Africa**				23°40.287'S	27° 43.765'E	
		465						
Source:		**Daily rainfall data extraction utility (actual data series)**						**This data source was chosen as it most accurately represents the rainfall in the sub-catchment and was generated using a programme that is widely used and respected within the hydrology industry.**
		534						
Source:		**TR102 data**	**(actual data series)**			23°40.287'S	27° 43.765'E	
0674400W	Ellisras Police Station	385						
Source:		**RLMA SAWS**	**(summary spread sheet)**					
		No data available in spreadsheet						
2. Design rainfall depths:						**Lat**	**Long**	
Source:		**Design rainfall estimation for South Africa**				23°40.287'S	27° 43.765'E	
1:50		148.5	(129.5L)	(168.4U)				
1:100		168.3	(145.4L)	(192.2U)				
Source:		**TR102 data**	0674400W	Ellisras Police Station	(summary spread sheet)			
1:50		No data						
1:100		No data						
Source:		**RLMA SAWS**	No data available in spreadsheet		(summary spread sheet)			
1:50		No data						
1:100		No data						

Evaporation Calculations:

WR2005 Evaporation data:

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Average	MAE from WR2005 spread sheets
Evap Zone 1D monthly proportions	11.6	10.78	10.78	10.72	8.94	8.45	6.63	5.63	4.65	5.23	7.03	9.56	100	8.33	1949
Actual Evap	226.08	210.10	210.10	208.93	174.24	164.69	129.22	109.73	90.63	101.93	137.01	186.32	1949.00	162.42	



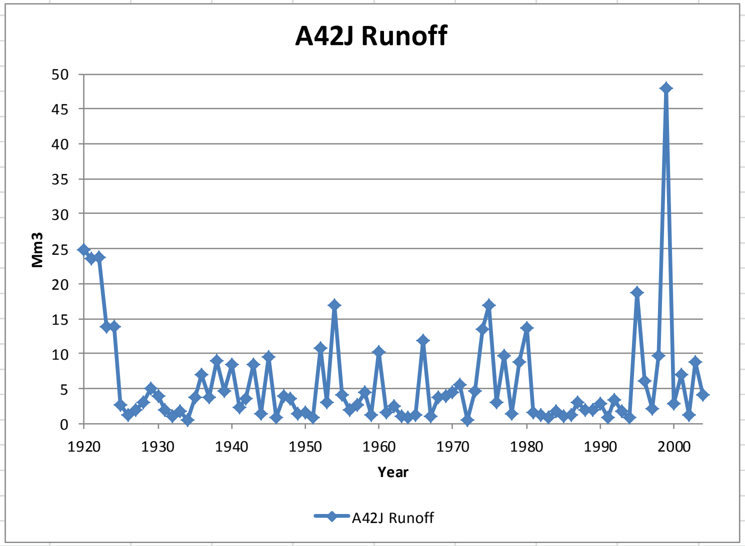
Monthly Runoff – Calculated Using a Correction Factor

A42J													
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	**Total**	**Average**
1920	2.52	2.05	2.04	2.04	2.04	2.04	2.04	2.03	2.03	2.03	2.03	2.02	**24.91**	**2.08**
1921	2.01	2.01	2	1.99	1.99	1.98	1.97	1.95	1.94	1.93	1.91	1.9	**23.58**	**1.96**
1922	1.87	1.85	1.82	5.11	1.75	1.74	1.71	1.67	1.64	1.6	1.55	1.51	**23.82**	**1.99**
1923	1.45	1.4	1.34	1.28	1.22	1.25	1.1	1.06	1.01	0.95	0.89	0.83	**13.79**	**1.15**
1924	0.78	0.69	0.64	0.59	0.56	6.36	2.12	0.51	0.47	0.44	0.4	0.36	**13.91**	**1.16**
1925	0.34	0.31	0.28	0.26	0.24	0.21	0.2	0.18	0.17	0.15	0.14	0.13	**2.61**	**0.22**
1926	0.12	0.19	0.1	0.1	0.19	0.13	0.08	0.08	0.07	0.07	0.07	0.06	**1.26**	**0.11**
1927	0.08	0.05	0.25	0.93	0.34	0.06	0.05	0.05	0.05	0.04	0.04	0.04	**1.97**	**0.16**
1928	0.03	0.46	0.31	0.27	0.39	1.04	0.34	0.04	0.04	0.04	0.04	0.06	**3.06**	**0.26**
1929	0.05	0.84	0.95	1.72	0.57	0.12	0.4	0.12	0.06	0.06	0.06	0.05	**5**	**0.42**
1930	0.05	0.05	0.37	1.86	0.67	0.35	0.17	0.07	0.07	0.06	0.06	0.06	**3.84**	**0.32**
1931	0.06	0.68	0.36	0.14	0.06	0.15	0.15	0.06	0.06	0.06	0.05	0.05	**1.87**	**0.16**
1932	0.05	0.05	0.13	0.42	0.16	0.05	0.04	0.04	0.04	0.04	0.03	0.03	**1.09**	**0.09**
1933	0.03	0.11	0.08	0.52	0.71	0.2	0.04	0.03	0.03	0.03	0.03	0.03	**1.84**	**0.15**
1934	0.02	0.04	0.18	0.06	0.04	0.06	0.02	0.02	0.02	0.02	0.01	0.01	**0.49**	**0.04**
1935	0.01	0.01	0.01	2.02	1.08	0.37	0.08	0.04	0.04	0.03	0.03	0.03	**3.75**	**0.31**
1936	0.06	1.39	0.52	1.89	2.15	0.65	0.07	0.07	0.07	0.06	0.06	0.06	**7.06**	**0.59**
1937	0.05	0.05	1.98	0.95	0.11	0.07	0.21	0.07	0.06	0.06	0.05	0.05	**3.71**	**0.31**
1938	0.05	0.05	0.53	0.76	4.75	2.06	0.17	0.11	0.11	0.1	0.1	0.09	**8.89**	**0.74**
1939	0.09	2.76	1.01	0.1	0.1	0.09	0.09	0.09	0.08	0.08	0.07	0.07	**4.62**	**0.38**
1940	0.07	0.5	5.19	1.91	0.12	0.12	0.11	0.11	0.1	0.1	0.09	0.09	**8.49**	**0.71**
1941	0.08	0.08	0.11	0.99	0.33	0.33	0.11	0.07	0.07	0.06	0.06	0.06	**2.35**	**0.2**
1942	0.26	0.1	0.24	0.52	0.19	1.34	0.56	0.06	0.06	0.06	0.06	0.06	**3.51**	**0.29**
1943	0.05	0.25	0.47	0.99	4.51	1.57	0.11	0.11	0.1	0.1	0.09	0.09	**8.45**	**0.7**
1944	0.28	0.33	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	**1.31**	**0.11**
1945	0.06	0.06	0.06	4.1	3.6	0.97	0.12	0.12	0.11	0.11	0.1	0.09	**9.49**	**0.79**
1946	0.09	0.08	0.1	0.07	0.07	0.17	0.09	0.06	0.06	0.05	0.05	0.05	**0.94**	**0.08**

1947	0.04	0.12	0.41	1.55	0.54	0.72	0.27	0.06	0.06	0.06	0.05	0.05	**3.92**	**0.33**
1948	0.3	0.5	0.13	1.52	0.57	0.13	0.06	0.06	0.06	0.05	0.05	0.05	**3.48**	**0.29**
1949	0.04	0.25	0.62	0.21	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	**1.42**	**0.12**
1950	0.03	0.03	0.23	0.08	0.05	0.16	0.13	0.52	0.17	0.03	0.03	0.03	**1.49**	**0.12**
1951	0.37	0.12	0.07	0.03	0.1	0.03	0.03	0.03	0.03	0.03	0.03	0.02	**0.88**	**0.07**
1952	0.03	0.38	0.57	0.68	4.48	3.34	0.72	0.11	0.11	0.1	0.1	0.1	**10.73**	**0.89**
1953	0.09	0.09	0.08	0.84	1.06	0.27	0.1	0.1	0.09	0.09	0.08	0.08	**2.97**	**0.25**
1954	0.08	0.75	1.1	1.37	9.33	3.15	0.19	0.19	0.18	0.17	0.17	0.16	**16.82**	**1.4**
1955	0.15	0.15	0.54	0.28	1.62	0.63	0.14	0.14	0.13	0.12	0.11	0.11	**4.12**	**0.34**
1956	0.1	0.09	0.49	0.18	0.5	0.17	0.09	0.08	0.08	0.07	0.07	0.07	**1.99**	**0.17**
1957	0.07	0.07	0.06	1.48	0.52	0.08	0.07	0.06	0.06	0.05	0.05	0.04	**2.62**	**0.22**
1958	0.04	0.06	2.54	1.12	0.21	0.24	0.07	0.06	0.05	0.05	0.05	0.04	**4.54**	**0.38**
1959	0.04	0.33	0.35	0.15	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	**1.13**	**0.09**
1960	0.03	1.62	4.07	1.24	1.43	1.18	0.27	0.09	0.09	0.08	0.08	0.08	**10.26**	**0.85**
1961	0.07	0.3	0.12	0.42	0.14	0.06	0.11	0.05	0.06	0.05	0.05	0.05	**1.49**	**0.12**
1962	0.05	0.69	0.35	0.57	0.18	0.05	0.23	0.08	0.05	0.05	0.05	0.05	**2.39**	**0.2**
1963	0.17	0.06	0.07	0.44	0.14	0.04	0.04	0.04	0.03	0.03	0.03	0.03	**1.12**	**0.09**
1964	0.26	0.13	0.14	0.07	0.1	0.03	0.02	0.02	0.02	0.02	0.02	0.02	**0.85**	**0.07**
1965	0.01	0.17	0.06	0.54	0.24	0.02	0.02	0.02	0.02	0.01	0.01	0.01	**1.13**	**0.09**
1966	0.01	0.14	0.4	6.44	3.69	0.65	0.1	0.09	0.08	0.08	0.07	0.07	**11.81**	**0.98**
1967	0.06	0.06	0.05	0.1	0.04	0.04	0.39	0.13	0.04	0.04	0.04	0.04	**1.04**	**0.09**
1968	0.04	0.26	0.33	0.23	0.08	1.88	0.67	0.07	0.06	0.06	0.06	0.06	**3.79**	**0.32**
1969	0.05	0.05	2.45	0.88	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	**3.94**	**0.33**
1970	0.04	0.41	1.95	1.38	0.31	0.07	0.06	0.06	0.06	0.05	0.05	0.05	**4.49**	**0.37**
1971	0.04	0.7	0.29	2.35	1.39	0.35	0.07	0.07	0.07	0.06	0.06	0.06	**5.51**	**0.46**
1972	0.05	0.05	0.05	0.04	0.1	0.04	0.04	0.04	0.04	0.04	0.03	0.03	**0.54**	**0.05**
1973	0.07	0.03	2.44	1.48	0.3	0.1	0.06	0.06	0.05	0.05	0.05	0.04	**4.72**	**0.39**
1974	0.04	0.53	0.73	6.89	3.34	0.39	0.8	0.27	0.12	0.11	0.11	0.1	**13.43**	**1.12**
1975	0.09	0.09	4.38	1.85	6.96	2.47	0.2	0.19	0.18	0.18	0.17	0.16	**16.93**	**1.41**
1976	0.15	0.22	0.15	0.38	0.5	0.81	0.23	0.14	0.13	0.13	0.13	0.12	**3.08**	**0.26**
1977	0.12	0.12	0.71	2.79	3.52	1.44	0.17	0.17	0.16	0.15	0.15	0.14	**9.63**	**0.8**
1978	0.13	0.12	0.12	0.26	0.11	0.11	0.1	0.1	0.09	0.09	0.08	0.08	**1.37**	**0.11**
1979	0.07	0.16	0.06	1.03	5.12	1.71	0.13	0.12	0.11	0.11	0.1	0.1	**8.82**	**0.73**
1980	0.09	4.39	1.62	4.5	2	0.22	0.16	0.15	0.14	0.13	0.12	0.11	**13.64**	**1.14**
1981	0.11	0.27	0.14	0.26	0.27	0.08	0.08	0.08	0.08	0.07	0.07	0.07	**1.57**	**0.13**

1982	0.31	0.22	0.1	0.1	0.06	0.18	0.06	0.05	0.05	0.05	0.05	0.04	**1.27**	**0.11**
1983	0.04	0.13	0.07	0.14	0.05	0.19	0.06	0.03	0.03	0.03	0.02	0.02	**0.8**	**0.07**
1984	0.02	0.02	0.02	0.84	0.53	0.11	0.03	0.03	0.02	0.02	0.02	0.02	**1.67**	**0.14**
1985	0.02	0.02	0.05	0.02	0.07	0.02	0.52	0.19	0.02	0.02	0.02	0.02	**0.98**	**0.08**
1986	0.3	0.17	0.25	0.24	0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.01	**1.13**	**0.09**
1987	0.01	0.02	0.75	0.29	0.77	0.77	0.19	0.04	0.03	0.03	0.03	0.03	**2.97**	**0.25**
1988	0.58	0.21	0.05	0.18	0.57	0.18	0.03	0.03	0.03	0.03	0.03	0.03	**1.95**	**0.16**
1989	0.03	0.21	1.04	0.37	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	**1.94**	**0.16**
1990	0.03	0.03	0.05	1.39	0.74	0.33	0.08	0.04	0.04	0.04	0.03	0.03	**2.81**	**0.23**
1991	0.03	0.03	0.37	0.19	0.06	0.03	0.03	0.02	0.02	0.02	0.02	0.02	**0.83**	**0.07**
1992	0.26	0.14	1.94	0.72	0.12	0.06	0.04	0.04	0.03	0.03	0.03	0.03	**3.44**	**0.29**
1993	0.02	0.21	0.72	0.45	0.22	0.05	0.03	0.03	0.03	0.02	0.02	0.02	**1.82**	**0.15**
1994	0.02	0.02	0.11	0.19	0.14	0.25	0.08	0.02	0.02	0.02	0.02	0.02	**0.91**	**0.08**
1995	0.02	0.61	4.05	5.46	6.08	1.68	0.16	0.15	0.14	0.13	0.13	0.12	**18.75**	**1.56**
1996	0.11	1.22	0.44	1.97	0.84	0.7	0.22	0.12	0.12	0.12	0.11	0.11	**6.07**	**0.51**
1997	0.11	0.3	0.19	0.1	0.1	0.62	0.21	0.1	0.1	0.1	0.1	0.1	**2.12**	**0.18**
1998	0.09	0.96	5.77	1.93	0.16	0.14	0.13	0.12	0.11	0.11	0.1	0.09	**9.73**	**0.81**
1999	0.09	0.08	1.09	1.77	32.34	10.82	0.35	0.29	0.28	0.27	0.26	0.24	**47.87**	**3.99**
2000	0.23	0.2	0.2	0.19	0.73	0.24	0.18	0.17	0.16	0.16	0.15	0.15	**2.76**	**0.23**
2001	0.14	4.01	1.44	0.17	0.17	0.16	0.16	0.14	0.14	0.14	0.13	0.13	**6.94**	**0.58**
2002	0.12	0.12	0.11	0.14	0.1	0.1	0.09	0.09	0.08	0.07	0.06	0.06	**1.15**	**0.1**
2003	0.05	0.05	0.04	1.92	1.42	3.67	1.21	0.1	0.09	0.09	0.08	0.08	**8.8**	**0.73**
2004	0.07	0.06	2.56	0.93	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	**4.15**	**0.35**
AVERAGE	**0.19**	**0.46**	**0.83**	**1.12**	**1.44**	**0.76**	**0.26**	**0.17**	**0.15**	**0.15**	**0.14**	**0.14**	**5.81**	**0.48**
TOTAL	**16.44**	**38.99**	**70.43**	**95**	**122.59**	**64.79**	**22.17**	**14.39**	**13.11**	**12.55**	**12.09**	**11.72**	**494.13**	**41.18**

Total	**494.13**
Length	**85**
Average	**5.813294**



Natural Catchment 1	
Area 2 (quat catch/WR2005)	1 027.00
MAP 2 (quat catch/WR2005)	428.00
Area 1 (site)	82.21
MAP 1 (site)	465
Correction factor:	
	0.09930659

Natural Catchment 2	
Area 1 (site)	56.64
MAP 1 (site)	465.00
Area 2 (quat catch(WR2005))	1 027.00
MAP 2 (quat catch(WR2005))	428
Correction factor:	
	0.06841899

	A42J monthly runoff once corrected for area												
YEAR	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**Aprl**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**	**Average**
1920	0.250253	0.203579	0.202585	0.202585	0.202585	0.202585	0.202585	0.201592	0.201592	0.201592	0.201592	0.200599	**2.473727**	**0.206144**
1921	0.199606	0.199606	0.198613	0.19762	0.19762	0.196627	0.195634	0.193648	0.192655	0.191662	0.189676	0.188683	**2.341649**	**0.195137**
1922	0.185703	0.183717	0.180738	0.507457	0.173787	0.172793	0.169814	0.165842	0.162863	0.158891	0.153925	0.149953	**2.365483**	**0.197124**
1923	0.143995	0.139029	0.133071	0.127112	0.121154	0.124133	0.109237	0.105265	0.1003	0.094341	0.088383	0.082424	**1.368445**	**0.114037**
1924	0.077459	0.068522	0.063556	0.058591	0.055612	0.63159	0.21053	0.050646	0.046674	0.043695	0.039723	0.03575	**1.382348**	**0.115196**
1925	0.033764	0.030785	0.027806	0.02582	0.023834	0.020854	0.019861	0.017875	0.016882	0.014896	0.013903	0.01291	**0.25919**	**0.021599**
1926	0.011917	0.018868	0.009931	0.009931	0.018868	0.01291	0.007945	0.007945	0.006951	0.006951	0.006951	0.005958	**0.125126**	**0.010427**
1927	0.007945	0.004965	0.024827	0.092355	0.033764	0.005958	0.004965	0.004965	0.004965	0.003972	0.003972	0.003972	**0.196627**	**0.016386**
1928	0.002979	0.045681	0.030785	0.026813	0.03873	0.103279	0.033764	0.003972	0.003972	0.003972	0.003972	0.005958	**0.303878**	**0.025323**
1929	0.004965	0.083418	0.094341	0.170807	0.056605	0.011917	0.039723	0.011917	0.005958	0.005958	0.005958	0.004965	**0.496533**	**0.041378**
1930	0.004965	0.004965	0.036743	0.18471	0.066535	0.034757	0.016882	0.006951	0.006951	0.005958	0.005958	0.005958	**0.381337**	**0.031778**
1931	0.005958	0.067528	0.03575	0.013903	0.005958	0.014896	0.014896	0.005958	0.005958	0.005958	0.004965	0.004965	**0.186696**	**0.015558**
1932	0.004965	0.004965	0.01291	0.041709	0.015889	0.004965	0.003972	0.003972	0.003972	0.003972	0.002979	0.002979	**0.107251**	**0.008938**
1933	0.002979	0.010924	0.007945	0.051639	0.070508	0.019861	0.003972	0.002979	0.002979	0.002979	0.002979	0.002979	**0.182724**	**0.015227**
1934	0.001986	0.003972	0.017875	0.005958	0.003972	0.005958	0.001986	0.001986	0.001986	0.001986	0.000993	0.000993	**0.049653**	**0.004138**
1935	0.000993	0.000993	0.000993	0.200599	0.107251	0.036743	0.007945	0.003972	0.003972	0.002979	0.002979	0.002979	**0.3724**	**0.031033**
1936	0.005958	0.138036	0.051639	0.187689	0.213509	0.064549	0.006951	0.006951	0.006951	0.005958	0.005958	0.005958	**0.700111**	**0.058343**
1937	0.004965	0.004965	0.196627	0.094341	0.010924	0.006951	0.020854	0.006951	0.005958	0.005958	0.004965	0.004965	**0.368427**	**0.030702**
1938	0.004965	0.004965	0.052632	0.075473	0.471706	0.204572	0.016882	0.010924	0.010924	0.009931	0.009931	0.008938	**0.881843**	**0.073487**
1939	0.008938	0.274086	0.1003	0.009931	0.009931	0.008938	0.008938	0.008938	0.007945	0.007945	0.006951	0.006951	**0.45979**	**0.038316**
1940	0.006951	0.049653	0.515401	0.189676	0.011917	0.011917	0.010924	0.010924	0.009931	0.009931	0.008938	0.008938	**0.845099**	**0.070425**
1941	0.007945	0.007945	0.010924	0.098314	0.032771	0.032771	0.010924	0.006951	0.006951	0.005958	0.005958	0.005958	**0.23337**	**0.019448**
1942	0.02582	0.009931	0.023834	0.051639	0.018868	0.133071	0.055612	0.005958	0.005958	0.005958	0.005958	0.005958	**0.348566**	**0.029047**

1943	0.004965	0.024827	0.046674	0.098314	0.447873	0.155911	0.010924	0.010924	0.009931	0.009931	0.008938	0.008938	**0.838148**	**0.069846**
1944	0.027806	0.032771	0.007945	0.007945	0.006951	0.006951	0.006951	0.006951	0.006951	0.006951	0.006951	0.005958	**0.131085**	**0.010924**
1945	0.005958	0.005958	0.005958	0.407157	0.357504	0.096327	0.011917	0.011917	0.010924	0.010924	0.009931	0.008938	**0.943413**	**0.078618**
1946	0.008938	0.007945	0.009931	0.006951	0.006951	0.016882	0.008938	0.005958	0.005958	0.004965	0.004965	0.004965	**0.093348**	**0.007779**
1947	0.003972	0.011917	0.040716	0.153925	0.053626	0.071501	0.026813	0.005958	0.005958	0.005958	0.004965	0.004965	**0.390275**	**0.032523**
1948	0.029792	0.049653	0.01291	0.150946	0.056605	0.01291	0.005958	0.005958	0.005958	0.004965	0.004965	0.004965	**0.345587**	**0.028799**
1949	0.003972	0.024827	0.06157	0.020854	0.003972	0.003972	0.003972	0.003972	0.003972	0.003972	0.002979	0.002979	**0.141015**	**0.011751**
1950	0.002979	0.002979	0.022841	0.007945	0.004965	0.015889	0.01291	0.051639	0.016882	0.002979	0.002979	0.002979	**0.147967**	**0.012331**
1951	0.036743	0.011917	0.006951	0.002979	0.009931	0.002979	0.002979	0.002979	0.002979	0.002979	0.002979	0.001986	**0.088383**	**0.007365**
1952	0.002979	0.037737	0.056605	0.067528	0.444894	0.331684	0.071501	0.010924	0.010924	0.009931	0.009931	0.009931	**1.064567**	**0.088714**
1953	0.008938	0.008938	0.007945	0.083418	0.105265	0.026813	0.009931	0.009931	0.008938	0.008938	0.007945	0.007945	**0.294941**	**0.024578**
1954	0.007945	0.07448	0.109237	0.13605	0.926531	0.312816	0.018868	0.018868	0.017875	0.016882	0.016882	0.015889	**1.672323**	**0.13936**
1955	0.014896	0.014896	0.053626	0.027806	0.160877	0.062563	0.013903	0.013903	0.01291	0.011917	0.010924	0.010924	**0.409143**	**0.034095**
1956	0.009931	0.008938	0.04866	0.017875	0.049653	0.016882	0.008938	0.007945	0.007945	0.006951	0.006951	0.006951	**0.19762**	**0.016468**
1957	0.006951	0.006951	0.005958	0.146974	0.051639	0.007945	0.006951	0.005958	0.005958	0.004965	0.004965	0.003972	**0.25919**	**0.021599**
1958	0.003972	0.005958	0.252239	0.111223	0.020854	0.023834	0.006951	0.005958	0.004965	0.004965	0.004965	0.003972	**0.449859**	**0.037488**
1959	0.003972	0.032771	0.034757	0.014896	0.003972	0.003972	0.003972	0.002979	0.002979	0.002979	0.002979	0.002979	**0.11321**	**0.009434**
1960	0.002979	0.160877	0.404178	0.12314	0.142008	0.117182	0.026813	0.008938	0.008938	0.007945	0.007945	0.007945	**1.018886**	**0.084907**
1961	0.006951	0.029792	0.011917	0.041709	0.013903	0.005958	0.010924	0.004965	0.005958	0.004965	0.004965	0.004965	**0.146974**	**0.012248**
1962	0.004965	0.068522	0.034757	0.056605	0.017875	0.004965	0.022841	0.007945	0.004965	0.004965	0.004965	0.004965	**0.238336**	**0.019861**
1963	0.016882	0.005958	0.006951	0.043695	0.013903	0.003972	0.003972	0.003972	0.002979	0.002979	0.002979	0.002979	**0.111223**	**0.009269**
1964	0.02582	0.01291	0.013903	0.006951	0.009931	0.002979	0.001986	0.001986	0.001986	0.001986	0.001986	0.001986	**0.084411**	**0.007034**
1965	0.000993	0.016882	0.005958	0.053626	0.023834	0.001986	0.001986	0.001986	0.001986	0.000993	0.000993	0.000993	**0.112216**	**0.009351**
1966	0.000993	0.013903	0.039723	0.639534	0.366441	0.064549	0.009931	0.008938	0.007945	0.007945	0.006951	0.006951	**1.173804**	**0.097817**
1967	0.005958	0.005958	0.004965	0.009931	0.003972	0.003972	0.03873	0.01291	0.003972	0.003972	0.003972	0.003972	**0.102286**	**0.008524**
1968	0.003972	0.02582	0.032771	0.022841	0.007945	0.186696	0.066535	0.006951	0.005958	0.005958	0.005958	0.005958	**0.377365**	**0.031447**
1969	0.004965	0.004965	0.243301	0.08739	0.007945	0.006951	0.006951	0.005958	0.005958	0.005958	0.004965	0.004965	**0.390275**	**0.032523**

1970	0.003972	0.040716	0.193648	0.137043	0.030785	0.006951	0.005958	0.005958	0.005958	0.004965	0.004965	0.004965	**0.445887**	**0.037157**
1971	0.003972	0.069515	0.028799	0.23337	0.138036	0.034757	0.006951	0.006951	0.006951	0.005958	0.005958	0.005958	**0.547179**	**0.045598**
1972	0.004965	0.004965	0.004965	0.003972	0.009931	0.003972	0.003972	0.003972	0.003972	0.003972	0.002979	0.002979	**0.054619**	**0.004552**
1973	0.006951	0.002979	0.242308	0.146974	0.029792	0.009931	0.005958	0.005958	0.004965	0.004965	0.004965	0.003972	**0.46972**	**0.039143**
1974	0.003972	0.052632	0.072494	0.684222	0.331684	0.03873	0.079445	0.026813	0.011917	0.010924	0.010924	0.009931	**1.333688**	**0.111141**
1975	0.008938	0.008938	0.434963	0.183717	0.691174	0.245287	0.019861	0.018868	0.017875	0.017875	0.016882	0.015889	**1.680268**	**0.140022**
1976	0.014896	0.021847	0.014896	0.037737	0.049653	0.080438	0.022841	0.013903	0.01291	0.01291	0.01291	0.011917	**0.306857**	**0.025571**
1977	0.011917	0.011917	0.070508	0.277065	0.349559	0.143001	0.016882	0.016882	0.015889	0.014896	0.014896	0.013903	**0.957316**	**0.079776**
1978	0.01291	0.011917	0.011917	0.02582	0.010924	0.010924	0.009931	0.009931	0.008938	0.008938	0.007945	0.007945	**0.138036**	**0.011503**
1979	0.006951	0.015889	0.005958	0.102286	0.50845	0.169814	0.01291	0.011917	0.010924	0.010924	0.009931	0.009931	**0.875884**	**0.07299**
1980	0.008938	0.435956	0.160877	0.44688	0.198613	0.021847	0.015889	0.014896	0.013903	0.01291	0.011917	0.010924	**1.353549**	**0.112796**
1981	0.010924	0.026813	0.013903	0.02582	0.026813	0.007945	0.007945	0.007945	0.007945	0.006951	0.006951	0.006951	**0.156904**	**0.013075**
1982	0.030785	0.021847	0.009931	0.009931	0.005958	0.017875	0.005958	0.004965	0.004965	0.004965	0.004965	0.003972	**0.126119**	**0.01051**
1983	0.003972	0.01291	0.006951	0.013903	0.004965	0.018868	0.005958	0.002979	0.002979	0.002979	0.001986	0.001986	**0.080438**	**0.006703**
1984	0.001986	0.001986	0.001986	0.083418	0.052632	0.010924	0.002979	0.002979	0.001986	0.001986	0.001986	0.001986	**0.166835**	**0.013903**
1985	0.001986	0.001986	0.004965	0.001986	0.006951	0.001986	0.051639	0.018868	0.001986	0.001986	0.001986	0.001986	**0.098314**	**0.008193**
1986	0.029792	0.016882	0.024827	0.023834	0.005958	0.001986	0.001986	0.001986	0.001986	0.001986	0.001986	0.000993	**0.114203**	**0.009517**
1987	0.000993	0.001986	0.07448	0.028799	0.076466	0.076466	0.018868	0.003972	0.002979	0.002979	0.002979	0.002979	**0.293948**	**0.024496**
1988	0.057598	0.020854	0.004965	0.017875	0.056605	0.017875	0.002979	0.002979	0.002979	0.002979	0.002979	0.002979	**0.193648**	**0.016137**
1989	0.002979	0.020854	0.103279	0.036743	0.006951	0.002979	0.002979	0.002979	0.002979	0.002979	0.002979	0.002979	**0.191662**	**0.015972**
1990	0.002979	0.002979	0.004965	0.138036	0.073487	0.032771	0.007945	0.003972	0.003972	0.003972	0.002979	0.002979	**0.281038**	**0.02342**
1991	0.002979	0.002979	0.036743	0.018868	0.005958	0.002979	0.002979	0.001986	0.001986	0.001986	0.001986	0.001986	**0.083418**	**0.006951**
1992	0.02582	0.013903	0.192655	0.071501	0.011917	0.005958	0.003972	0.003972	0.002979	0.002979	0.002979	0.002979	**0.341615**	**0.028468**
1993	0.001986	0.020854	0.071501	0.044688	0.021847	0.004965	0.002979	0.002979	0.002979	0.001986	0.001986	0.001986	**0.180738**	**0.015061**
1994	0.001986	0.001986	0.010924	0.018868	0.013903	0.024827	0.007945	0.001986	0.001986	0.001986	0.001986	0.001986	**0.090369**	**0.007531**
1995	0.001986	0.060577	0.402192	0.542214	0.603784	0.166835	0.015889	0.014896	0.013903	0.01291	0.01291	0.011917	**1.860012**	**0.155001**
1996	0.010924	0.121154	0.043695	0.195634	0.083418	0.069515	0.021847	0.011917	0.011917	0.011917	0.010924	0.010924	**0.603784**	**0.050315**
1997	0.010924	0.029792	0.018868	0.009931	0.009931	0.06157	0.020854	0.009931	0.009931	0.009931	0.009931	0.009931	**0.211523**	**0.017627**
1998	0.008938	0.095334	0.572999	0.191662	0.015889	0.013903	0.01291	0.011917	0.010924	0.010924	0.009931	0.008938	**0.964267**	**0.080356**
1999	0.008938	0.007945	0.108244	0.175773	3.211575	1.074497	0.034757	0.028799	0.027806	0.026813	0.02582	0.023834	**4.7548**	**0.396233**
2000	0.022841	0.019861	0.019861	0.018868	0.072494	0.023834	0.017875	0.016882	0.015889	0.015889	0.014896	0.014896	**0.274086**	**0.022841**
2001	0.013903	0.398219	0.143001	0.016882	0.016882	0.015889	0.015889	0.013903	0.013903	0.013903	0.01291	0.01291	**0.688195**	**0.05735**
2002	0.011917	0.011917	0.010924	0.013903	0.009931	0.009931	0.008938	0.008938	0.007945	0.006951	0.005958	0.005958	**0.11321**	**0.009434**
2003	0.004965	0.004965	0.003972	0.190669	0.141015	0.364455	0.120161	0.009931	0.008938	0.008938	0.007945	0.007945	**0.873898**	**0.072825**
2004	0.006951	0.005958	0.254225	0.092355	0.007945	0.007945	0.006951	0.006951	0.005958	0.005958	0.005958	0.004965	**0.412122**	**0.034344**
Average	**0.019207**	**0.045553**	**0.082284**	**0.11099**	**0.143223**	**0.075695**	**0.025901**	**0.016812**	**0.015317**	**0.014662**	**0.014125**	**0.013693**	**0.577462**	
Total	**1.6326**	**3.871964**	**6.994163**	**9.434126**	**12.174**	**6.434074**	**2.201627**	**1.429022**	**1.301909**	**1.246298**	**1.200617**	**1.163873**	**49.08427**	
												total	**49.08427**	
												length	**85**	
												average	**0.577462**	

A42J monthly runoff once corrected for area - Natural catchment 2													
YEAR	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**Aprl**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**	**Average**
1920	0.172416	0.140259	0.139575	0.139575	0.139575	0.139575	0.139575	0.138891	0.138891	0.138891	0.138891	0.138206	**1.704317**	**0.142026**
1921	0.137522	0.137522	0.136838	0.136154	0.136154	0.13547	0.134785	0.133417	0.132733	0.132049	0.13068	0.129996	**1.61332**	**0.134443**
1922	0.127944	0.126575	0.124523	0.349621	0.119733	0.119049	0.116996	0.11426	0.112207	0.10947	0.106049	0.103313	**1.62974**	**0.135812**
1923	0.099208	0.095787	0.091681	0.087576	0.083471	0.085524	0.075261	0.072524	0.069103	0.064998	0.060893	0.056788	**0.942814**	**0.078568**
1924	0.053367	0.047209	0.043788	0.040367	0.038315	0.435145	0.145048	0.034894	0.032157	0.030104	0.027368	0.024631	**0.952392**	**0.079366**
1925	0.023262	0.02121	0.019157	0.017789	0.016421	0.014368	0.013684	0.012315	0.011631	0.010263	0.009579	0.008894	**0.178574**	**0.014881**
1926	0.00821	0.013	0.006842	0.006842	0.013	0.008894	0.005474	0.005474	0.004789	0.004789	0.004789	0.004105	**0.086208**	**0.007184**
1927	0.005474	0.003421	0.017105	0.06363	0.023262	0.004105	0.003421	0.003421	0.003421	0.002737	0.002737	0.002737	**0.13547**	**0.011289**
1928	0.002053	0.031473	0.02121	0.018473	0.026683	0.071156	0.023262	0.002737	0.002737	0.002737	0.002737	0.004105	**0.209362**	**0.017447**
1929	0.003421	0.057472	0.064998	0.117681	0.038999	0.00821	0.027368	0.00821	0.004105	0.004105	0.004105	0.003421	**0.342095**	**0.028508**
1930	0.003421	0.003421	0.025315	0.127259	0.045841	0.023947	0.011631	0.004789	0.004789	0.004105	0.004105	0.004105	**0.262729**	**0.021894**
1931	0.004105	0.046525	0.024631	0.009579	0.004105	0.010263	0.010263	0.004105	0.004105	0.004105	0.003421	0.003421	**0.128628**	**0.010719**
1932	0.003421	0.003421	0.008894	0.028736	0.010947	0.003421	0.002737	0.002737	0.002737	0.002737	0.002053	0.002053	**0.073893**	**0.006158**
1933	0.002053	0.007526	0.005474	0.035578	0.048577	0.013684	0.002737	0.002053	0.002053	0.002053	0.002053	0.002053	**0.125891**	**0.010491**
1934	0.001368	0.002737	0.012315	0.004105	0.002737	0.004105	0.001368	0.001368	0.001368	0.001368	0.000684	0.000684	**0.034209**	**0.002851**
1935	0.000684	0.000684	0.000684	0.138206	0.073893	0.025315	0.005474	0.002737	0.002737	0.002053	0.002053	0.002053	**0.256571**	**0.021381**
1936	0.004105	0.095102	0.035578	0.129312	0.147101	0.044472	0.004789	0.004789	0.004789	0.004105	0.004105	0.004105	**0.482354**	**0.040196**
1937	0.003421	0.003421	0.13547	0.064998	0.007526	0.004789	0.014368	0.004789	0.004105	0.004105	0.003421	0.003421	**0.253834**	**0.021153**
1938	0.003421	0.003421	0.036262	0.051998	0.32499	0.140943	0.011631	0.007526	0.007526	0.006842	0.006842	0.006158	**0.607561**	**0.05063**
1939	0.006158	0.188836	0.069103	0.006842	0.006842	0.006158	0.006158	0.006158	0.005474	0.005474	0.004789	0.004789	**0.31678**	**0.026398**
1940	0.004789	0.034209	0.355095	0.13068	0.00821	0.00821	0.007526	0.007526	0.006842	0.006842	0.006158	0.006158	**0.582246**	**0.04852**
1941	0.005474	0.005474	0.007526	0.067735	0.022578	0.022578	0.007526	0.004789	0.004789	0.004105	0.004105	0.004105	**0.160785**	**0.013399**
1942	0.017789	0.006842	0.016421	0.035578	0.013	0.091681	0.038315	0.004105	0.004105	0.004105	0.004105	0.004105	**0.240151**	**0.020013**
1943	0.003421	0.017105	0.032157	0.067735	0.30857	0.107418	0.007526	0.007526	0.006842	0.006842	0.006158	0.006158	**0.577456**	**0.048121**
1944	0.019157	0.022578	0.005474	0.005474	0.004789	0.004789	0.004789	0.004789	0.004789	0.004789	0.004789	0.004105	**0.090313**	**0.007526**

1945	0.004105	0.004105	0.004105	0.280518	0.246308	0.066366	0.00821	0.00821	0.007526	0.007526	0.006842	0.006158	**0.64998**	**0.054165**
1946	0.006158	0.005474	0.006842	0.004789	0.004789	0.011631	0.006158	0.004105	0.004105	0.003421	0.003421	0.003421	**0.064314**	**0.005359**
1947	0.002737	0.00821	0.028052	0.106049	0.036946	0.049262	0.018473	0.004105	0.004105	0.004105	0.003421	0.003421	**0.268887**	**0.022407**
1948	0.020526	0.034209	0.008894	0.103997	0.038999	0.008894	0.004105	0.004105	0.004105	0.003421	0.003421	0.003421	**0.238098**	**0.019842**
1949	0.002737	0.017105	0.04242	0.014368	0.002737	0.002737	0.002737	0.002737	0.002737	0.002737	0.002053	0.002053	**0.097155**	**0.008096**
1950	0.002053	0.002053	0.015736	0.005474	0.003421	0.010947	0.008894	0.035578	0.011631	0.002053	0.002053	0.002053	**0.101944**	**0.008495**
1951	0.025315	0.00821	0.004789	0.002053	0.006842	0.002053	0.002053	0.002053	0.002053	0.002053	0.002053	0.001368	**0.060893**	**0.005074**
1952	0.002053	0.025999	0.038999	0.046525	0.306517	0.228519	0.049262	0.007526	0.007526	0.006842	0.006842	0.006842	**0.733452**	**0.061121**
1953	0.006158	0.006158	0.005474	0.057472	0.072524	0.018473	0.006842	0.006842	0.006158	0.006158	0.005474	0.005474	**0.203204**	**0.016934**
1954	0.005474	0.051314	0.075261	0.093734	0.638349	0.21552	0.013	0.013	0.012315	0.011631	0.011631	0.010947	**1.152176**	**0.096015**
1955	0.010263	0.010263	0.036946	0.019157	0.110839	0.043104	0.009579	0.009579	0.008894	0.00821	0.007526	0.007526	**0.281886**	**0.023491**
1956	0.006842	0.006158	0.033525	0.012315	0.034209	0.011631	0.006158	0.005474	0.005474	0.004789	0.004789	0.004789	**0.136154**	**0.011346**
1957	0.004789	0.004789	0.004105	0.10126	0.035578	0.005474	0.004789	0.004105	0.004105	0.003421	0.003421	0.002737	**0.178574**	**0.014881**
1958	0.002737	0.004105	0.173784	0.076629	0.014368	0.016421	0.004789	0.004105	0.003421	0.003421	0.003421	0.002737	**0.309938**	**0.025828**
1959	0.002737	0.022578	0.023947	0.010263	0.002737	0.002737	0.002737	0.002053	0.002053	0.002053	0.002053	0.002053	**0.077998**	**0.0065**
1960	0.002053	0.110839	0.278465	0.08484	0.097839	0.080734	0.018473	0.006158	0.006158	0.005474	0.005474	0.005474	**0.701979**	**0.058498**
1961	0.004789	0.020526	0.00821	0.028736	0.009579	0.004105	0.007526	0.003421	0.004105	0.003421	0.003421	0.003421	**0.10126**	**0.008438**
1962	0.003421	0.047209	0.023947	0.038999	0.012315	0.003421	0.015736	0.005474	0.003421	0.003421	0.003421	0.003421	**0.164206**	**0.013684**
1963	0.011631	0.004105	0.004789	0.030104	0.009579	0.002737	0.002737	0.002737	0.002053	0.002053	0.002053	0.002053	**0.076629**	**0.006386**
1964	0.017789	0.008894	0.009579	0.004789	0.006842	0.002053	0.001368	0.001368	0.001368	0.001368	0.001368	0.001368	**0.058156**	**0.004846**
1965	0.000684	0.011631	0.004105	0.036946	0.016421	0.001368	0.001368	0.001368	0.001368	0.000684	0.000684	0.000684	**0.077313**	**0.006443**
1966	0.000684	0.009579	0.027368	0.440618	0.252466	0.044472	0.006842	0.006158	0.005474	0.005474	0.004789	0.004789	**0.808712**	**0.067393**
1967	0.004105	0.004105	0.003421	0.006842	0.002737	0.002737	0.026683	0.008894	0.002737	0.002737	0.002737	0.002737	**0.070472**	**0.005873**
1968	0.002737	0.017789	0.022578	0.015736	0.005474	0.128628	0.045841	0.004789	0.004105	0.004105	0.004105	0.004105	**0.259992**	**0.021666**
1969	0.003421	0.003421	0.167627	0.060209	0.005474	0.004789	0.004789	0.004105	0.004105	0.004105	0.003421	0.003421	**0.268887**	**0.022407**
1970	0.002737	0.028052	0.133417	0.094418	0.02121	0.004789	0.004105	0.004105	0.004105	0.003421	0.003421	0.003421	**0.307201**	**0.0256**
1971	0.002737	0.047893	0.019842	0.160785	0.095102	0.023947	0.004789	0.004789	0.004789	0.004105	0.004105	0.004105	**0.376989**	**0.031416**

1972	0.003421	0.003421	0.003421	0.002737	0.006842	0.002737	0.002737	0.002737	0.002737	0.002737	0.002053	0.002053	**0.03763**	**0.003136**
1973	0.004789	0.002053	0.166942	0.10126	0.020526	0.006842	0.004105	0.004105	0.003421	0.003421	0.003421	0.002737	**0.323622**	**0.026968**
1974	0.002737	0.036262	0.049946	0.471407	0.228519	0.026683	0.054735	0.018473	0.00821	0.007526	0.007526	0.006842	**0.918867**	**0.076572**
1975	0.006158	0.006158	0.299675	0.126575	0.476196	0.168995	0.013684	0.013	0.012315	0.012315	0.011631	0.010947	**1.157649**	**0.096471**
1976	0.010263	0.015052	0.010263	0.025999	0.034209	0.055419	0.015736	0.009579	0.008894	0.008894	0.008894	0.00821	**0.211415**	**0.017618**
1977	0.00821	0.00821	0.048577	0.190889	0.240835	0.098523	0.011631	0.011631	0.010947	0.010263	0.010263	0.009579	**0.659559**	**0.054963**
1978	0.008894	0.00821	0.00821	0.017789	0.007526	0.007526	0.006842	0.006842	0.006158	0.006158	0.005474	0.005474	**0.095102**	**0.007925**
1979	0.004789	0.010947	0.004105	0.070472	0.350305	0.116996	0.008894	0.00821	0.007526	0.007526	0.006842	0.006842	**0.603456**	**0.050288**
1980	0.006158	0.300359	0.110839	0.307885	0.136838	0.015052	0.010947	0.010263	0.009579	0.008894	0.00821	0.007526	**0.932551**	**0.077713**
1981	0.007526	0.018473	0.009579	0.017789	0.018473	0.005474	0.005474	0.005474	0.005474	0.004789	0.004789	0.004789	**0.108102**	**0.009009**
1982	0.02121	0.015052	0.006842	0.006842	0.004105	0.012315	0.004105	0.003421	0.003421	0.003421	0.003421	0.002737	**0.086892**	**0.007241**
1983	0.002737	0.008894	0.004789	0.009579	0.003421	0.013	0.004105	0.002053	0.002053	0.002053	0.001368	0.001368	**0.055419**	**0.004618**
1984	0.001368	0.001368	0.001368	0.057472	0.036262	0.007526	0.002053	0.002053	0.001368	0.001368	0.001368	0.001368	**0.114944**	**0.009579**
1985	0.001368	0.001368	0.003421	0.001368	0.004789	0.001368	0.035578	0.013	0.001368	0.001368	0.001368	0.001368	**0.067735**	**0.005645**
1986	0.020526	0.011631	0.017105	0.016421	0.004105	0.001368	0.001368	0.001368	0.001368	0.001368	0.001368	0.000684	**0.078682**	**0.006557**
1987	0.000684	0.001368	0.051314	0.019842	0.052683	0.052683	0.013	0.002737	0.002053	0.002053	0.002053	0.002053	**0.20252**	**0.016877**
1988	0.039683	0.014368	0.003421	0.012315	0.038999	0.012315	0.002053	0.002053	0.002053	0.002053	0.002053	0.002053	**0.133417**	**0.011118**
1989	0.002053	0.014368	0.071156	0.025315	0.004789	0.002053	0.002053	0.002053	0.002053	0.002053	0.002053	0.002053	**0.132049**	**0.011004**
1990	0.002053	0.002053	0.003421	0.095102	0.05063	0.022578	0.005474	0.002737	0.002737	0.002737	0.002053	0.002053	**0.193626**	**0.016135**
1991	0.002053	0.002053	0.025315	0.013	0.004105	0.002053	0.002053	0.001368	0.001368	0.001368	0.001368	0.001368	**0.057472**	**0.004789**
1992	0.017789	0.009579	0.132733	0.049262	0.00821	0.004105	0.002737	0.002737	0.002053	0.002053	0.002053	0.002053	**0.235361**	**0.019613**
1993	0.001368	0.014368	0.049262	0.030789	0.015052	0.003421	0.002053	0.002053	0.002053	0.001368	0.001368	0.001368	**0.124523**	**0.010377**
1994	0.001368	0.001368	0.007526	0.013	0.009579	0.017105	0.005474	0.001368	0.001368	0.001368	0.001368	0.001368	**0.062261**	**0.005188**
1995	0.001368	0.041736	0.277097	0.373568	0.415987	0.114944	0.010947	0.010263	0.009579	0.008894	0.008894	0.00821	**1.281488**	**0.106791**
1996	0.007526	0.083471	0.030104	0.134785	0.057472	0.047893	0.015052	0.00821	0.00821	0.00821	0.007526	0.007526	**0.415987**	**0.034666**
1997	0.007526	0.020526	0.013	0.006842	0.006842	0.04242	0.014368	0.006842	0.006842	0.006842	0.006842	0.006842	**0.145732**	**0.012144**
1998	0.006158	0.065682	0.394778	0.132049	0.010947	0.009579	0.008894	0.00821	0.007526	0.007526	0.006842	0.006158	**0.664348**	**0.055362**
1999	0.006158	0.005474	0.074577	0.121102	2.21267	0.740294	0.023947	0.019842	0.019157	0.018473	0.017789	0.016421	**3.275901**	**0.272992**
2000	0.015736	0.013684	0.013684	0.013	0.049946	0.016421	0.012315	0.011631	0.010947	0.010947	0.010263	0.010263	**0.188836**	**0.015736**
2001	0.009579	0.27436	0.098523	0.011631	0.011631	0.010947	0.010947	0.009579	0.009579	0.009579	0.008894	0.008894	**0.474144**	**0.039512**
2002	0.00821	0.00821	0.007526	0.009579	0.006842	0.006842	0.006158	0.006158	0.005474	0.004789	0.004105	0.004105	**0.077998**	**0.0065**
2003	0.003421	0.003421	0.002737	0.131364	0.097155	0.251098	0.082787	0.006842	0.006158	0.006158	0.005474	0.005474	**0.602087**	**0.050174**
2004	0.004789	0.004105	0.175153	0.06363	0.005474	0.005474	0.004789	0.004789	0.004105	0.004105	0.004105	0.003421	**0.283939**	**0.023662**
Average	**0.013233**	**0.031384**	**0.056691**	**0.076468**	**0.098676**	**0.052151**	**0.017845**	**0.011583**	**0.010553**	**0.010102**	**0.009732**	**0.009434**	**0.397852**	
Total	**1.124808**	**2.667657**	**4.81875**	**6.499804**	**8.387484**	**4.432867**	**1.516849**	**0.984549**	**0.896973**	**0.858658**	**0.827186**	**0.801871**	**33.81746**	
												total	**33.81746**	
												length	**85**	
												average	**0.397852**	

Mean Annual Runoff:

A1	Quaternary catchment area size km2
A2	Site catchment area size in km2
V1	Quaternary catchment MAR in Mm3
V2	Site catchment MAR in Mm3

Catchment	Site Area	Quaternary catchment	Quat Area	Quat MAR	% Sub-catchment Area	Basic MAR V2=(A2*V1)/A1	% MAR	Correction factor	Corrected MAR
	(km^2)		*(km^2)*	*(Mm^3)*	*(%)*	*(Mm^3)*	*(%)*	*dimentionless*	*(Mm^3)*
Current conditions									
Natural Catchment 1	82.21	A42J	1 027	5.81	8.00	0.47	8.00	0.099	0.58
Natural Catchment 2	56.64	A42J	1 027	5.81	5.52	0.32	5.52	0.068	0.40

WMA	Area	MAR	% Sub-catchment Area	Actual MAR	% MAR
	(km^2)	*(Mm^3)*	*(%)*	*(Mm^3)*	*(%)*
WMA 1	52643	931	0.1562	1.454	0.1562
WMA 1	52643	931	0.1076	1.002	0.1076

Peak Flow Calculations Using 4 Methods:

RATIONAL METHOD

Description of catchment	Actual catchment 1			
River detail	Small tributary of Sandloop just downstream of Ash Dump			
Calculated by	K King		Date	2013/06/06

Physical characteristics

Size of catchment (A)	0.77	km^2	Rainfall region	A4E		
Longest watercourse (L)	0.94	km	**Area distribution factors**			
Average slope (S_{av})	0.0021	m/m	Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%	1	0	0	
Mean annual rainfall(MAR)	465	mm				

Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2 %	0	0.00	0
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep >7%	0	0.00	0
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0	0.00	0
Total	100.00	0.53	8.00	Heavy s,steep>7%	0	0.00	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0	0.04	0.00	Houses	0	0	0
Permeable	0	0.08	0.00	Flats	0	0	0
Semi-permeable	100	0.16	16.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0	0
Total	100	0.54	16.00	Heavy industry	0	0	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	10	0.04	0.40	City centre	0	0	0
Light bush & farm-lands	35	0.11	3.85	Suburban	0	0	0
Grasslands	30	0.21	6.30	Streets	0	0	0
No vegatation	25	0.28	7.00	Max flood		0	
Total	100	0.64	17.55	Total (C2)	0		0

Time of concentration (TC)

Overland flow		Defined channel	
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$	
1.611	hours		hours
		0.677	

Run-off coefficient

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1					0.416	0.416	
Adjusted for dolomitic areas, C_{1D}					0.416	0.416	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.345	0.416	
Combined run - off coefficient, C_T					0.345	0.416	

Rainfall

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T					32.00	51.00	
Point Intensity (mm/h), P_{it}					47.25	75.30	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					47.247	75.299	

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					3.5	6.7	

ALTERNATIVE RATIONAL METHOD

Description of catchment	Catchment 1		
River detail	Small tributary of Sandloop just downstream of Ash Dump		
Calculated by	K King	Date	2013/06/06

Physical characteristics

Size of catchment (A)	0.77	km^2	Days of thunder per year (R)	40	days
Longest watercourse (L)	0.94	km	Weather service station	Ellisras Police Station	
Average slope (S_{av})	0.0021	m/m	Weather service number	0674400W	
Dolomite area (D%)	0	%	**Area distribution factors**		
Mean annual rainfall(MAR)	465	mm	Rural (α)	Urban (β)	Lakes (γ)
2-year return period rainfall (M)	54.9	mm	1	0	0

Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2%	0.00	0.08	0.00
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep>7%	0.00	0.18	0.00
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0.00	0.15	0.00
Total	100.00		8.00	Heavy s,steep>7%	0.00	0.30	0.00
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0.00	0.04	0.00	Houses	0.00	0.40	0.00
Permeable	0.00	0.08	0.00	Flats	0.00	0.60	0.00
Semi-permeable	100.00	0.16	16.00	Industry			
Impermeable	0.00	0.26	0.00	Light industry	0.00	0.65	0.00
Total	100		16.00	Heavy industry	0.00	0.75	0.00
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	10	0.04	0.40	City centre	0.00	0.87	0.00
Light bush & farm-lands	35	0.11	3.85	Suburban	0.00	0.60	0.00
Grasslands	30	0.21	6.30	Streets	0.00	0.87	0.00
No vegatation	25	0.28	7.00	Max flood	0.00	1.00	0.00
Total	100		17.55	Total (C2)	0.00		0.00

Time of concentration (TC)

Overland flow	Defined watercourse		
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$		r=0.4 medium grass cover 1.611
1.611		hours	
	0.677		

Run-off coefficient

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1					0.416	0.416	
Adjusted for dolomitic areas, C_{1D}					0.416	0.416	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.345	0.416	
Combined run - off coefficient, C_T					0.345	0.416	

Rainfall

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T					96.9933	111.7607	
Point Intensity (mm/h), P_{it}					60.19	69.36	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					60.194	69.358	
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					4.4	6.2	

STANDARD DESIGN FLOOD METHOD							
Description of catchment	Actual catchment 1						
River detail	Small tributary of Sandloop just downstream of Ash Dump						
Calculated by	K King				Date	2013/06/06	
Physical characteristics							
Size of catchment (A)	0.77	km^2		Days of thunder per year (R)		44	days
Longest watercourse (L)	0.94	km		Time of concentration, t		40.638	minutes
Average slope (S_{av})	0.0021	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$		0.6773
SDF Basin	2						
2-year return period rainfall (M)	54.9	mm					
TR102 n-day rainfall data							
Weather Service Station	Ellisras Police Station			MAP		465	mm
Weather Service Station no.	0674400W			Coordinates	23°40.287'S & 27°43.765'E		
	Return Period (years)						
Duration	**2**	**5**	**10**	**20**	**50**	**100**	**200**
1 day					133.1	151.5	
2 days					157.5	179	
3 days					163.4	183.7	
7 days					206.6	230.1	
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$					78.2828	90.2014	
Area reduction factor (%),ARF_T					1.1098	1.1098	
Average intensity (mm/hour),I_T					128.2765	147.8068	
Run-off coefficient							
Calibration factors C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0	0	0	2.05	2.33	0
Run-off coefficient, C_T					0.27	0.3	
Peak flow (m3/s)					7.4	9.5	

EMPIRICAL METHODS						
Description of catchment	Actual catchment 1					
River detail	Small Tributary of Ash Dump					
Calculated by	K King			**Date**	2012/11/06	
Physical charateristics						
Size of catchment (A)	0.77	km^2	Veld type			8
Longest watercourse (L)	0.94	km	Catchment parameter (C) with regard to reaction time $C = \frac{A\sqrt{S}}{LL_C}$			0.037672
Length to catchment centriod (L_c)	1	km				
Average slope (S_{av})	0.0021	m/m	Kovacs region		K4	
Mean annual rainfall (P)	465	mm				
Return period (years), T			10	20	50	100
Constant value for Kt					0.79	1
Peak flow (m^3/s), Q_T based on Midgley & Pitman					6.14	7.78
Peak flow (m^3/s), Q_{RMF} based on Kovacs		90.54542				
Return period (years), T			50	100	200	
Q_T/Q_{RMF} ratios			0.416	0.524		
Peak flow (m_3/s) Based on Q_T/Q_{RMF} ratios			37.667	47.446		

RATIONAL METHOD

Description of catchment	Actual catchment 2		
River detail	Tributary of Sandloop River adjacent to proposed Ash dump site 2		
Calculated by	K King	Date	2012/11/06

Physical characteristics

Size of catchment (A)	54.61	km^2	Rainfall region	A4E		
Longest watercourse (L)	7.71	km	**Area distribution factors**			
Average slope (S_{av})	0.1099	m/m	Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%	1	0	0	
Mean annual rainfall(MAR)	465	mm				

Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2 %	0	0.075	0
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep >7%	0	0.175	0
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0	0.15	0
Total	100.00	0.53	8.00	Heavy s,steep>7%	0	0.3	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0	0.04	0.00	Houses	0	0.4	0
Permeable	25	0.08	2.00	Flats	0	0.6	0
Semi-permeable	75	0.16	12.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0.65	0
Total	100	0.54	14.00	Heavy industry	0	0.75	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	0	0.04	0.00	City centre	0	0.87	0
Light bush & farm-lands	87	0.11	9.57	Suburban	0	0.6	0
Grasslands	10	0.21	2.10	Streets	0	0.87	0
No vegetation	3	0.28	0.84	Max flood		1	
Total	100	0.64	12.51	Total (C2)	0		0

Time of concentration (TC)

$$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$$

1.712 hours

$$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$$

0.748 hours

Run-off coefficient

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1					0.345	0.345	
Adjusted for dolomitic areas, C_{1D}					0.345	0.345	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.286	0.345	
Combined run - off coefficient, C_T					0.286	0.345	

Rainfall

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T					58.00	75.00	
Point Intensity (mm/h), P_{it}					77.52	100.24	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					77.520	100.242	

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					336.8	524.8	

ALTERNATIVE RATIONAL METHOD

Description of catchment		Actual catchment 2					
River detail	Tributary of Sandloop River adjacent to proposed Ash dump site 2						
Calculated by	K King			Date	2012/11/06		
Physical characteristics							
Size of catchment (A)	54.61	km^2		Days of thunder per year (R)		40	days
Longest watercourse (L)	7.71	km		Weather service station		Ellisras Police Station	
Average slope (S_{av})	0.1099	m/m		Weather service number		0674400W	
Dolomite area (D%)	0	%		**Area distribution factors**			
Mean annual rainfall(MAR)	465	mm		Rural (α)	Urban (β)	Lakes (γ)	
2-year return period rainfall (M)	54.9	mm		1	0	0	
Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2 %	0.00	0.08	0.00
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep> 7%	0.00	0.18	0.00
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0.00	0.15	0.00
Total	100.00	0.53	8.00	Heavy s,steep>7%	0.00	0.30	0.00
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0.00	0.04	0.00	Houses	0.00	0.40	0.00
Permeable	25.00	0.08	2.00	Flats	0.00	0.60	0.00
Semi-permeable	75.00	0.16	12.00	Industry			
Impermeable	0.00	0.26	0.00	Light industry	0.00	0.65	0.00
Total	100	0.54	14.00	Heavy industry	0.00	0.75	0.00
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	0	0.04	0.00	City centre	0.00	0.87	0.00
Light bush & farm-lands	87	0.11	9.57	Suburban	0.00	0.60	0.00
Grasslands	10	0.21	2.10	Streets	0.00	0.87	0.00
No vegatation	3	0.28	0.84	Max flood	0.00	1.00	0.00
Total	100	0.64	12.51	Total (C2)	0.00		0.00
Time of concentration (TC)							
Overland flow	Defined watercourse						
				r=0.4 medium grass cover			
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$						
1.712			hours				
	0.748						

Run-off coefficient							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1					0.345	0.345	
Adjusted for dolomitic areas, C_{1D}					0.345	0.345	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.286	0.345	
Combined run - off coefficient, C_T					0.286	0.345	
Rainfall							
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T					98.3997	113.3812	
Point Intensity (mm/h), P_{it}					57.49	66.24	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					57.489	66.242	
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					249.8	346.8	

STANDARD DESIGN FLOOD METHOD							
Description of catchment		Actual catchment 2					
River detail		Small tributary of Sandloop just downstream of Ash Dump					
Calculated by		K King			Date	2013/06/06	
Physical characteristics							
Size of catchment (A)		54.61	km^2		Days of thunder per year (R)	44	days
Longest watercourse (L)		7.71	km		Time of concentration, t	44.891	minutes
Average slope (S_{av})		0.1099	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$	0.7482
SDF Basin		2					
2-year return period rainfall (M)		54.9	mm				
TR102 n-day rainfall data							
Weather Service Station		Ellisras Police Station			MAP	465	mm
Weather Service Station no.		0674400W			Coordinates	23°40.287'S & 27°43.765'E	
Duration		**Return Period (years)**					
		2	**5**	**10**	**20**	**50**	**100**	**200**
1 day						133.1	151.5	
2 days						157.5	179	
3 days						163.4	183.7	
7 days						206.6	230.1	
Rainfall								
Return Period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$						80.6462	92.9247	
Area reduction factor (%),ARF_T						0.8969	0.8969	
Average intensity (mm/hour),I_T						96.6802	111.3999	
Run-off coefficient								
Calibration factors	C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T		**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)						2.05	2.33	
Run-off coefficient, C_T						0.27	0.3	
Peak flow (m3/s)						395.9	507.0	

EMPIRICAL METHODS					
Description of catchment	Actual catchment 1				
River detail	Small Tributary of Ash Dump				
Calculated by	K King		**Date**	2012/11/06	
Physical charateristics					
Size of catchment (A)	56.64	km^2	Veld type		8
Longest watercourse (L)	7.71	km	Catchment parameter (C) with regard to reaction time $C = \frac{A\sqrt{S}}{LL_c}$		0.54597
Length to catchment centriod (L_c)	4.46	km			
Average slope (S_{av})	0.11	m/m	Kovacs region	K4	
Mean annual rainfall (P)	465	mm			
Return period (years), T			10	20	50	100
Constant value for Kt					0.79	1
Peak flow (m^3/s), Q_T based on Midgley & Pitman					138.27	175.03
Peak flow (m^3/s), Q_{RMF} based on Kovacs		463.6463				
Return period (years), T			50	100	200	
Q_T/Q_{RMF} ratios			0.416	0.524		
Peak flow (m_3/s) Based on Q_T/Q_{RMF} ratios			192.877	242.951		

RATIONAL METHOD

Description of catchment	Actual catchment 3		
River detail	Small tributary of Sandloop just west of of Ash Dump		
Calculated by	P Lourens	Date	2013/06/14

Physical characteristics

Size of catchment (A)	4.69	km^2	Rainfall region	A4E		
Longest watercourse (L)	3.70	km	**Area distribution factors**			
Average slope (S_{av})	0.0527	m/m	Rural (α)	Urban (β)	Lakes (γ)	
Dolomite area (D%)	0	%	1	0	0	
Mean annual rainfall(MAR)	465	mm				

Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2 %	0	0.00	0
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep >7%	0	0.00	0
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0	0.00	0
Total	100.00	0.53	8.00	Heavy s,steep>7%	0	0.00	0
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0	0.04	0.00	Houses	0	0	0
Permeable	0	0.08	0.00	Flats	0	0	0
Semi-permeable	100	0.16	16.00	Industry			
Impermeable	0	0.26	0.00	Light industry	0	0	0
Total	100	0.54	16.00	Heavy industry	0	0	0
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	10	0.04	0.40	City centre	0	0	0
Light bush & farm-lands	35	0.11	3.85	Suburban	0	0	0
Grasslands	30	0.21	6.30	Streets	0	0	0
No vegatation	25	0.28	7.00	Max flood		0	
Total	100	0.64	17.55	Total (C2)	0		0

Time of concentration (TC)

Overland flow		Defined channel	
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$		$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$	
1.442	hours		hours
		0.564	

Run-off coefficient

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Run-off coefficient, C_1					0.416	0.416	
Adjusted for dolomitic areas, C_{1D}					0.416	0.416	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.345	0.416	
Combined run - off coefficient, C_T					0.345	0.416	

Rainfall

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Point rainfall (mm), P_T					47.00	59.00	
Point Intensity (mm/h), P_{it}					83.34	104.62	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					83.338	104.616	

Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					37.4	56.6	

ALTERNATIVE RATIONAL METHOD

Description of catchment	Actual catchment 3		
River detail	Small tributary of Sandloop just west of of Ash Dump		
Calculated by	P Lourens	Date	2013/06/14

Physical characteristics

Size of catchment (A)	4.69	km^2	Days of thunder per year (R)	40	days
Longest watercourse (L)	3.70	km	Weather service station	Ellisras Police Station	
Average slope (S_{av})	0.0527	m/m	Weather service number	0674400W	
Dolomite area (D%)	0	%	**Area distribution factors**		
Mean annual rainfall(MAR)	465	mm	Rural (α)	Urban (β)	Lakes (γ)
2-year return period rainfall (M)	54.9	mm	1	0	0

Rural				**URBAN**			
Surface slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C2**
Vleis and pans (<3%)	0.00	0.03	0.00	**Lawns**			
Flat areas (3 - 10%)	100.00	0.08	8.00	Sandy,flat<2%	0.00	0.08	0.00
Hilly (10 - 30%)	0.00	0.16	0.00	Sandy,steep> 7%	0.00	0.18	0.00
Steep Areas (>30%)	0.00	0.26	0.00	Heavy s,flat<2%	0.00	0.15	0.00
Total	100.00		8.00	Heavy s,steep>7%	0.00	0.30	0.00
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very permeable	0.00	0.04	0.00	Houses	0.00	0.40	0.00
Permeable	0.00	0.08	0.00	Flats	0.00	0.60	0.00
Semi-permeable	100.00	0.16	16.00	Industry			
Impermeable	0.00	0.26	0.00	Light industry	0.00	0.65	0.00
Total	100		16.00	Heavy industry	0.00	0.75	0.00
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush & plantation	10	0.04	0.40	City centre	0.00	0.87	0.00
Light bush & farm-lands	35	0.11	3.85	Suburban	0.00	0.60	0.00
Grasslands	30	0.21	6.30	Streets	0.00	0.87	0.00
No vegatation	25	0.28	7.00	Max flood	0.00	1.00	0.00
Total	100		17.55	Total (C2)	0.00		0.00

Time of concentration (TC)

Overland flow	Defined watercourse		r=0.4 medium grass cover
$T_C = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$		1.442
1.442		hours	
	0.564		

Run-off coefficient

Return Period (years)	2	5	10	20	50	100	PMF
Run-off coefficient, C_1					0.416	0.416	
Adjusted for dolomitic areas, C_{1D}					0.416	0.416	
Adj factor for initial saturation, F_t					0.83	1	
Adjusted run - off coefficient, C_{1T}					0.345	0.416	
Combined run - off coefficient, C_T					0.345	0.416	

Rainfall

Return Period (years)	2	5	10	20	50	100	PMF
Point rainfall (mm), P_T					94.4065	108.7800	
Point Intensity (mm/h), P_{it}					167.40	192.88	
Area reduction factor (%),ARF_T					1.000	1.000	
Average intensity (mm/hour),I_T					167.397	192.884	
Return Period (years)	**2**	**5**	**10**	**20**	**50**	**100**	**PMF**
Peak flow (m3/s)					75.2	104.4	

STANDARD DESIGN FLOOD METHOD							
Description of catchment	Actual catchment 3						
River detail	Small tributary of Sandloop just west of of Ash Dump						
Calculated by	P Lourens				Date	2013/06/14	
Physical characteristics							
Size of catchment (A)	4.69	km^2		Days of thunder per year (R)		44	days
Longest watercourse (L)	3.70	km		Time of concentration, t		33.838	minutes
Average slope (S_{av})	0.0527	m/m		Time of concentration, T_c	$T_c = \left[\frac{0.87L^2}{1000S_{AV}}\right]^{0.385}$		0.5640
SDF Basin	2						
2-year return period rainfall (M)	54.9	mm					
TR102 n-day rainfall data							
Weather Service Station	Ellisras Police Station			MAP		465	mm
Weather Service Station no.	0674400W			Coordinates	23°40.287'S & 27°43.765'E		
	Return Period (years)						
Duration	**2**	**5**	**10**	**20**	**50**	**100**	**200**
1 day					133.1	151.5	
2 days					157.5	179	
3 days					163.4	183.7	
7 days					206.6	230.1	
Rainfall							
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Point precipitation depth (mm) $P_{t,T}$					73.9354	85.1921	
Area reduction factor (%),ARF_T					1.0191	1.0191	
Average intensity (mm/hour),I_T					133.5986	153.9392	
Run-off coefficient							
Calibration factors — C_2 (%)	5		C_{100} (%)		30		
Return Period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Return period factors (Y_T)	0	0	0	0	2.05	2.33	0
Run-off coefficient, C_T					0.27	0.3	
Peak flow (m3/s)					47.0	60.2	

Peak Flow Summary:

Catchment	Method: Rational 1:50	Rational 1:100	Alternative Rational 1:50	Alternative Rational 1:100	SDF 1:50	SDF 1:100	Empirical 1:50	Empirical 1:100
	(m^3/s)							
Actual catchment 1	3.49	6.69	4.44	6.16	7.41	6.16	37.67	47.45
Actual catchment 2	336.83	524.76	249.79	346.77	395.92	506.96	192.88	242.95
Actual catchment 3	37.44	56.63	75.21	104.41	46.99	104.41	n/c	n/c

Volume Calculations:

Catchment	Tc 1:50 *(hours)*	Tc 1:50 *(seconds)*	3Tc 1:50 *(seconds)*	Tc 1:100 *(hours)*	Tc 1:100 *(seconds)*	3Tc 1:100 *(seconds)*	Constant *dimentionless*
Actual catchment 1	0.68	2 438.27	7 314.80	0.68	2 438.27	7 314.80	0.5
Actual catchment 2	0.75	2 693.49	8 080.46	0.75	2 693.49	8 080.46	0.5
Actual catchment 3	0.56	2 030.28	6 090.85	0.56	2 030.28	6 090.85	0.5

Peak Volume: Rational 1:50	Rational 1:100	Alternative Rational 1:50	Alternative Rational 1:100	SDF 1:50	SDF 1:100	Empirical 1:50	Empirical 1:100
(m^3)							
12 746.21	24 475.03	16 239.11	22 544.02	27 089.61	22 544.02	137 762.95	173 528.33
1 360 863.23	2 120 164.99	1 009 210.88	1 401 041.79	1 599 587.21	2 048 244.09	779 266.57	981 576.17
114 027.89	172 459.51	229 041.91	317 968.52	143 091.77	317 968.52	n/c	n/c

Peak Volume Summary:

Catchment	Peak Volume: Rational 1:50	Rational 1:100	Alternative Rational 1:50	Alternative Rational 1:100	SDF 1:50	SDF 1:100	Empirical 1:50	Empirical 1:100
	(m3)							
Actual catchment 1	12 746.21	24 475.03	16 239.11	22 544.02	**27 089.61**	**22 544.02**	137 762.95	173 528.33
Actual catchment 2	1 360 863.23	2 120 164.99	1 009 210.88	1 401 041.79	**1 599 587.21**	**2 048 244.09**	779 266.57	981 576.17
Actual catchment 3	114 027.89	172 459.51	229 041.91	317 968.52	**143 091.77**	**317 968.52**	n/c	n/c

APPENDIX C: WARMS DATA

WARMS QA Data Reports	
As at	2012/11/05 13:57
Requested By :	ANNA VERWEY
Filter Criteria	
Office :	LIMPOPO OFFICE
Water Use Statuses :	COMPLETE, REGISTERED
Water User Types :	CMA - Inter-WMA Transfer, Individual, Company, Business or Partnership, National Government, Provincial Government, Water Services Provider, Water User Association
Water Use Type :	DW762
Include Permit Deta	No
Include Properties :	No

Office ID	Office Name	Register No.	Register Status ID	Register Status	Office Hardcopy File No.	Part 1 Submission Date	Part 1 Capture Date	Customer Type	Customer Title	Customer Name	Enterprise Type Code
7	LIMPOPO OFFICE	27023435	836	ACTIVE			2001/06/07	COMPANY		MATLABAS BEES EN V	07
7	LIMPOPO OFFICE	27023257	836	ACTIVE			2001/06/07	COMPANY		CCG 088 INVESTMEN	07
7	LIMPOPO OFFICE	27089481	836	ACTIVE			2010/05/06	COMPANY		PENTALIN TRADING !	23
7	LIMPOPO OFFICE	27087768	836	ACTIVE			2009/02/12	COMPANY		NATURE CONSERVAT	XY
7	LIMPOPO OFFICE	27082282	836	ACTIVE	27/2/1/A42A/KR371/2		2005/04/14	INDIVIDUAL	MR	CA VAN DER MERWE	
7	LIMPOPO OFFICE	27086288	836	ACTIVE		2012/06/20	2007/09/14	COMPANY		CASTELCO	23
7	LIMPOPO OFFICE	27087367	836	ACTIVE	A42A		2008/06/11	COMPANY		MAC EN MARTIN	23
7	LIMPOPO OFFICE	27094812	836	ACTIVE		2012/08/28	2012/08/28	COMPANY		EQUISALE 60	23
7	LIMPOPO OFFICE	27084235	836	ACTIVE			2006/07/11	INDIVIDUAL	MR	JP KRIEL	
7	LIMPOPO OFFICE	27090889	836	ACTIVE			2010/10/18	COMPANY		NATURE CONSERVAT	XY
7	LIMPOPO OFFICE	27003046	836	ACTIVE			2001/03/09	COMPANY		KLIPRIVIER BESIGHEI	XY
7	LIMPOPO OFFICE	27081924	836	ACTIVE	27/2/1/A42B/KR359/1		2005/02/03	COMPANY		TWEE TESAME	07
7	LIMPOPO OFFICE	27071631	836	ACTIVE			2001/11/12	INDIVIDUAL	MR	JC WEILBACH	
7	LIMPOPO OFFICE	27090460	836	ACTIVE			2010/06/01	INDIVIDUAL	MR	HS BOSMAN	
7	LIMPOPO OFFICE	27090870	836	ACTIVE			2010/10/15	COMPANY		NATURE CONSERVAT	XY
7	LIMPOPO OFFICE	27020376	836	ACTIVE			2001/05/31	INDIVIDUAL	MR	HS BOSMAN	
7	LIMPOPO OFFICE	27085216	836	ACTIVE			2007/01/08	INDIVIDUAL	MR	JC WEILBACH	
7	LIMPOPO OFFICE	27084253	836	ACTIVE			2006/07/12	COMPANY		GOUWS BOERDERY T	XY
7	LIMPOPO OFFICE	27081924	836	ACTIVE	27/2/1/A42B/KR359/1		2005/02/03	COMPANY		TWEE TESAME	07
7	LIMPOPO OFFICE	27003046	836	ACTIVE			2001/03/09	COMPANY		KLIPRIVIER BESIGHEI	XY
7	LIMPOPO OFFICE	27090601	836	ACTIVE			2010/07/20	COMPANY		DRV TABAK BOERDEF	07
7	LIMPOPO OFFICE	27084805	836	ACTIVE			2006/10/20	INDIVIDUAL	MR	SJM PUTTER	
7	LIMPOPO OFFICE	27023220	836	ACTIVE			2001/09/26	COMPANY		ZANDRIVIER BOERDE	23
7	LIMPOPO OFFICE	27023355	836	ACTIVE			2001/06/07	COMPANY		GINGER GYPSY	07
7	LIMPOPO OFFICE	27002813	836	ACTIVE			2001/09/19	INDIVIDUAL	MRS	N BOSCH	
7	LIMPOPO OFFICE	27002797	836	ACTIVE			2001/10/10	COMPANY		BUFFALO WINGS PR(	23
7	LIMPOPO OFFICE	27090567	836	ACTIVE			2010/06/28	COMPANY		NEW ORDER INV 102	07
7	LIMPOPO OFFICE	27090601	836	ACTIVE			2010/07/20	COMPANY		DRV TABAK BOERDEF	07
7	LIMPOPO OFFICE	27023275	836	ACTIVE			2001/06/07	COMPANY		GINGER GYPSSY	07
7	LIMPOPO OFFICE	27071999	836	ACTIVE			2001/11/15	COMPANY		MATSWANE LODGE	07
7	LIMPOPO OFFICE	27023391	836	ACTIVE			2001/06/07	COMPANY		PICCADILLY FLOWER	07
7	LIMPOPO OFFICE	27087553	836	ACTIVE			2008/12/09	COMPANY		TRIDAX TRADE AND I	07
7	LIMPOPO OFFICE	27069617	836	ACTIVE			2001/09/14	INDIVIDUAL	MR	TF VAN DER MERWE	
7	LIMPOPO OFFICE	27023373	836	ACTIVE			2001/06/07	COMPANY		FAAN VAN DER MERV	XY
7	LIMPOPO OFFICE	27087553	836	ACTIVE			2008/12/09	COMPANY		TRIDAX TRADE AND I	07
7	LIMPOPO OFFICE	27023300	836	ACTIVE			2001/06/07	COMPANY		DANERISTALOU LANI	07
7	LIMPOPO OFFICE	27078493	836	ACTIVE			2002/12/23	COMPANY		EUCALYPTUS FARM	07
7	LIMPOPO OFFICE	27088703	836	ACTIVE	A42F		2010/03/03	COMPANY		BAR CIRCLE INVESTM	07
7	LIMPOPO OFFICE	27023293	836	ACTIVE			2001/06/07	COMPANY		WELTEVREDEN TRUS	XY

7	LIMPOPO OFFICE	27023177	836	ACTIVE			2001/06/07	INDIVIDUAL	MR	PS BEITH	
7	LIMPOPO OFFICE	27074086	836	ACTIVE			2002/03/09	INDIVIDUAL	MR	G STORM	
7	LIMPOPO OFFICE	27020394	836	ACTIVE			2001/09/20	COMPANY		CHARLES BABER TRU	XZ
7	LIMPOPO OFFICE	27094493	836	ACTIVE		2012/05/30	2012/05/30	COMPANY		I A N DEVELOPMENTS	23
7	LIMPOPO OFFICE	27082530	836	ACTIVE	27/2/1/A50G/LR509/15		2005/08/04	COMPANY		KITSBELEG 11	07
7	LIMPOPO OFFICE	27086723	836	ACTIVE	27/2/1/A50E/KQ253/1		2007/11/08	COMPANY		DAMDAL BOERDERY	06
7	LIMPOPO OFFICE	27047179	836	ACTIVE			2001/08/02	COMPANY		CHEROKEE RANCH	23
7	LIMPOPO OFFICE	27047179	836	ACTIVE			2001/08/02	COMPANY		CHEROKEE RANCH	23
7	LIMPOPO OFFICE	27040648	836	ACTIVE			2001/09/20	COMPANY		CHERIKUS TRUST	XZ
7	LIMPOPO OFFICE	27041594	836	ACTIVE			2001/07/25	INDIVIDUAL	MR	DK STRATFORD	
7	LIMPOPO OFFICE	27086368	836	ACTIVE			2007/10/08	COMPANY		DE VECHT TRUST	XY
7	LIMPOPO OFFICE	27071668	836	ACTIVE			2001/10/18	INDIVIDUAL	MR	S VENTER	
7	LIMPOPO OFFICE	27086368	836	ACTIVE			2007/10/08	COMPANY		DE VECHT TRUST	XY
7	LIMPOPO OFFICE	27060769	836	ACTIVE			2001/08/28	COMPANY		REPUBLIC OF SOUTH	XZ
7	LIMPOPO OFFICE	27060527	836	ACTIVE			2001/08/28	INDIVIDUAL	MR	WH BOOYSE	
7	LIMPOPO OFFICE	27082709	836	ACTIVE			2005/09/14	INDIVIDUAL	MR	RL GLOVER	
7	LIMPOPO OFFICE	27088062	836	ACTIVE	A61H/KR175/9		2009/09/29	COMPANY		8 MILE INV 192	07
7	LIMPOPO OFFICE	27059815	836	ACTIVE	27/2/1/A61H/KR305/4		2001/08/23	COMPANY		LEKKERBREEK WILDS	XZ
7	LIMPOPO OFFICE	27082479	836	ACTIVE	27/2/1/A61H/KR311/1		2005/07/15	COMPANY		ASG BOERDERY	23
7	LIMPOPO OFFICE	27085092	836	ACTIVE			2006/12/12	COMPANY		BUFFELSFONTEIN BE	07
7	LIMPOPO OFFICE	27085537	836	ACTIVE	27/2/1/A61H/KR305/14		2007/04/13	COMPANY		8 MILE INVE 164	07
7	LIMPOPO OFFICE	27087946	836	ACTIVE			2009/08/06	COMPANY		GREENWAY FARMS	07
7	LIMPOPO OFFICE	27060634	836	ACTIVE			2001/08/28	INDIVIDUAL	MR	JH VORSTER	
7	LIMPOPO OFFICE	27080248	836	ACTIVE	27/2/1/A61H/KR306/9		2003/11/13	COMPANY		JOHAN WILLEN PONT	XY
7	LIMPOPO OFFICE	27041264	836	ACTIVE			2001/07/25	INDIVIDUAL	MR	EC PAUER	
7	LIMPOPO OFFICE	27041077	836	ACTIVE			2001/07/25	COMPANY		ENTABENI GAME LOD	07
7	LIMPOPO OFFICE	27057817	836	ACTIVE			2001/08/16	COMPANY		MOOIPLAAS 296 KR	23
7	LIMPOPO OFFICE	27072532	836	ACTIVE			2002/02/28	COMPANY		BOYLES FAMILY TRUS	XZ
7	LIMPOPO OFFICE	27056701	836	ACTIVE			2001/08/16	INDIVIDUAL	MR	AD KOTZE	
7	LIMPOPO OFFICE	27058264	836	ACTIVE			2001/08/17	INDIVIDUAL	MR	F SCHOLTZ	
7	LIMPOPO OFFICE	27058335	836	ACTIVE	27/2/1/A61J/KR220/2		2001/08/17	INDIVIDUAL	MR	JG PEENS	
7	LIMPOPO OFFICE	27071310	836	ACTIVE			2001/09/19	INDIVIDUAL	MR	AD KOTZE	
7	LIMPOPO OFFICE	27056202	836	ACTIVE			2001/08/15	INDIVIDUAL	MR	JP VAN STADEN	
7	LIMPOPO OFFICE	27058629	836	ACTIVE			2001/08/17	COMPANY		MATAPO	23
7	LIMPOPO OFFICE	27058521	836	ACTIVE	27/2/1/A61J/KR253/212		2001/09/14	COMPANY		WOESTALLEEN BOER	23
7	LIMPOPO OFFICE	27058291	836	ACTIVE			2001/08/17	COMPANY		THINUS MARITZ KRA	07
7	LIMPOPO OFFICE	27058086	836	ACTIVE	27/2/1/A62A/KR216/1		2001/08/17	COMPANY		HOOGESTRAAT ONDI	07
7	LIMPOPO OFFICE	27072033	836	ACTIVE			2001/11/14	INDIVIDUAL	MR	FJ ENGELBRECHT	
7	LIMPOPO OFFICE	27058086	836	ACTIVE	27/2/1/A62A/KR216/1		2001/08/17	COMPANY		HOOGESTRAAT ONDI	07
7	LIMPOPO OFFICE	27058996	836	ACTIVE			2001/08/20	COMPANY		KETA CATTLE RANCH	07
7	LIMPOPO OFFICE	27086251	836	ACTIVE			2007/09/09	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27060821	836	ACTIVE			2001/08/29	INDIVIDUAL	MR	J COETZER	
7	LIMPOPO OFFICE	27047188	836	ACTIVE			2001/08/02	INDIVIDUAL	MR	JJ VENTER	
7	LIMPOPO OFFICE	27006953	836	ACTIVE			2001/03/22	COMPANY		DE BEERS CONSOLID	06
7	LIMPOPO OFFICE	27006971	836	ACTIVE	27/2/2/A63E/MS7/0/VHEMBE GAME RES		2001/03/22	COMPANY		BORGANUM AB	10
7	LIMPOPO OFFICE	27017594	836	ACTIVE			2001/09/20	COMPANY		BORGANUM AB	10
7	LIMPOPO OFFICE	27006864	836	ACTIVE			2001/03/22	COMPANY		BORGANUM AB	10
7	LIMPOPO OFFICE	27061296	836	ACTIVE			2001/08/29	COMPANY		DE BEERS CONSOLID	06
7	LIMPOPO OFFICE	27061786	836	ACTIVE			2001/08/30	COMPANY		BRESLAU GAME FARI	07
7	LIMPOPO OFFICE	27006604	836	ACTIVE			2001/03/20	INDIVIDUAL	MR	GP HODGSON	
7	LIMPOPO OFFICE	27006962	836	ACTIVE			2001/03/22	COMPANY		DE BEERS CONSOLID	06
7	LIMPOPO OFFICE	27006953	836	ACTIVE			2001/03/22	COMPANY		DE BEERS CONSOLID	06
7	LIMPOPO OFFICE	27036341	836	ACTIVE			2001/07/19	COMPANY		LAHN BELEGGINGS	07
7	LIMPOPO OFFICE	27008997	836	ACTIVE			2001/04/02	COMPANY		SCHURWEKLOOF BO	07
7	LIMPOPO OFFICE	27018708	836	ACTIVE			2001/09/28	COMPANY		BLOEMTUIN BOERDE	07
7	LIMPOPO OFFICE	27042405	836	ACTIVE			2001/09/25	COMPANY		DIKGALE BOERDERY	07
7	LIMPOPO OFFICE	27006267	836	ACTIVE			2001/03/19	COMPANY		ALLAN IVY TRUST	XY
7	LIMPOPO OFFICE	27018682	836	ACTIVE			2001/11/13	COMPANY		BLOEMTUIN BOERDE	07
7	LIMPOPO OFFICE	27008354	836	ACTIVE	27/2/1/A71C/LS778/15		2001/03/29	INDIVIDUAL	MR	D FOURIE	
7	LIMPOPO OFFICE	27018708	836	ACTIVE			2001/09/28	COMPANY		BLOEMTUIN BOERDE	07
7	LIMPOPO OFFICE	27042600	836	ACTIVE			2001/09/25	COMPANY		VAN ZYLSRUST BOER	07
7	LIMPOPO OFFICE	27042600	836	ACTIVE			2001/09/25	COMPANY		VAN ZYLSRUST BOER	07
7	LIMPOPO OFFICE	27095125	836	ACTIVE		2012/11/05	2012/11/05	COMPANY		GEDEELTE VAN DIE P	XY
7	LIMPOPO OFFICE	27042520	836	ACTIVE			2001/07/26	COMPANY		APPELFONTEIN PLAS	07
7	LIMPOPO OFFICE	27042566	836	ACTIVE			2001/07/26	COMPANY		C T VAN DER MERWE	07
7	LIMPOPO OFFICE	27042646	836	ACTIVE			2001/08/23	COMPANY		DIDEMUS PLASE	07
7	LIMPOPO OFFICE	27042548	836	ACTIVE			2001/07/26	COMPANY		APPELFONTEIN PLAS	07
7	LIMPOPO OFFICE	27042548	836	ACTIVE			2001/07/26	COMPANY		APPELFONTEIN PLAS	07
7	LIMPOPO OFFICE	27026352	836	ACTIVE			2001/06/26	INDIVIDUAL	MS	AZJ JONGBLOED	
7	LIMPOPO OFFICE	27042496	836	ACTIVE			2001/07/26	COMPANY		PATRYSPAN PLASE	07
7	LIMPOPO OFFICE	27042520	836	ACTIVE			2001/07/26	COMPANY		APPELFONTEIN PLAS	07
7	LIMPOPO OFFICE	27042478	836	ACTIVE			2001/07/26	COMPANY		LOSKOP PLASE	07
7	LIMPOPO OFFICE	27095081	836	ACTIVE		2012/11/03	2012/11/03	COMPANY		WITKLIP NR 2	XY
7	LIMPOPO OFFICE	27011509	836	ACTIVE			2001/04/11	COMPANY		AGRIDEN	07
7	LIMPOPO OFFICE	27010485	836	ACTIVE			2001/04/09	INDIVIDUAL	MR	GC FICK	
7	LIMPOPO OFFICE	27042272	836	ACTIVE			2001/09/27	COMPANY		TELSEK BELEGGINGS	07
7	LIMPOPO OFFICE	27011858	836	ACTIVE			2001/04/12	INDIVIDUAL	MR	GC FICK	
7	LIMPOPO OFFICE	27061410	836	ACTIVE			2001/08/29	COMPANY		RIA VAN DER WALT B	23
7	LIMPOPO OFFICE	27010261	836	ACTIVE			2001/04/06	INDIVIDUAL	MR	TJG FOURIE	
7	LIMPOPO OFFICE	27063089	836	ACTIVE			2001/09/28	NATIONAL DEPARTMENT		DEPARTMENT OF AG	
7	LIMPOPO OFFICE	27042673	836	ACTIVE			2001/09/25	COMPANY		TWYFEL NIE PLASE	07
7	LIMPOPO OFFICE	27042628	836	ACTIVE			2001/09/21	COMPANY		TWYFEL NIE PLASE	07
7	LIMPOPO OFFICE	27042673	836	ACTIVE			2001/09/25	COMPANY		TWYFEL NIE PLASE	07
7	LIMPOPO OFFICE	27082656	836	ACTIVE			2005/09/05	COMPANY		TWYFEL NIE PLASE	07
7	LIMPOPO OFFICE	27017497	836	ACTIVE			2001/09/27	COMPANY		MUSINA MUNICIPAL	XZ
7	LIMPOPO OFFICE	27007845	836	ACTIVE	27/2/1/A71K/MS503/0		2001/03/27	COMPANY		SHELDRAKE GAME R	23
7	LIMPOPO OFFICE	27019280	836	ACTIVE			2001/09/25	INDIVIDUAL	MR	N VOS	
7	LIMPOPO OFFICE	27007827	836	ACTIVE			2001/03/27	COMPANY		HONEYMOON TRUST	XY
7	LIMPOPO OFFICE	27019280	836	ACTIVE			2001/09/25	INDIVIDUAL	MR	N VOS	
7	LIMPOPO OFFICE	27014793	836	ACTIVE			2001/09/27	INDIVIDUAL	MR	PR NEL	
7	LIMPOPO OFFICE	27014793	836	ACTIVE			2001/09/27	INDIVIDUAL	MR	PR NEL	
7	LIMPOPO OFFICE	27019878	836	ACTIVE			2001/06/11	COMPANY		OVERVLAKTE EIENDO	23
7	LIMPOPO OFFICE	27013099	836	ACTIVE			2001/09/21	COMPANY		KONGO TRUST	XY
7	LIMPOPO OFFICE	27013188	836	ACTIVE			2001/09/25	INDIVIDUAL	MS	MM VAN DER WALT	
7	LIMPOPO OFFICE	27007015	836	ACTIVE			2001/03/22	COMPANY		DE BEERS CONSOLID	06
7	LIMPOPO OFFICE	27006695	836	ACTIVE			2001/08/02	INDIVIDUAL	MR	P ESTERHUYSE	
7	LIMPOPO OFFICE	27006739	836	ACTIVE	27/2/1/A71L/MS126/0		2001/08/29	COMPANY		MASWIRI BOERDERY	07
7	LIMPOPO OFFICE	27014793	836	ACTIVE			2001/09/27	INDIVIDUAL	MR	PR NEL	
7	LIMPOPO OFFICE	27009629	836	ACTIVE			2001/04/05	COMPANY		KROON BEDRYFS	XY
7	LIMPOPO OFFICE	27015364	836	ACTIVE			2001/05/17	COMPANY		FRAAIFONTEIN	07
7	LIMPOPO OFFICE	27086625	836	ACTIVE			2007/10/27	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27083511	836	ACTIVE			2006/03/21	COMPANY		STEVE SCHOEMAN BE	07
7	LIMPOPO OFFICE	27086616	836	ACTIVE	27/2/1/A80C/MT181/0		2007/10/27	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27009978	836	ACTIVE			2001/04/05	COMPANY		NOMIS	XY
7	LIMPOPO OFFICE	27014007	836	ACTIVE			2001/09/21	COMPANY		BERTIE KNOTT GAME	07
7	LIMPOPO OFFICE	27018030	836	ACTIVE			2001/05/23	COMPANY		MAREMANI NATURE	10
7	LIMPOPO OFFICE	27017861	836	ACTIVE			2001/05/22	COMPANY		MAREMANI NATURE	10
7	LIMPOPO OFFICE	27064006	836	ACTIVE			2001/09/04	COMPANY		BERGHEIM ESTATES	07
7	LIMPOPO OFFICE	27064006	836	ACTIVE			2001/09/04	COMPANY		BERGHEIM ESTATES	07
7	LIMPOPO OFFICE	27064006	836	ACTIVE			2001/09/04	COMPANY		BERGHEIM ESTATES	07
7	LIMPOPO OFFICE	27064006	836	ACTIVE			2001/09/04	COMPANY		BERGHEIM ESTATES	07
7	LIMPOPO OFFICE	27065808	836	ACTIVE			2001/09/06	INDIVIDUAL	MR	GB WHITAKER	
7	LIMPOPO OFFICE	27063999	836	ACTIVE			2001/09/04	COMPANY		MUMUNZWU ESTAT	XZ
7	LIMPOPO OFFICE	27064033	836	ACTIVE			2001/09/04	COMPANY		MUNUNZWU ESTATI	XZ
7	LIMPOPO OFFICE	27064033	836	ACTIVE			2001/09/04	COMPANY		MUNUNZWU ESTATI	XZ
7	LIMPOPO OFFICE	27064033	836	ACTIVE			2001/09/04	COMPANY		MUNUNZWU ESTATI	XZ
7	LIMPOPO OFFICE	27064033	836	ACTIVE			2001/09/04	COMPANY		MUNUNZWU ESTATI	XZ
7	LIMPOPO OFFICE	27000165	836	ACTIVE	27/2/1/A91C/LT15/148		2001/01/29	INDIVIDUAL	MR	MP THEUNISSEN	
7	LIMPOPO OFFICE	27063720	836	ACTIVE			2001/09/04	INDIVIDUAL	MR	HK ROTTCHER	

7	LIMPOPO OFFICE	27066264	836	ACTIVE			2001/09/07	COMPANY		ENSHALA FARMING	07
7	LIMPOPO OFFICE	27026432	836	ACTIVE	27/2/1/A91C/LT33/0		2001/11/05	COMPANY		EASTERN PRODUCE E	07
7	LIMPOPO OFFICE	27065069	836	ACTIVE			2001/09/05	COMPANY		SPRINGFIELD TRUST	XY
7	LIMPOPO OFFICE	27088302	836	ACTIVE			2009/12/09	COMPANY		XENUS BELEGGINGS	XY
7	LIMPOPO OFFICE	27026432	836	ACTIVE	27/2/1/A91C/LT33/0		2001/11/05	COMPANY		EASTERN PRODUCE E	07
7	LIMPOPO OFFICE	27002751	836	ACTIVE			2001/11/01	INDIVIDUAL	MR	LA WILKEN	
7	LIMPOPO OFFICE	27026254	836	ACTIVE	27/2/1/A91C/LT9/0		2001/06/26	COMPANY		EASTERN PRODUCE E	07
7	LIMPOPO OFFICE	27064710	836	ACTIVE			2001/09/05	COMPANY		OSWALD MUIRHEAD	XY
7	LIMPOPO OFFICE	27064998	836	ACTIVE			2001/09/05	COMPANY		SPRINGFIELD TRUST	XY
7	LIMPOPO OFFICE	27064890	836	ACTIVE			2001/09/05	INDIVIDUAL	MS	EW JOUBERT	
7	LIMPOPO OFFICE	27065005	836	ACTIVE			2001/09/05	COMPANY		KLEIN AUSTRALIE BO	XY
7	LIMPOPO OFFICE	27064890	836	ACTIVE			2001/09/05	INDIVIDUAL	MS	EW JOUBERT	
7	LIMPOPO OFFICE	27066399	836	ACTIVE	27/2/1/A91D/LT15/199		2001/09/07	COMPANY		DE FIN AND WAGNER	23
7	LIMPOPO OFFICE	27029885	836	ACTIVE			2001/09/19	COMPANY		VENTECO	07
7	LIMPOPO OFFICE	27026593	836	ACTIVE			2001/06/27	COMPANY		EASTERN PRODUCE E	07
7	LIMPOPO OFFICE	27070874	836	ACTIVE	27/2/2/A92D/MT281/0/TSHIKONDENI M		2001/09/18	COMPANY		EXXARO COAL	07
7	LIMPOPO OFFICE	27075316	836	ACTIVE	27/2/2/B81A/LS931/0/POLOKWANE MUI		2002/07/16	WATER SERVICES PROVIDER		POLOKWANE MUNIC	
7	LIMPOPO OFFICE	27001903	836	ACTIVE	27/2/2/B81A/LS1022/2		2001/03/02	COMPANY		STANFORD FARM TRU	XY
7	LIMPOPO OFFICE	27089025	836	ACTIVE			2010/03/04	COMPANY		MIROME PROPERTIES	07
7	LIMPOPO OFFICE	27088008	836	ACTIVE			2009/09/10	COMPANY		HANS MERENSKY HO	07
7	LIMPOPO OFFICE	27088008	836	ACTIVE			2009/09/10	COMPANY		HANS MERENSKY HO	07
7	LIMPOPO OFFICE	27026076	836	ACTIVE			2001/06/25	COMPANY		DOTCOM TRADING 3	07
7	LIMPOPO OFFICE	27001093	836	ACTIVE			2001/08/07	COMPANY		AFRICAN REALITY TRU	07
7	LIMPOPO OFFICE	27034664	836	ACTIVE			2001/09/25	COMPANY		B J VORSTER	07
7	LIMPOPO OFFICE	27087973	836	ACTIVE			2009/08/19	COMPANY		WESTFALIA FRUIT ES	07
7	LIMPOPO OFFICE	27088008	836	ACTIVE			2009/09/10	COMPANY		HANS MERENSKY HO	07
7	LIMPOPO OFFICE	27088008	836	ACTIVE			2009/09/10	COMPANY		HANS MERENSKY HO	07
7	LIMPOPO OFFICE	27027734	836	ACTIVE			2001/09/26	COMPANY		DOORNLAB EIENDOM	07
7	LIMPOPO OFFICE	27027253	836	ACTIVE	27/2/2/B81B/LT479/0		2001/06/28	COMPANY		PALLAS PROPERTIES	07
7	LIMPOPO OFFICE	27001093	836	ACTIVE			2001/08/07	COMPANY		AFRICAN REALITY TRU	07
7	LIMPOPO OFFICE	27001556	836	ACTIVE	27/2/2/B81B/LT623/8		2001/03/01	INDIVIDUAL	MR	PN MCGAFFIN	
7	LIMPOPO OFFICE	27001155	836	ACTIVE			2001/03/08	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27001155	836	ACTIVE			2001/03/08	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27001164	836	ACTIVE			2001/03/08	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27081595	836	ACTIVE	27/2/1/B81C/LT534/12		2004/11/01	INDIVIDUAL	MR	H BOUWER	
7	LIMPOPO OFFICE	27001217	836	ACTIVE			2001/03/07	INDIVIDUAL	MR	PF HESLINGA	
7	LIMPOPO OFFICE	27028421	836	ACTIVE			2001/07/03	COMPANY		LEDZEE ESTATES	07
7	LIMPOPO OFFICE	27000762	836	ACTIVE	27/2/1/B81C/LT530/0		2001/04/05	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27001155	836	ACTIVE			2001/03/08	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27001164	836	ACTIVE			2001/03/08	COMPANY		AFRICAN REALTY TRU	07
7	LIMPOPO OFFICE	27023998	836	ACTIVE			2001/06/18	COMPANY		BJ VORSTER	XY
7	LIMPOPO OFFICE	27092896	836	ACTIVE			2011/07/22	COMPANY		MACADRIFT CC	23
7	LIMPOPO OFFICE	27028421	836	ACTIVE			2001/07/03	COMPANY		LEDZEE ESTATES	07
7	LIMPOPO OFFICE	27028421	836	ACTIVE			2001/07/03	COMPANY		LEDZEE ESTATES	07
7	LIMPOPO OFFICE	27086590	836	ACTIVE	27/2/1/B81D/LT11/0		2007/10/27	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27087982	836	ACTIVE	27/2/1/B81D/LT/579/1		2009/08/27	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27000110	836	ACTIVE	27/2/1/B81D/LT579/0		2001/05/24	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27000110	836	ACTIVE	27/2/1/B81D/LT579/0		2001/05/24	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27000619	836	ACTIVE			2001/03/08	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27002626	836	ACTIVE	27/2/1/B81D/LT571/1		2001/04/03	INDIVIDUAL	MR	P OOSTHUIZEN	
7	LIMPOPO OFFICE	27002699	836	ACTIVE			2001/03/06	INDIVIDUAL	MR	A COETZEE	
7	LIMPOPO OFFICE	27033353	836	ACTIVE			2001/07/10	COMPANY		BRAIN BRADY FAMILY	XY
7	LIMPOPO OFFICE	27033399	836	ACTIVE			2001/07/10	COMPANY		RODNEY COOPER	XY
7	LIMPOPO OFFICE	27080319	836	ACTIVE	27/2/1/B81D/LT580/3		2003/11/27	COMPANY		AGATHA AVOCADO'S	07
7	LIMPOPO OFFICE	27032327	836	ACTIVE			2001/07/09	COMPANY		MONAVEIN	07
7	LIMPOPO OFFICE	27033219	836	ACTIVE			2001/07/10	COMPANY		ROY COOPER	XY
7	LIMPOPO OFFICE	27028109	836	ACTIVE			2001/09/19	COMPANY		MURLEBROOK ESTAT	07
7	LIMPOPO OFFICE	27000110	836	ACTIVE	27/2/1/B81D/LT579/0		2001/05/24	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27000110	836	ACTIVE	27/2/1/B81D/LT579/0		2001/05/24	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27000110	836	ACTIVE	27/2/1/B81D/LT579/0		2001/05/24	COMPANY		BASSAN FARM	07
7	LIMPOPO OFFICE	27002626	836	ACTIVE	27/2/1/B81D/LT571/1		2001/04/03	INDIVIDUAL	MR	P OOSTHUIZEN	
7	LIMPOPO OFFICE	27002644	836	ACTIVE			2001/03/06	COMPANY		KAHLI INVESTMENTS	07
7	LIMPOPO OFFICE	27033157	836	ACTIVE			2001/07/10	COMPANY		FAEROES PROPERTIES	07
7	LIMPOPO OFFICE	27033353	836	ACTIVE			2001/07/10	COMPANY		BRAIN BRADY FAMILY	XY
7	LIMPOPO OFFICE	27038027	836	ACTIVE	27/2/1/B81D/LETSITELE RIVER IRRIGATIO		2001/07/17	WATER USER ASSOCIATION		LETSITELERIVIER IRRI	
7	LIMPOPO OFFICE	27075067	836	ACTIVE			2002/06/06	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27023578	836	ACTIVE			2001/06/18	COMPANY		LUFAFA HATCHERY	07
7	LIMPOPO OFFICE	27023621	836	ACTIVE			2001/06/18	COMPANY		BUITENDAG FAMILIE	XY
7	LIMPOPO OFFICE	27023649	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023676	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023676	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023989	836	ACTIVE			2001/09/25	COMPANY		SWAMPOL	07
7	LIMPOPO OFFICE	27024782	836	ACTIVE			2001/06/20	INDIVIDUAL	MR	DJ DE NYSSCHEN	
7	LIMPOPO OFFICE	27024899	836	ACTIVE			2001/09/25	COMPANY		RODEV CHICKENS	07
7	LIMPOPO OFFICE	27023667	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27024540	836	ACTIVE			2001/06/20	INDIVIDUAL	MR	MS MARAIS	
7	LIMPOPO OFFICE	27084645	836	ACTIVE			2006/09/26	COMPANY		THINUS MARITZ VAA	07
7	LIMPOPO OFFICE	27088703	836	ACTIVE	A42F		2010/03/03	COMPANY		BAR CIRCLE INVESTM	07
7	LIMPOPO OFFICE	27023202	836	ACTIVE			2001/06/07	INDIVIDUAL	MR	JCC PISTORIUS	
7	LIMPOPO OFFICE	27047570	836	ACTIVE			2001/09/26	COMPANY		HENQUE 3198	23
7	LIMPOPO OFFICE	27020438	836	ACTIVE			2001/09/21	COMPANY		ESKOM MATIMBA PC	07
7	LIMPOPO OFFICE	27020321	836	ACTIVE			2001/05/31	COMPANY		SCHALK VAN SCHALK	XY
7	LIMPOPO OFFICE	27094821	836	ACTIVE		2012/08/30	2012/08/30	COMPANY		PURPLE BOX TRADIN	07
7	LIMPOPO OFFICE	27023499	836	ACTIVE			2001/06/07	COMPANY		GIDEON ROOS GESIN	XZ
7	LIMPOPO OFFICE	27020349	836	ACTIVE			2001/05/31	COMPANY		HENQUE 3198	23
7	LIMPOPO OFFICE	27084556	836	ACTIVE			2006/08/23	COMPANY		ZELPY 2604	07
7	LIMPOPO OFFICE	27085911	836	ACTIVE	27/2/1/A50C/KR464/0		2007/07/03	COMPANY		STAR CHOICE TRADIN	07
7	LIMPOPO OFFICE	27020330	836	ACTIVE	27/2/1/A50A/KR261/0		2001/05/31	COMPANY		KNS BELEGGINGS	07
7	LIMPOPO OFFICE	27023097	836	ACTIVE			2001/06/07	INDIVIDUAL	MR	CJ MULLER	
7	LIMPOPO OFFICE	27048105	836	ACTIVE			2001/08/03	COMPANY		J D BELEGGINGS TRU	XY
7	LIMPOPO OFFICE	27023159	836	ACTIVE			2001/06/07	INDIVIDUAL	MR	WSJ LOUW	
7	LIMPOPO OFFICE	27023346	836	ACTIVE			2001/07/20	COMPANY		SNYSPRUIT	23
7	LIMPOPO OFFICE	27020303	836	ACTIVE			2001/05/31	INDIVIDUAL	MR	CJ MULLER	
7	LIMPOPO OFFICE	27072514	836	ACTIVE			2002/02/28	COMPANY		NUA RANCH	07
7	LIMPOPO OFFICE	27072523	836	ACTIVE			2002/02/28	COMPANY		LOBETAL RANCH	07
7	LIMPOPO OFFICE	27072319	836	ACTIVE	27/2/1/A50B/KR46/1		2002/01/29	COMPANY		THULAMELA SAFARIS	07
7	LIMPOPO OFFICE	27020303	836	ACTIVE			2001/05/31	INDIVIDUAL	MR	CJ MULLER	
7	LIMPOPO OFFICE	27072328	836	ACTIVE	27/2/1/A50B/KR45/3		2002/01/29	COMPANY		THULAMELA SAFARIS	07
7	LIMPOPO OFFICE	27072523	836	ACTIVE			2002/02/28	COMPANY		LOBETAL RANCH	07
7	LIMPOPO OFFICE	27020385	836	ACTIVE			2001/09/20	COMPANY		CHARLES BABER TRU	XY

7	LIMPOPO OFFICE	27024755	836	ACTIVE			2001/06/20	COMPANY		JANETSI	07
7	LIMPOPO OFFICE	27086643	836	ACTIVE			2007/10/30	COMPANY		DEER PARK ESTATES	07
7	LIMPOPO OFFICE	27036528	836	ACTIVE			2001/09/25	NATIONAL DEPARTMENT		LIMPOPO-TZANEEN A	
7	LIMPOPO OFFICE	27023658	836	ACTIVE			2001/06/18	COMPANY		KNAPSAK BELEGGIN	07
7	LIMPOPO OFFICE	27002323	836	ACTIVE			2001/03/05	COMPANY		J.M. DU TOIT BOERD	07
7	LIMPOPO OFFICE	27002733	836	ACTIVE			2001/09/19	COMPANY		DELHI BOERDERY	07
7	LIMPOPO OFFICE	27023765	836	ACTIVE			2001/09/25	COMPANY		BELIELE	07
7	LIMPOPO OFFICE	27023881	836	ACTIVE			2001/06/18	COMPANY		BELIELE	07
7	LIMPOPO OFFICE	27023890	836	ACTIVE			2001/06/18	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27024096	836	ACTIVE			2001/06/19	INDIVIDUAL	MR	T KRUGER	
7	LIMPOPO OFFICE	27024112	836	ACTIVE			2001/06/19	COMPANY		KLEYNHANS ONDERN	07
7	LIMPOPO OFFICE	27024577	836	ACTIVE			2001/06/20	COMPANY		R MAAL VIER BOERDI	23
7	LIMPOPO OFFICE	27025200	836	ACTIVE			2001/06/21	INDIVIDUAL	MR	JC KOEKEMOER	
7	LIMPOPO OFFICE	27026913	836	ACTIVE			2001/06/27	INDIVIDUAL	MR	H VAN DYK	
7	LIMPOPO OFFICE	27026968	836	ACTIVE			2001/06/27	INDIVIDUAL	MR	WJ VAN DYK	
7	LIMPOPO OFFICE	27027020	836	ACTIVE			2001/06/27	INDIVIDUAL	MR	WA BROWN	
7	LIMPOPO OFFICE	27027066	836	ACTIVE			2001/06/28	COMPANY		LUCAS MCLEAN FAM	XY
7	LIMPOPO OFFICE	27028582	836	ACTIVE			2001/07/10	COMPANY		B J VORSTER	07
7	LIMPOPO OFFICE	27028699	836	ACTIVE			2001/09/19	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27028760	836	ACTIVE	27/2/1/B81E/LT564/15		2001/09/19	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27034307	836	ACTIVE			2001/07/11	INDIVIDUAL	MR	WD THOMPSON	
7	LIMPOPO OFFICE	27034316	836	ACTIVE			2001/07/11	COMPANY		GCL FAMILIE TRUST	XY
7	LIMPOPO OFFICE	27023514	836	ACTIVE			2001/06/18	INDIVIDUAL	MR	JE TOLMAY	
7	LIMPOPO OFFICE	27028582	836	ACTIVE			2001/07/10	COMPANY		B J VORSTER	07
7	LIMPOPO OFFICE	27023872	836	ACTIVE			2001/06/18	COMPANY		NAGUDE BOERDERY	07
7	LIMPOPO OFFICE	27023943	836	ACTIVE			2001/06/18	COMPANY		PGA VORSTER	07
7	LIMPOPO OFFICE	27026995	836	ACTIVE			2001/06/27	INDIVIDUAL	MR	JH BENCH	
7	LIMPOPO OFFICE	27023621	836	ACTIVE			2001/06/18	COMPANY		BUITENDAG FAMILIE	XY
7	LIMPOPO OFFICE	27023649	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023649	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023676	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023783	836	ACTIVE			2001/06/18	INDIVIDUAL	MR	JJ DE NYSSCHEN	
7	LIMPOPO OFFICE	27024773	836	ACTIVE			2001/06/20	COMPANY		DE NYSSCHEN BROEF	23
7	LIMPOPO OFFICE	27024540	836	ACTIVE			2001/06/20	INDIVIDUAL	MR	MS MARAIS	
7	LIMPOPO OFFICE	27023747	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27024620	836	ACTIVE			2001/06/20	INDIVIDUAL	MR	PJH DU PLESSIS	
7	LIMPOPO OFFICE	27086643	836	ACTIVE			2007/10/30	COMPANY		DEER PARK ESTATES	07
7	LIMPOPO OFFICE	27028635	836	ACTIVE			2001/09/19	COMPANY		ROBA LANDGOED	07
7	LIMPOPO OFFICE	27002733	836	ACTIVE			2001/09/19	COMPANY		DELHI BOERDERY	07
7	LIMPOPO OFFICE	27023756	836	ACTIVE			2001/06/18	COMPANY		BELIELE	07
7	LIMPOPO OFFICE	27023774	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27023881	836	ACTIVE			2001/06/18	COMPANY		BELIELE	07
7	LIMPOPO OFFICE	27023890	836	ACTIVE			2001/06/18	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27024096	836	ACTIVE			2001/06/19	INDIVIDUAL	MR	T KRUGER	
7	LIMPOPO OFFICE	27024112	836	ACTIVE			2001/06/19	COMPANY		KLEYNHANS ONDERN	07
7	LIMPOPO OFFICE	27024568	836	ACTIVE			2001/06/20	COMPANY		KAIMANDIA	XY
7	LIMPOPO OFFICE	27025139	836	ACTIVE			2001/06/20	INDIVIDUAL	MR	AWA DUVENHAGE	
7	LIMPOPO OFFICE	27025228	836	ACTIVE			2001/06/21	INDIVIDUAL	MR	CMV DU TOIT	
7	LIMPOPO OFFICE	27027066	836	ACTIVE			2001/06/28	COMPANY		LUCAS MCLEAN FAM	XY
7	LIMPOPO OFFICE	27028699	836	ACTIVE			2001/09/19	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27028742	836	ACTIVE			2001/07/03	COMPANY		PLAAS EUREKA 564	07
7	LIMPOPO OFFICE	27034307	836	ACTIVE			2001/07/11	INDIVIDUAL	MR	WD THOMPSON	
7	LIMPOPO OFFICE	27034325	836	ACTIVE			2001/07/11	COMPANY		HENDRIK J ZIETSMAN	07
7	LIMPOPO OFFICE	27023667	836	ACTIVE			2001/06/18	COMPANY		GROEP 91 UITVOER	07
7	LIMPOPO OFFICE	27002323	836	ACTIVE			2001/03/05	COMPANY		J.M. DU TOIT BOERD	07
7	LIMPOPO OFFICE	27028699	836	ACTIVE			2001/09/19	COMPANY		BOSVELD SITRUS	07
7	LIMPOPO OFFICE	27023872	836	ACTIVE			2001/06/18	COMPANY		NAGUDE BOERDERY	07
7	LIMPOPO OFFICE	27023943	836	ACTIVE			2001/06/18	COMPANY		PGA VORSTER	07
7	LIMPOPO OFFICE	27027057	836	ACTIVE			2001/06/28	INDIVIDUAL	MR	JH DE LA REY	
7	LIMPOPO OFFICE	27033433	836	ACTIVE	27/2/1/B81E/LT659/0		2001/08/16	INDIVIDUAL	MR	JH DE LA REY	
7	LIMPOPO OFFICE	27024014	836	ACTIVE			2001/06/19	COMPANY		DU ROI	XY
7	LIMPOPO OFFICE	27085822	836	ACTIVE			2007/06/20	COMPANY		KUNO VENTER FAMIL	XY
7	LIMPOPO OFFICE	27033941	836	ACTIVE			2001/07/11	COMPANY		TASK BOERDERY	07
7	LIMPOPO OFFICE	27033576	836	ACTIVE			2001/07/11	COMPANY		SCHEEPERS TRUST	XY
7	LIMPOPO OFFICE	27033610	836	ACTIVE			2001/07/11	COMPANY		PETRUS MINNAAR	XY
7	LIMPOPO OFFICE	27034352	836	ACTIVE			2001/09/19	COMPANY		MIAMI CANNERS	23
7	LIMPOPO OFFICE	27033610	836	ACTIVE			2001/07/11	COMPANY		PETRUS MINNAAR	XY
7	LIMPOPO OFFICE	27033905	836	ACTIVE			2001/07/11	COMPANY		MANHARU BOERDER	07
7	LIMPOPO OFFICE	27034101	836	ACTIVE	27/2/1/B81F/LT727/0		2001/11/01	INDIVIDUAL	MR	EC LANDMAN	
7	LIMPOPO OFFICE	27034129	836	ACTIVE			2001/07/11	COMPANY		LA PARISA PRODUKT	23
7	LIMPOPO OFFICE	27036430	836	ACTIVE			2001/09/25	COMPANY		H D L EIENDOMME	07
7	LIMPOPO OFFICE	27036494	836	ACTIVE			2001/07/16	COMPANY		NOUVELLE-LACOTT	07
7	LIMPOPO OFFICE	27036608	836	ACTIVE			2001/09/18	COMPANY		FARM CHESTER	23
7	LIMPOPO OFFICE	27033656	836	ACTIVE			2001/07/11	COMPANY		SC WIID BOERDERY	07
7	LIMPOPO OFFICE	27033576	836	ACTIVE			2001/07/11	COMPANY		SCHEEPERS TRUST	XY
7	LIMPOPO OFFICE	27036494	836	ACTIVE			2001/07/16	COMPANY		NOUVELLE-LACOTT	07
7	LIMPOPO OFFICE	27033941	836	ACTIVE			2001/07/11	COMPANY		TASK BOERDERY	07
7	LIMPOPO OFFICE	27034138	836	ACTIVE			2001/07/11	COMPANY		LOMPIES KWEKERYE	07
7	LIMPOPO OFFICE	27033558	836	ACTIVE			2001/07/11	COMPANY		PLAAS CONSTANTIA (	07
7	LIMPOPO OFFICE	27033709	836	ACTIVE			2001/07/11	COMPANY		PETRUS MINNAAR	XY
7	LIMPOPO OFFICE	27034058	836	ACTIVE			2001/07/11	COMPANY		LETABA DRIFT TRUST	XY
7	LIMPOPO OFFICE	27034101	836	ACTIVE	27/2/1/B81F/LT727/0		2001/11/01	INDIVIDUAL	MR	EC LANDMAN	
7	LIMPOPO OFFICE	27034129	836	ACTIVE			2001/07/11	COMPANY		LA PARISA PRODUKT	23
7	LIMPOPO OFFICE	27036430	836	ACTIVE			2001/09/25	COMPANY		H D L EIENDOMME	07
7	LIMPOPO OFFICE	27036608	836	ACTIVE			2001/09/18	COMPANY		FARM CHESTER	23
7	LIMPOPO OFFICE	27036608	836	ACTIVE			2001/09/18	COMPANY		FARM CHESTER	23
7	LIMPOPO OFFICE	27032853	836	ACTIVE			2001/09/25	COMPANY		HENLEY	XY
7	LIMPOPO OFFICE	27034138	836	ACTIVE			2001/07/11	COMPANY		LOMPIES KWEKERYE	07
7	LIMPOPO OFFICE	27030338	836	ACTIVE			2001/11/02	NATIONAL DEPARTMENT		DEPARTMENT OF AGI	
7	LIMPOPO OFFICE	27038170	836	ACTIVE			2001/07/17	NATIONAL DEPARTMENT		DEPARTMENT OF AGI	
7	LIMPOPO OFFICE	27036421	836	ACTIVE			2001/09/25	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27077332	836	ACTIVE	27/2/2/B81G/LT424/0/MADJADJES LOCA		2002/10/15	WATER SERVICES PROVIDER		LEPELLE NORTHERN	
7	LIMPOPO OFFICE	27025264	836	ACTIVE			2001/06/21	COMPANY		MAMRE BOERDERY	07
7	LIMPOPO OFFICE	27025264	836	ACTIVE			2001/06/21	COMPANY		MAMRE BOERDERY	07
7	LIMPOPO OFFICE	27027681	836	ACTIVE			2001/10/09	COMPANY		KOEDOESRIVIER BOE	07
7	LIMPOPO OFFICE	27000405	836	ACTIVE			2001/10/01	COMPANY		KLIPDRIFT TRUST	XY
7	LIMPOPO OFFICE	27026986	836	ACTIVE			2001/06/27	COMPANY		MATOMAHOEK BOER	07
7	LIMPOPO OFFICE	27000726	836	ACTIVE			2001/09/19	COMPANY		MOOKETSI PLASE BES	XY
7	LIMPOPO OFFICE	27087973	836	ACTIVE			2009/08/19	COMPANY		WESTFALIA FRUIT ES	07
7	LIMPOPO OFFICE	27000398	836	ACTIVE			2001/09/19	COMPANY		DIE PLAAS STYLDRIFT	07

7	LIMPOPO OFFICE	27000897	836	ACTIVE			2001/09/27	INDIVIDUAL	MS	MR SHORT	
7	LIMPOPO OFFICE	27024274	836	ACTIVE			2001/06/19	COMPANY		BOSCHPLAATS BOER	07
7	LIMPOPO OFFICE	27025317	836	ACTIVE			2001/09/25	COMPANY		GROOTBOOM BOERD	07
7	LIMPOPO OFFICE	27027627	836	ACTIVE			2001/09/26	COMPANY		BERTIE VAN ZYL TRUS	XY
7	LIMPOPO OFFICE	27027869	836	ACTIVE			2001/06/29	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27027985	836	ACTIVE			2001/09/27	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27034539	836	ACTIVE			2001/07/12	COMPANY		IL POGGIO FARM	07
7	LIMPOPO OFFICE	27037046	836	ACTIVE			2001/09/25	COMPANY		REIN NOFFKE	07
7	LIMPOPO OFFICE	27037402	836	ACTIVE			2001/09/25	COMPANY		REIN NOFFKE	07
7	LIMPOPO OFFICE	27009905	836	ACTIVE			2001/11/01	INDIVIDUAL	MR	MM POHL	
7	LIMPOPO OFFICE	27024176	836	ACTIVE			2001/06/19	COMPANY		DONKERVAL BOERDE	07
7	LIMPOPO OFFICE	27000502	836	ACTIVE			2001/02/08	INDIVIDUAL	MR	APC COETZEE	
7	LIMPOPO OFFICE	27001182	836	ACTIVE			2001/09/19	INDIVIDUAL	MR	AG SHORT	
7	LIMPOPO OFFICE	27027850	836	ACTIVE			2001/06/29	COMPANY		CLEMENTE BERETTA	07
7	LIMPOPO OFFICE	27001182	836	ACTIVE			2001/09/19	INDIVIDUAL	MR	AG SHORT	
7	LIMPOPO OFFICE	27027716	836	ACTIVE			2001/10/01	COMPANY		KOEDOESRIVIER BOE	07
7	LIMPOPO OFFICE	27027592	836	ACTIVE			2001/09/26	COMPANY		BERTIE VAN ZYL	XY
7	LIMPOPO OFFICE	27088008	836	ACTIVE			2009/09/10	COMPANY		HANS MERENSKY HO	07
7	LIMPOPO OFFICE	27000352	836	ACTIVE			2001/02/05	INDIVIDUAL	MR	GH EMMERICH	
7	LIMPOPO OFFICE	27000398	836	ACTIVE			2001/09/19	COMPANY		DIE PLAAS STYLDRIFT	07
7	LIMPOPO OFFICE	27000628	836	ACTIVE			2001/11/15	INDIVIDUAL	MR	MM POHL	
7	LIMPOPO OFFICE	27025326	836	ACTIVE			2001/06/21	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27026922	836	ACTIVE			2001/10/10	COMPANY		MATOMAHOEK BOER	07
7	LIMPOPO OFFICE	27026977	836	ACTIVE			2001/09/27	COMPANY		MATOMAHOEK BOER	07
7	LIMPOPO OFFICE	27027556	836	ACTIVE			2001/06/28	COMPANY		BERTIE VAN ZYL	XY
7	LIMPOPO OFFICE	27027985	836	ACTIVE			2001/09/27	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27034539	836	ACTIVE			2001/07/12	COMPANY		IL POGGIO FARM	07
7	LIMPOPO OFFICE	27037224	836	ACTIVE			2001/07/16	COMPANY		MANORVLEI FARM	07
7	LIMPOPO OFFICE	27000405	836	ACTIVE			2001/10/01	COMPANY		KLIPDRIFT TRUST	XY
7	LIMPOPO OFFICE	27026227	836	ACTIVE			2001/09/25	COMPANY		GROOTBOOM BOERD	07
7	LIMPOPO OFFICE	27026904	836	ACTIVE			2001/10/10	COMPANY		MATOMAHOEK BOER	07
7	LIMPOPO OFFICE	27037297	836	ACTIVE			2001/07/16	COMPANY		REIN NOFFKE	07
7	LIMPOPO OFFICE	27038303	836	ACTIVE			2001/09/18	COMPANY		VENTECO	07
7	LIMPOPO OFFICE	27028001	836	ACTIVE			2001/07/04	COMPANY		BERTIE VAN ZYL	07
7	LIMPOPO OFFICE	27037322	836	ACTIVE			2001/09/25	COMPANY		REIN NOFFKE	07
7	LIMPOPO OFFICE	27038376	836	ACTIVE			2001/07/17	WATER SERVICES PROVIDER		GREATER LETABA MU	
7	LIMPOPO OFFICE	27000539	836	ACTIVE			2001/02/08	INDIVIDUAL	MS	GS POHL	
7	LIMPOPO OFFICE	27000986	836	ACTIVE			2001/02/22	COMPANY		WHITE BAT ESTATES	07
7	LIMPOPO OFFICE	27001459	836	ACTIVE			2001/03/08	COMPANY		ROOIBOK NATUURRE	23
7	LIMPOPO OFFICE	27024354	836	ACTIVE			2001/06/19	COMPANY		CLEMENTE BERETTA	07
7	LIMPOPO OFFICE	27027976	836	ACTIVE			2001/06/29	COMPANY		SM POHL	07
7	LIMPOPO OFFICE	27034478	836	ACTIVE			2001/07/12	INDIVIDUAL	MR	JGT DICKE	
7	LIMPOPO OFFICE	27000922	836	ACTIVE			2001/09/27	COMPANY		WINTER FAMILIE TRU	XY
7	LIMPOPO OFFICE	27000548	836	ACTIVE			2001/02/26	COMPANY		PIETER DUVENHAGE	XY
7	LIMPOPO OFFICE	27000959	836	ACTIVE			2001/02/21	COMPANY		MONTINA TRUST	XY
7	LIMPOPO OFFICE	27000986	836	ACTIVE			2001/02/22	COMPANY		WHITE BAT ESTATES	07
7	LIMPOPO OFFICE	27001226	836	ACTIVE			2001/07/02	COMPANY		ROOIBOK NATUURRE	23
7	LIMPOPO OFFICE	27024354	836	ACTIVE			2001/06/19	COMPANY		CLEMENTE BERETTA	07
7	LIMPOPO OFFICE	27026851	836	ACTIVE			2001/06/27	COMPANY		RIETRIVIER BOERDER	07
7	LIMPOPO OFFICE	27027921	836	ACTIVE			2001/10/10	COMPANY		RIETRIVIER BOERDER	07
7	LIMPOPO OFFICE	27000986	836	ACTIVE			2001/02/22	COMPANY		WHITE BAT ESTATES	07
7	LIMPOPO OFFICE	27000931	836	ACTIVE			2001/09/19	COMPANY		PIETER DUVENAGE TI	XY
7	LIMPOPO OFFICE	27027903	836	ACTIVE			2001/06/29	COMPANY		BERTIE VAN ZYL	07
7	LIMPOPO OFFICE	27026753	836	ACTIVE			2001/06/27	INDIVIDUAL	MR	PJ VAN ZYL	
7	LIMPOPO OFFICE	27026771	836	ACTIVE			2001/07/10	INDIVIDUAL	MR	PJ VAN ZYL	
7	LIMPOPO OFFICE	27086607	836	ACTIVE	27/2/1/LT97/0/B82D		2007/10/27	NATIONAL DEPARTMENT		DEPARTMENT OF WA	
7	LIMPOPO OFFICE	27026717	836	ACTIVE			2001/06/27	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27026682	836	ACTIVE			2001/06/27	COMPANY		PAARDEDOOD BOER	07
7	LIMPOPO OFFICE	27004205	836	ACTIVE	27/2/1/B82E/LS1177/0		2001/03/13	INDIVIDUAL	MR	JHP BOTHA	
7	LIMPOPO OFFICE	27004205	836	ACTIVE	27/2/1/B82E/LS1177/0		2001/03/13	INDIVIDUAL	MR	JHP BOTHA	
7	LIMPOPO OFFICE	27030123	836	ACTIVE	27/2/2/B83A/LU0/0/KRUGER NATIONAL I		2001/09/21	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27030123	836	ACTIVE	27/2/2/B83A/LU0/0/KRUGER NATIONAL I		2001/09/21	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27030123	836	ACTIVE	27/2/2/B83A/LU0/0/KRUGER NATIONAL I		2001/09/21	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27030123	836	ACTIVE	27/2/2/B83A/LU0/0/KRUGER NATIONAL I		2001/09/21	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27030123	836	ACTIVE	27/2/2/B83A/LU0/0/KRUGER NATIONAL I		2001/09/21	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27072382	836	ACTIVE	27/2/2/B83A/MU0/0		2002/02/07	COMPANY		SOUTH AFRICAN NAT	XX
7	LIMPOPO OFFICE	27029992	836	ACTIVE			2001/09/12	NATIONAL DEPARTMENT		DEPARTMENT OF AG	
7	LIMPOPO OFFICE	27032229	836	ACTIVE	27/2/1/B90F/LT206/0/SHINGWIDZI DAM		2001/07/09	PROVINCIAL DEPARTMENT		LIMPOPO DEPARTME	

APPENDIX D: RISK ASSESSMENT TABLE

	Activities with Environmental Impacts	Focus Area	Impacts before Mitigation							Recommended Mitigation Measures	Intervention	Impacts after Mitigation							Action Plan / Intervention
			Extent	Duration	Intensity	Probability	Impact	Desirability	Risk Rating			Extent	Duration	Intensity	Probability	Impact	Desirability	Risk Rating	
	Issues related to Surface Water																		
> +12	Construction Phase																		
> +9	Separation of clean and dirty water areas: Clean water runoff from areas outside the dirty water footprint area of the mine could flow into this area and potentially become polluted.	SWMP	3	4	3	4	14	-	-14	Divert all clean water resources away from dirty water areas	Designed diversion works	3	3	2	2	10	-	-10	Design of and construction of diversion works with regular inspections and reporting
> +6	Seepage to surface water (and groundwater) resources from the ash dump.	EMP	4	4	2	4	14	-	-14	Classification of waste, salts and other polutants will influence design parameters for the dump and lead to recommendations with regards to design, lining, filtration and monitoring requirements.	Design criteria	3	4	1	2	10	-	-10	Professional design
+	Vegetation and topsoil cleared from building sites and roadways could obstruct natural drainage, divert clean water into dirty water areas, cause waterlogging of adjacent areas or pollute water resources	SWMP	4	4	3	4	15	-	-15	Place all removed/excavated vegetation and topsoil in demarkated overburden stockpile areas to prevent obstruction of natural drainage paths	Specified measures	3	3	2	2	10	-	-10	Quality control monitoring
N	Soil disturbance could cause siltation of the surface water resource during soil turning activities.	SWMP	1	2	2	4	9	-	-9	Divert all clean water resources away from dirty water areas prior to construction and compact the base of working areas	Specified measures	1	1	2	2	6	-	-6	Quality control monitoring
-	Slopes could significantly contibute to erosion and siltation during the construction phase.	Construction management	2	4	2	4	12	-	-12	Contractors shall maintain safe working soil slopes and other erosion protection measures to prevent eroson and the deposits of silt into watercourses	Specified measures	1	3	2	3	9	-	-9	Quality control monitoring
> - 6	Builders rubble, packaging and other waste generated in the construction process could become a source of pollution for water	Construction management	3	3	3	3	12	-	-12	Builders' contracts should stipulate the appropriate storage and removal of builders' waste	Specified measures	2	1	2	2	7	-	-7	Quality control monitoring

> -9	Fuels and/or toxic materials could be spilled and pollute local water resources	Waste Management	4	3	2	4	13	-	-13	Appropriate design of facilities to handle fuels and toxic waste. Specified waste handling procedures	Specified measures and design	3	3	2	1	9	-	-9	Design
> -12	Seepage to surface water resources from waste disposal areas.	SWMP	1	3	3	3	10	-	-10	Design drains to capture and transport water to pollution control dams	Monitoring and remediation	1	2	2	2	7	-	-7	Design
	Runoff from workshops and washbays could be contaminated with hydrocarbons	SWMP	2	3	1	4	10	-	-10	Contain runoff and remove hydrocarbons with an oil trap	Specified measures	2	3	2	1	8	-	-6	Design
	Wash water contains heavy silt loads which could settle in pollution control dams and reduce storage capacity	SWMP	2	3	2	3	10	-	-10	Provide a silt trap to contain and allow the removal of sediments	Specified measures	2	3	2	1	8	-	-5	Design
	Operation Phase																		
	Large quantities of runoff and seepage from the ash dump will exceed storage capacities and spill into the environment	SWMP	4	4	2	4	14	-	-14	Sizing of polution control dams - Design to accepted standards and norms	Design criterion	3	3	1	1	10	-	-10	Design and comissioning by professional engineer, with ongoing monitoring of volumes and water quality
	Decomissioning/Rehabilitation/Closure Phases																		
	Rubble and waste from site could pollute local water resources	EMP	2	4	2	3	11	-	-11	Waste that is not removed from site should be spread, covered and suitably rehabilitated	Specified measures	2	4	2	1	9	-	-9	Quality control and monitoring
	Runoff and drainage from stockpiles and TSFs continue to yield polluted water	EMP	3	4	3	4	14	-	-14	Stockpiles are spread and surfaces rehabilitated, the surfaces of TSFs are rehabilitated drains and return water dams are maintained and water transferred to a pollution control dam	Specified measures	3	4	1	2	10	-	-10	Monitoring of processes
	Continued flows of polluted water from mine drainage and TSFs	EMP	2	4	3	4	13	-	-13	A pollution control dam or treatment works that safely contains or treats water continues to function	Design criterion	2	4	1	1	8	-	-8	Contingency plan