HYDROLOGY ASSESSMENT FOR THE BUSHVELD CHROME MINE - STEELPOORT

Prepared For: Environmental Management Assistance (Pty) Ltd

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HYDROLOGY ASSESSMENT FOR THE BUSHVELD CHROME MINE - STEELPOORT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

HYDROLOGY ASSESSMENT FOR THE BUSHVELD CHROME MINE- STEELPOORT

1 INTRODUCTION

1.1 BACKGROUND

Highlands Hydrology (Pty) Ltd have been appointed by Environmental Management Assistance (Pty) Ltd to undertake a hydrological assessment for the proposed Bushveld Chrome Mine (Opencast) located near Steelpoort, in the Limpopo Province of South Africa. The investigation has been undertaken to form part of the Environmental Impact Assessment (EIA), associated management plan (EMP), as well as Integrated Water Use License Application (IWULA), to be submitted to the Department of Water and Sanitation (DWS). Figure 1-1 illustrates the regional setting of the proposed project.

1.2 SCOPE OF WORK

The scope of work will be achieved through the following:

- Baseline Assessment - The sourcing of appropriate rainfall data, site-specific rainfall depth/duration/frequency analysis as well as a regional and local hydrological assessment;
- Site examination – This helps to provide a better understanding of the dominant hydrological flow regimes at the site as well as help provide input for flood hydrology calculations;
- Mean Annual Runoff - This helps to quantify the impact of reduced runoff at a quaternary catchment level;
- Flood Assessment – This includes flood hydrology calculations for affected catchments for both the 1:50 and 1:100 year return periods for main streams which bisect the site as well as the adoption of 100m buffers;
- Conceptual Stormwater Management Plan - This is based on South African best practice guidance and conceptualized through mapping and indicative design drawings;
- Surface Water Sampling – This includes the monitoring of surrounding surface water to obtain an appropriate baseline. This will assist in quantifying the potential impact the operation has on receiving water resources over time;
- Static Water Balance - This is developed for average wet and dry seasons based on monthly input data; and
- A technical report detailing the achieved scope of work.

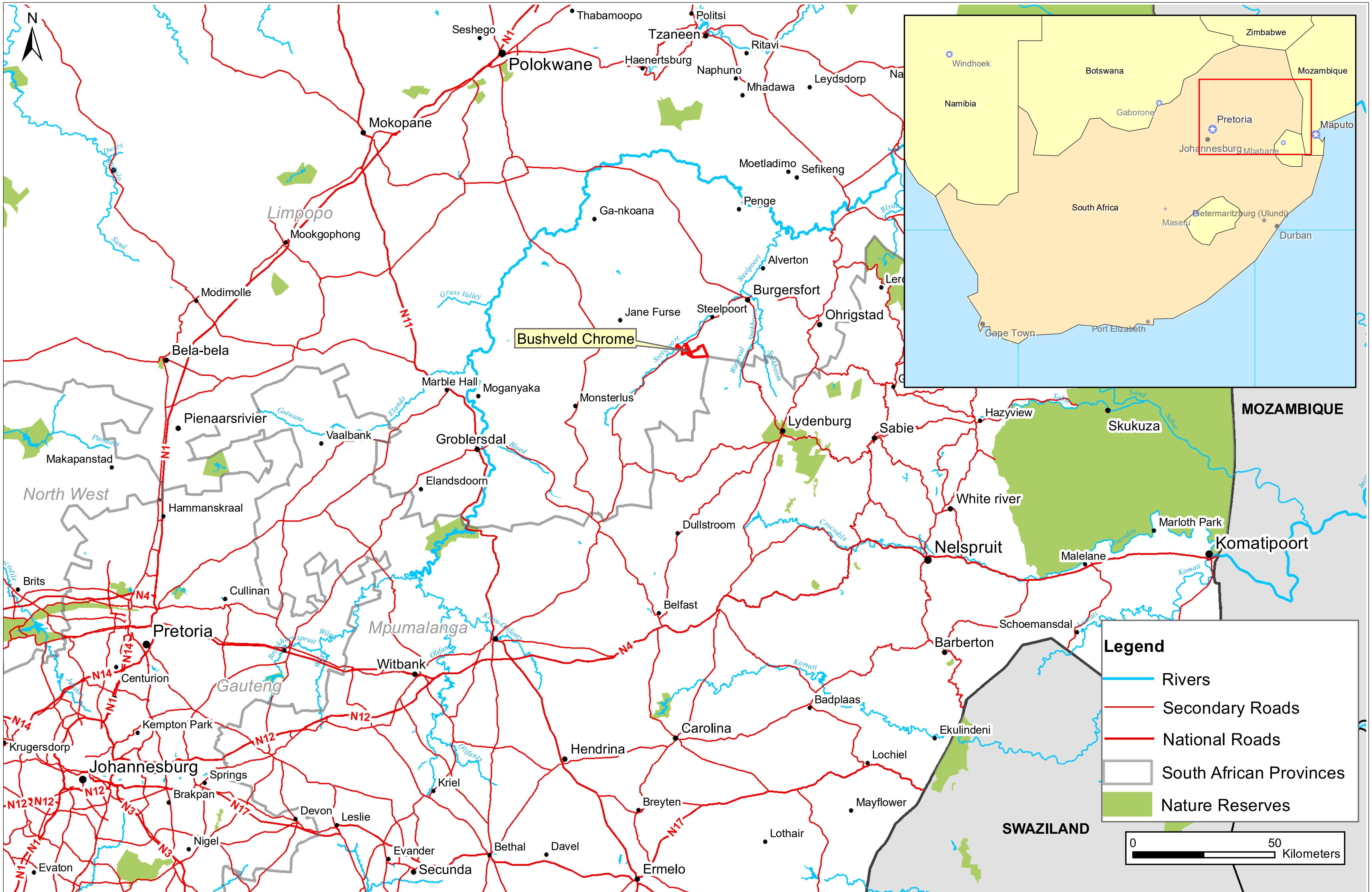

Figure 1-1 Regional Setting

1.3 SITE LAYOUT

Figure 1-2 presents the site layout. The full boundary of the site (henceforth 'the site') extends to include farm portions 'Kennedy's Vale 361 KT' and Spitskop 333 KT'. As illustrated by the figure, proposed site infrastructure is however, limited to a portion of the site, and exclude much of the western farm portion, 'Kennedy's Vale 361 KT' (being limited to the eastern end of the farm potion). Immediately south of the more concentrated area of proposed site infrastructure is the Samancor Chrome, Klarinet operation. This is an independent operation not associated with this study despite its proximity to the proposed Bushveld Chrome Mine.

The proposed layout for the Bushveld Chrome Mine is primarily comprised of opencast areas, stockpiles and roads. Support infrastructure such as a weigh bridge, offices, and workshops are also proposed. No processing of the excavated ore is intended on site and a processing plant is consequently not proposed.

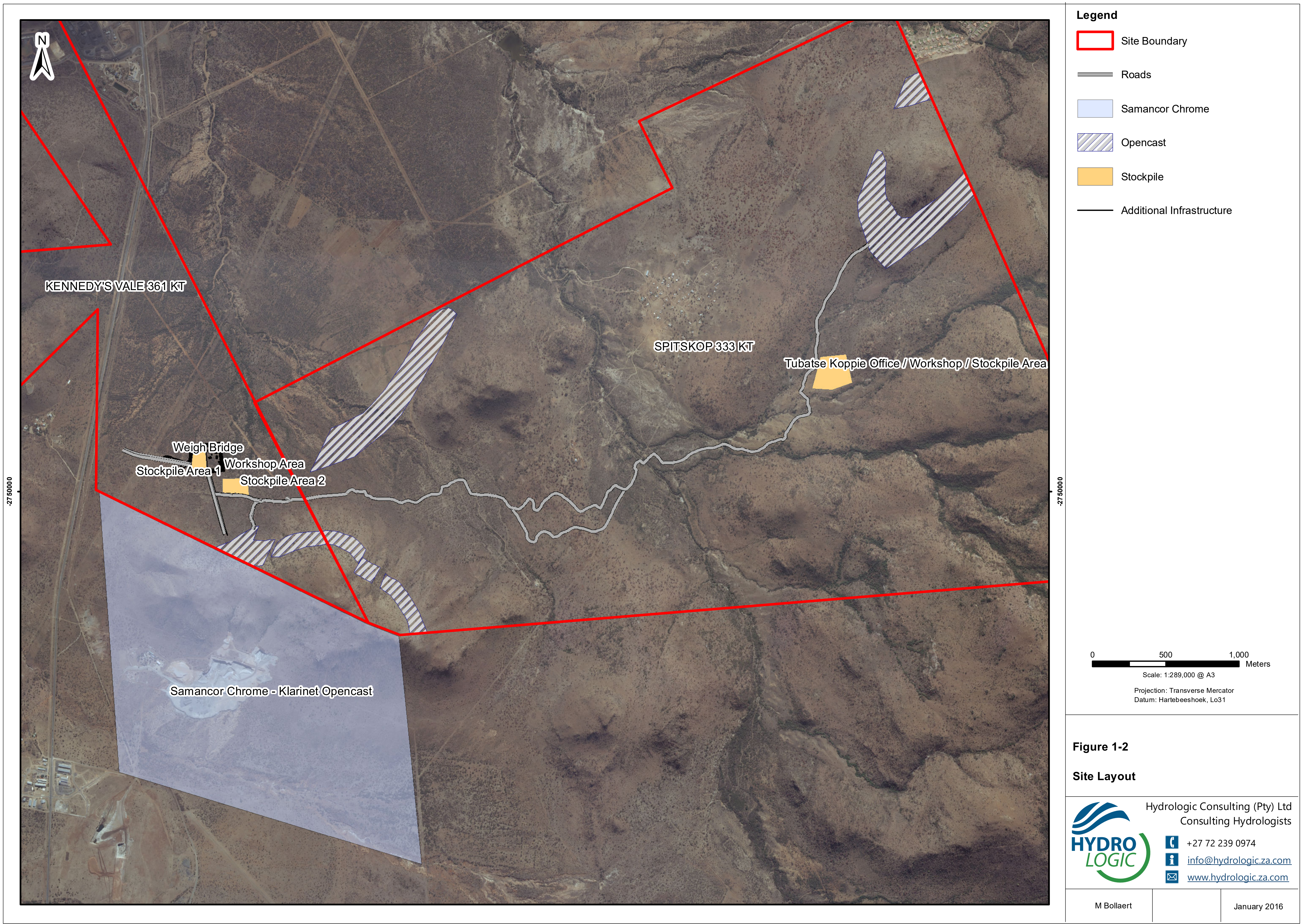

Figure 1-2

Site Layout

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2 BASELINE INFORMATION

Baseline information outlined in this section includes discussions on the regional and local catchment hydrology, rainfall, evaporation, as well as extreme event rainfall.

2.1 REGIONAL AND LOCAL CATCHMENT HYDROLOGY

Figure 2-1 illustrates the topographical and hydrological setting of the proposed project within the greater region.

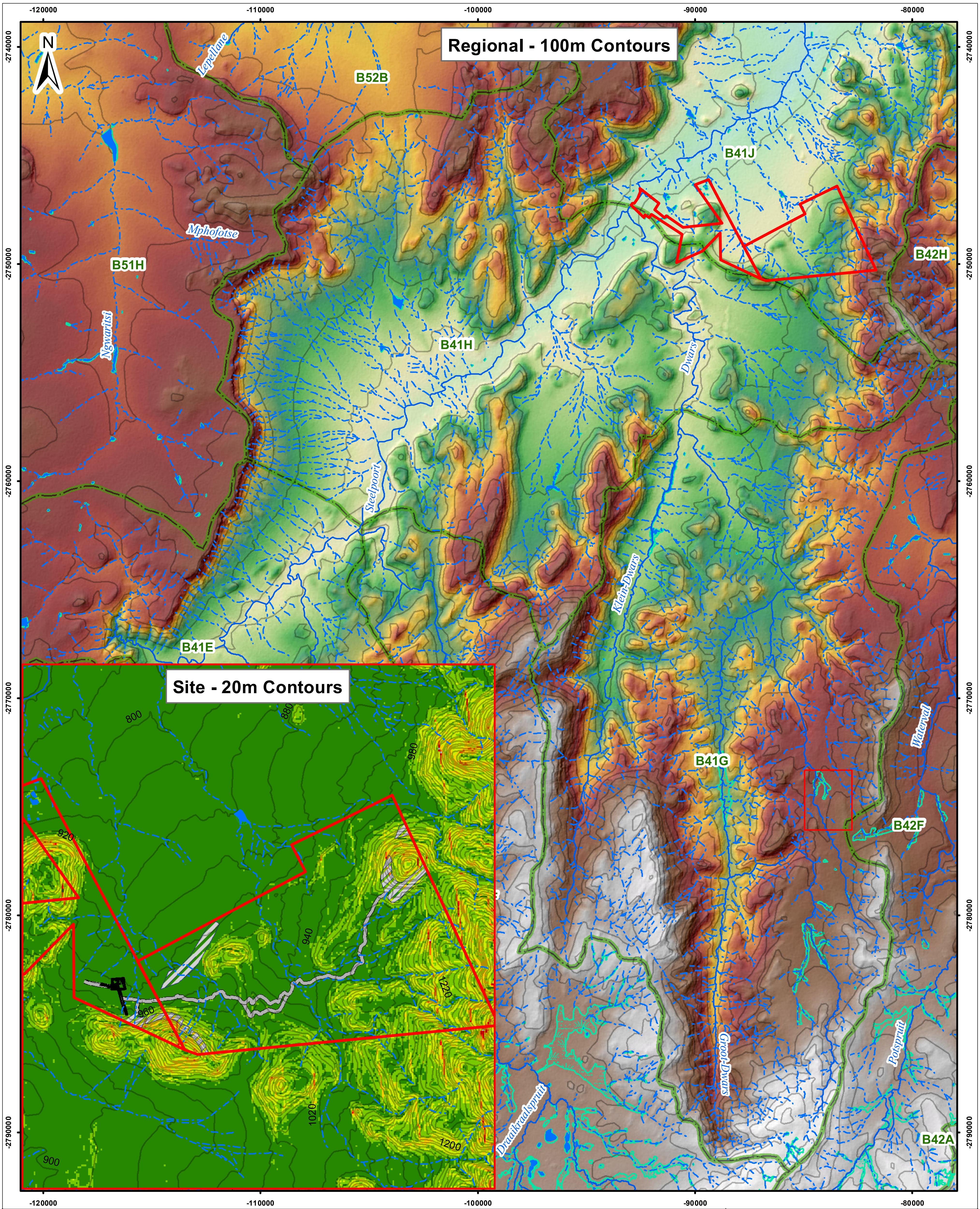
Elevation data was provided for a small extent of the proposed site infrastructure and consequently an alternative source of elevation covering the full site was required. The Shuttle Radar Topography Missing 30m digital elevation model (SRTM30[1]) was consequently used as the source of elevation data for the site. Elevations on site range from approximately 780m AMSL in the west becoming higher to the east, which reaches a maximum elevation of approximately 1600m AMSL. Slopes over the site are mild, becoming steeper in association location of the various hills over the site. Figure 2-1 presents a classification of the percent slope for the site.

The hydrology of the region is characterised by predominately non-perennial watercourses.The prevalence of non-perennial watercourses is due to both the balance of rainfall versus potential evaporation occurring over the year (discussed in Section 2.5) as well as the varied topography of the region. Watercourses within the site boundary are classified as non-perennials flowing only during the wet season or after rainfall events. The 1:50,000 topographic map for the site indicates the presence of a few small dams within the site boundary to the east, while the National Freshwater Ecosystems Priority Areas (NFEPA) map illustrates the presence of fringe wetland areas associated with the dams on the site. Wetlands aside for the few associated with the dams on the site are noted as being uncommon and no wetlands are noted as being within 1km of the proposed site infrastructure.

Two primary perennial rivers bound the western and northern sides of the site, forming the two dominant hydrological boundaries for this study. These two rivers are namely; the Dwars River and the Steelpoort River. The Dwars River is a tributary to the Steelpoort River, which is itself a primary tributary of the Oliphants River that flows into Mozambique at its border with the Kruger National Park.

The site is predominantly situated within quaternary catchment B41J although there is are small portions of the site to the south, which fall into quaternary catchment B41H.

[1] USGS (2014), Shuttle Radar Topography Mission, 1 Arc Second scene SRTM



Legend

- Site Boundary
- Additional Infrastructure
- Roads
- Opencast
- Non-Perennial River (50K)
- Perennial River (50K)
- Dams (50K)
- Wetlands (NFEPA, 2011)

Slope (%)

- < 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- >100

Elevation (SRTM 30m)

(m AMSL)

High : 1691

Low : 765

0 5 Kilometers

Scale: 1:168,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, Lo31

Figure 2-1

Site Topograpy and Hydrology

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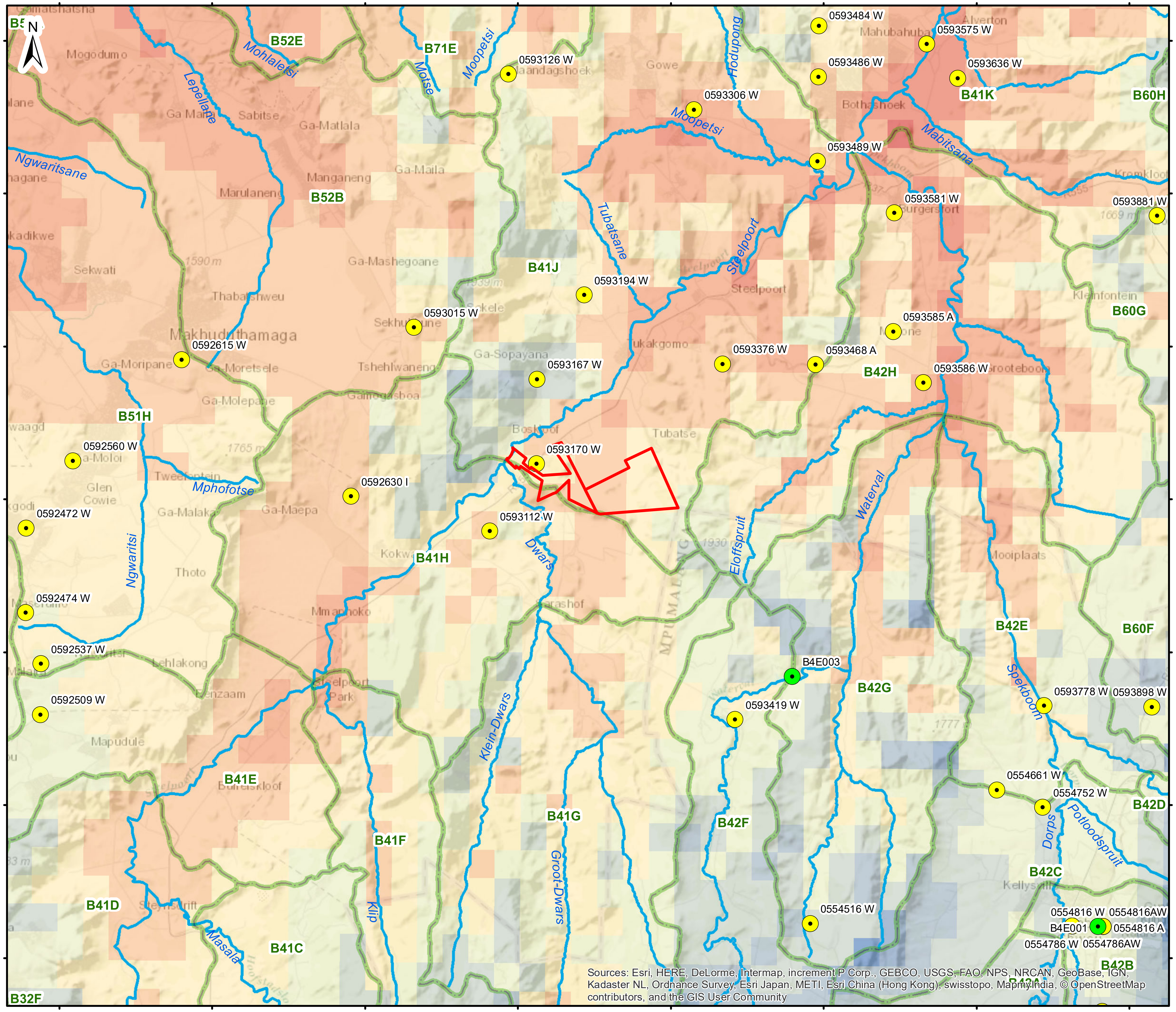
2.2 RAINFALL

Various weather stations managed by both the South African Weather Services (SAWS) and the DWS were considered in this project. These, together with their proximity to site are illustrated in Figure 2-2.

The most appropriate rainfall station due to its location relative to the site is SAWS station 0593170 W. No data is available for this station according to TR102 (Design Rainfall Depths at Selected Stations in South Africa). This was confirmed through correspondence with the SAWS. According to the SAWS, the closest of their stations with reliable data is station 0594075 W located approximately 37km east of the site boundary. Due to the distance of the SAWS station from the site, rainfall data was instead obtained and selected for use in this project from DWS station B4E003 (43 year record from 1973 to 2015), located approximately 13km south-east of the site boundary. This station (B4E003) has a Mean Annual Precipitation (MAP) of 679mm. Table 2-1 provides a summary of the monthly rainfall distribution at this DWS station. Figure 2-2 illustrates the rainfall variability in the greater area. The mean annual precipitation as presented in Table 2-1 corresponds well to the rainfall distribution highlighted in Figure 2-2.

TABLE 2-1: MONTHLY RAINFALL DISTRIBUTION

Month	Rainfall (mm)
Jan	107
Feb	88
Mar	74
Apr	49
May	12
Jun	4
Jul	4
Aug	8
Sep	20
Oct	67
Nov	122
Dec	124
Total	**679**



Legend

Site Boundary

Raingauges

DWAF

SAWS

Quaternary Catchments

Rivers (500K Dataset)

Dams (500K Dataset)

Mean Annual Precipitation (mm)

851 - 900

801 - 850

751 - 800

701 - 750

651 - 700

601 - 650

551 - 600

501 - 550

451 - 500

< 450

5 0 5 Kilometers

Scale: 1:245,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO31

Figure 2-2

Weather Stations and MAP

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2.3 RETURN PERIOD RAINFALL DEPTHS

Design storm estimates for various return periods and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm (RLMA) in conjunction with a Scale Invariance approach to provide site specific estimates of design rainfall (depth, duration and frequency), based on surrounding station records. WRC Report No. K5/1060 provides more detail on the verification and validation of the method.

The design rainfall estimates (24-hour storm) using the above technique have been compared to that obtained in TR102 for the SAWS rainfall station 0594075 W, which uses the MAP for the site and a site location factor in order to determine the design rainfall estimates (Hydrological Research Unit, 1978).

TABLE 2-2: 24-HOUR STORM DEPTHS

Return Period	Rainfall Depth (24 hour)	
	RLMA (Smithers /Schulze)	TR102
2	66	48
5	91	66
10	109	78
20	127	91
50	152	110
100	172	124
200	194	140

In this project, the RLMA technique was selected due to it being based on localised observed data which are specific to the site location and are more conservative for the return period of interest (50-year event).

2.4 EVAPORATION

Evaporation data was sourced for DWS station B4E003 which provided 43 years of Class S-Pan (for 1973 - 2015). This station is located south-west of the site as illustrated in Figure 2-2. Table 2-3 provides a summary of the monthly evaporation distribution (Class S-Pan) at this station.

TABLE 2-3: MONTHLY EVAPORATION DISTRIBUTION (CLASS S-PAN)

Month	Evaporation (mm)
Jan	180
Feb	159
Mar	149
Apr	121
May	108
Jun	92
Jul	99
Aug	123
Sep	154
Oct	172
Nov	165
Dec	170
Total	**1692**

2.5 AVERAGE CLIMATE

Figure 2-3 illustrates the average climate for the site, and the significant difference between rainfall and potential evaporation. This rainfall deficit (to evaporation) is a primary reason for the prevalence of non-perennial watercourses in the region about the site.

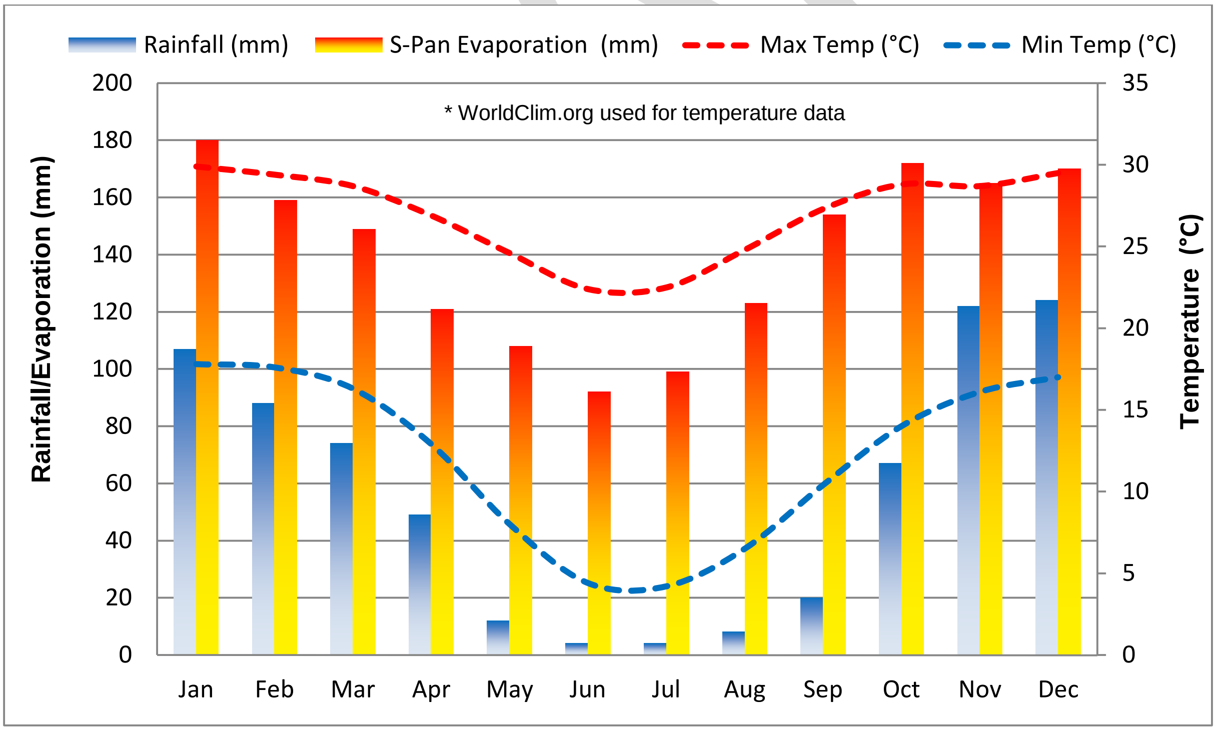

FIGURE 2-3: AVERAGE CLIMATE FOR THE SITE

3 FLOOD BUFFERS AND FLOWS

The development of a flood model for the site is proposed in order to fulfil the requirements of the National Water Act (Act 36 of 1998) and in particular, Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704). The principle condition of GN 704 applicable to this project with regards to flooding is:

- *Condition 4* which defines the area in which mine workings or associated structures may be located with reference to a watercourse and associated flooding. The 50-year floodline and 100 year floodline are used for defining suitable locations for mine workings (prospecting, underground mining or excavations) and associated structures respectively. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for both mine workings and associated infrastructure.

3.1 FLOOD BUFFERS

In this project, floodlines were not modelled due to the limited coverage of supplied elevation data which did not include much of the site. A buffer approach (100m) has however, been adopted in line with the conditions presented in GN 704 for all non-perennial tributaries as defined by the 1:50 000 topographical map sheets (Figure 3-1). These non-perennials are intersected by proposed project infrastructure such as opencast areas, stockpiles and roads. The proposed infrastructure in relation to the streams and associated buffers are presented in Figure 3-1.

As illustrated by Figure 3-1, there is a significant amount of overlap between proposed site infrastructure and the 100m river buffers, with some infrastructure and opencast areas intersecting non-perennial watercourses. These instances will need to be considered during the water use license process (Section 21 c and i). Flood modelling will enable a more accurate understanding of likely flood extents and affected infrastructure and will enable compliance with GN704 insofar as is possible.

River crossings associated with the roads on site have also been illustrated in Figure 3-1 and indicate those points at which culverts or bridges will be required in order to enable conveyance of normal flows and storm flows associated with these crossings. Culverts and bridges should consequently be sufficiently sized to provide capacity to convey the 1 in 100 year flood event over the expected life of the structure in order to minimise impacts and ensure that the natural flow regime can be maintained as far as possible. Culvert/bridge designs did not form part of this current scope but will need to be considered during the detailed design phase prior to construction.

Legend

- Site Boundary
- Contours (20m)
- Crossings
- Dams (50K)
- Non-Perennial River (50K)
- Perennial River (50K)
- 100m River Buffer
- Roads
- Opencast
- Stockpile
- Additional Infrastructure

0 500 1,000 Meters

Scale: 1:22,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, Lo31

Figure 3-1

Flood Buffers and River Crossings

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3.2 PEAK FLOWS AND HYDROGRAPHS

Appendix A presents the outcome of the modelling, undertaken in order to derive peak flows and hydrographs for key points on the site. The results of this modelling have been based upon natural site conditions. The development of the site would affect the modelled estimates due to the containment of flows by opencast areas and dirty water containment facilities. The peak flows and hydrographs that have been derived are of relevance to any future flood modelling as well as the design of any river crossings such as culverts or bridges.

It is important to note, that no allowances for climate change have not been made. A risk analysis using the expected life of a structure or process will indicate the relevance of considering climate change (i.e. as the expected life increases the influence of climate change increases).

Figure 3-2 presents the 1 in 100 year event hydrographs for the two primary catchments on site.

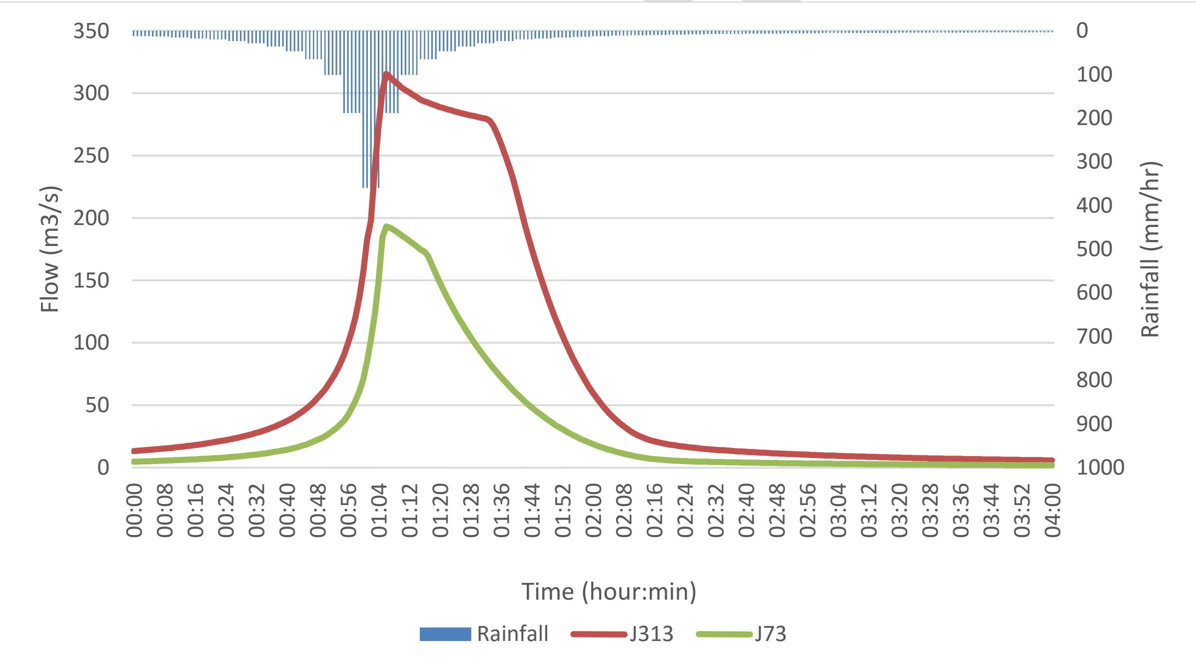


FIGURE 3-2: 100-YEAR EVENT HYDROGRAPHS

4 CONCEPTUAL STORM WATER MANAGEMENT PLAN

The aim of this storm water management plan (SWMP) is to fulfil the requirements presented in Government Notice 704 (Government Gazette 20118 of June 1999) which deals with the separation of clean and dirty water. The conceptual storm water management plan will form a necessary part of the Integrated Water Use License Application (IWULA), to be submitted to the Department of Water and Sanitation (DWS). This storm water management plan also complies with the principles presented in the DWS Best Practice Guideline G1 for Stormwater Management.

4.1 DWAF Government Notice 704

The Department of Water Affairs and Forestry (now the Department of Water and Sanitation), established GN 704 to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation which require understanding.

4.1.1 Important definitions in GN 704

- **Clean water system:** This includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted water.

- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste.

- **Dirty area:** This refers to any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource (i.e. polluted water)

4.1.2 Applicable conditions in GN 704

The principle conditions of GN 704 applicable to the development of a SWMP for the site are:

- *Condition 5* indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure.
- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these systems do not spill into each other more than once in 50 years.

- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which cause or are likely to cause pollution of a water resource either through natural flow or by seepage are to be mitigated.

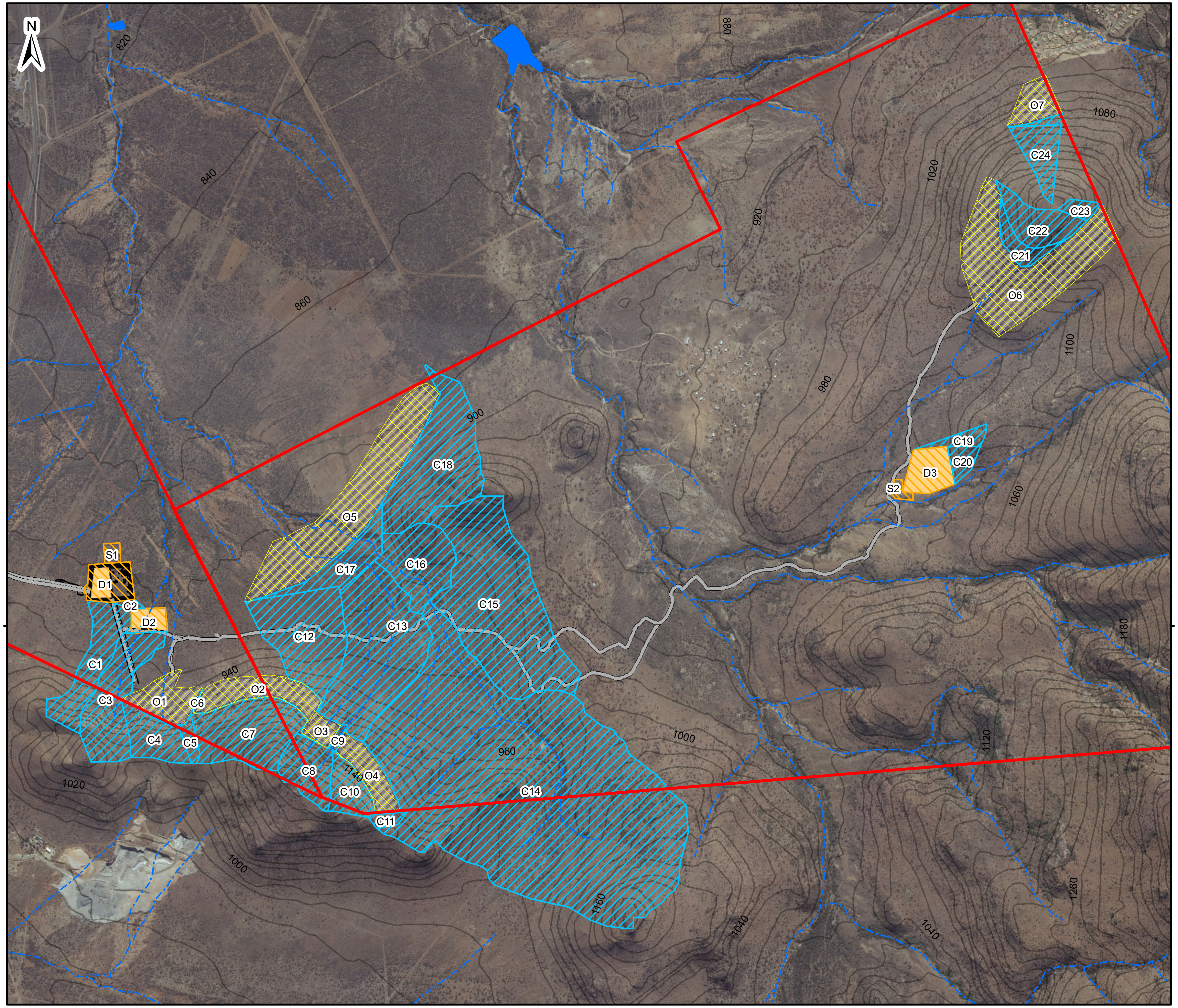
4.2 CLEAN AND DIRTY WATER CATCHMENTS

In Figure 4-1, clean and dirty areas have been delineated for the surface infrastructure. These areas were delineated using the 30m DEM (SRTM30). In addition to the dirty and clean areas, Figure 4-1 also indicates the position of the self-contained (dirty) opencast areas as well as site roads which require appropriate road side management to contain spillages as a result of site operation and haulage.

Dirty areas on site are comprised of 3 stockpiles (D1, D2 and D3). The dirty areas require diversions and associated containment facilities to manage dirty storm water generated, in accordance with the principles presented in GN704. Furthermore, the storage/handling of fuel, lubricants and chemicals will require special attention due to their hazardous nature. These areas are required to be managed on impermeable floors with appropriate bunding and sumps. Numerous opencast areas are also proposed and although classified as dirty areas, these areas are assumed to be self-contained.

The clean water areas on site are positioned upslope of the aforementioned stockpiles and opencast areas. These clean water areas require clean water diversions to prevent runoff from clean water areas mixing with runoff from dirty water areas.

Details on the methodology used to derive storm flows for the clean and dirty areas is provided in Appendix B.



Legend

- Site Boundary
- Contours (20m)
- Non-Perennial River (50K)
- Perennial River (50K)
- Dams (50K)
- Additional Infrastructure
- Roads
- Stockpile
- Opencast
- Dirty (Self-Contained)
- Clean Area
- Dirty Area

0 500 1,000 Meters

Scale: 1:19,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO31

Figure 4-1

Dirty and Clean Water Areas

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4.3 STORM WATER MANAGEMENT INFRASTRUCTURE

Storm water management infrastructure has been conceptually designed in this report as per the requirements of GN 704 and presented in Figure 4-2. The two dirty water containment facilities (S1 and S2) have been sized according to the layout of the site provided by the client.

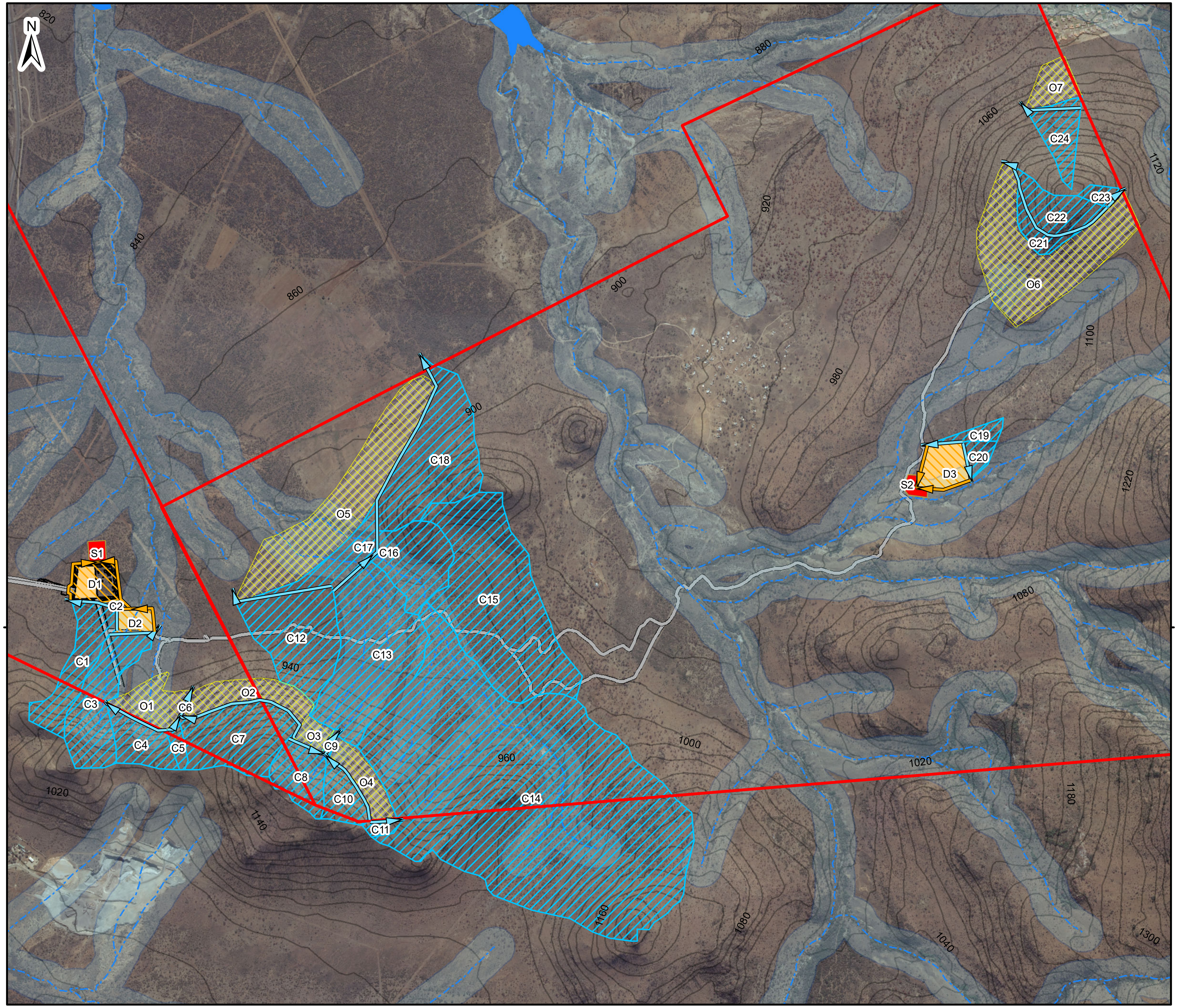
4.3.1 CLEAN WATER BERMS/CHANNELS

The three stockpiles and numerous opencast areas require clean water diversions. These diversions are comprised of a channel and berm component. The purpose of the channel section is to divert upstream clean water which would otherwise flow into the dirty area, while the berm section will ensure containment of dirty water within dirty areas. In order to maximise the separation of clean and dirty water, 24 clean water diversions have been proposed, labelled as C1 to C24 in Figure 4-2.

Figure 4-3 represents a typical clean water containment berm and channel. The berm component will be constructed from the material excavated from the channel and supplemented by topsoil stockpiling if required. The side slopes for all berms and channels will be kept constant at 1 vertical: 2 horizontal. The channel component has been sized using PCSWMM to meet the requirement of accommodating the 1:50 year flood. A Manning's 'n' roughness coefficient of 0.03 (maintained grass) was used in sizing of the diversions channels In Figure 4-3:

- a Channel Depth
- b = Channel Base Breadth

A velocity over 2m/s is high enough to potentially cause soil erosion and was noted in the hydraulic results of the conceptual SWMP. The South African National Roads Agency Limited (SANRAL) drainage manual (SANRAL, 2006) provides guidance on maximum permissible velocities for grass covers to avoid erosion and should be consulted during the detailed design phase.



Legend

- Site Boundary
- Contours (20m)
- Non-Perennial River (50K)
- Perennial River (50K)
- 100m River Buffer
- Additional Infrastructure
- Roads
- Stockpile
- Opencast
- Dams (50K)
- Containment
- Clean Diversion
- Dirty Diversion
- Dirty (Self-Contained)
- Clean Area
- Dirty Area

0 500 1,000 Meters

Scale: 1:20,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, Lo31

Figure 4-2

Storm Water Management Plan

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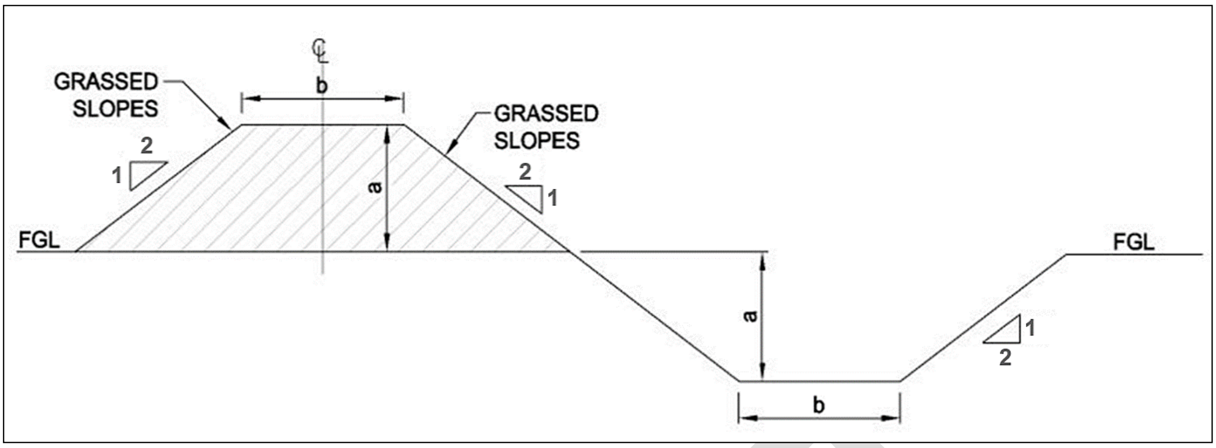


FIGURE 4-3: TYPICAL BERM AND CHANNEL FOR STORMWATER DIVERSION SYSTEM

Table 4-1 presents the dimensions of the clean diversions associated with the site. The average longitudinal slope used in the calculation of the channel dimensions has been extracted from the SRTM30 dataset. Once more detailed elevation data is available, together with a geotechnical investigation of the construction area and associated materials, a more informed decision can be made as to the optimum design (including space limitations) of such diversion infrastructure.

TABLE 4-1: BERM AND CHANNEL DIMENSIONS FOR CLEAN STORMWATER (50 YEAR FLOOD)

Catchment	a (m)	b (m)	Average Longitudinal Slope (%)	Peak Flow (m^3/s)**	Catchment	a (m)	b (m)	Average Longitudinal Slope (%)	Peak Flow (m^3/s)**
C1	0.75	1.0	0.8	2.1	C11	0.5	1.0	46.5	0.5
C3	0.75	1.0	3.7	3.2	C12	0.75	1.0	2.4	4.1
C4	0.5	1.0	13.7	2.1	C13	1.0	1.0	2.2	6.6
C5	0.5	1.0	23.3	0.6	C16+C18*	2.0	4.0	2.0	55.3
C6	0.5	1.0	28.3	5.1	C19	0.5	1.0	10.0	0.6
C7	0.5	1.0	16.3	4.6	C20	0.5	1.0	3.5	0.7
C8	0.5	1.0	17.9	2.7	C22	0.5	1.0	14.9	1.8
C9	0.5	1.0	49.4	4.4	C23	0.5	1.0	39.9	0.8
C10	0.5	1.0	19.1	1.6	C24	0.5	1.0	16.6	1.6

* This diversion has been sized using the combination of the two catchments.

** All subcatchments include the accumulation of flow from upslope subcatchments (i.e. runon).

4.3.2 DIRTY WATER BERMS/CHANNELS

Dirty water containment systems have been designed to ensure dirty water generated on the site is contained. These systems will also consist of a berm and channel component routing to a containment facility. Leach tests are required to be undertaken to determine the potential for pollutants to enter the environment through seepage, and thereby the requirement for lining of the dirty water channels. A conservative approach has nevertheless been assumed whereby all dirty channels will be concrete lined.

The berm and channel component have been designed to accommodate the 1:50 year flood and serve two main purposes:

- Diverting upstream clean water which would otherwise flow into the identified dirty areas.
- Contain dirty water in the identified dirty areas and direct towards the appropriate dirty water containment facility.

Figure 4-3 represents a typical dirty water containment berm and channel. The berm component will be constructed from the material excavated from the channel and supplemented by topsoil stockpiling if required. The side slopes for all berms and channels will be kept constant at 1 vertical: 2 horizontal. The channel component has been sized using PCSWMM to meet the requirement of accommodating the 1:50 year flood. A Manning's 'n of 0.015 was used in the calculations, associated with a concrete lined channel.

Table 4-2 presents the dimensions of the dirty diversions associated with the site. Since details on site levelling and subsequent drainage setup is not yet available, dirty water has been routed to a single diversion for each dirty area, collecting 100% of the water generated on the dirty area in order to retain a conservative approach.

TABLE 4-2: BERM AND CHANNEL DIMENSIONS FOR DIRTY STORMWATER (50 YEAR FLOOD)

Catchment	a (m)	b (m)	Average longitudinal Slope (%)	Peak Flow (m^3/s)
D1	0.75	1.0	2.2	5.7
D2	0.5	1.0	0.4	1.9
D3	0.5	1.0	5.5	4.0

The average longitudinal slope used in the calculation of the channel dimensions is likely to differ once the site has been levelled. The channel dimensions should consequently be reviewed during the detailed design phase.

4.3.3 DIRTY WATER CONTAINMENT – CAPACITY REQUIREMENTS

Condition 6 of GN 704 states that clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these clean and dirty water systems do not spill into each other as a result of storm events below and including the 1 in 50 year event. A minimum freeboard of 0.8 m above full supply level must also be maintained as per the requirements of GN 704.

In this project, the capacity of the dirty water containment facility was calculated based on the summation of the 1:50 year design rainfall (24 hour) event for the catchment area **and** the highest monthly rainfall (January) falling over the catchment, **less** the corresponding monthly evaporation (January) taking place over the surface area of the proposed containment facility. PCSWMM was used to model the containment of water, with the volume of runoff associated with monthly rainfall calculated using the Rational Method and set as an initial depth in PCSWMM.

It should be noted that it is assumed that the containment facilities will always have sufficient storage capacity to accommodate the 1 in 50 year rainfall event in order to comply with GN704. It is therefore anticipated that a management plan will accompany the construction of the containment facilities, such that water which accumulates over the year will either be reused as part of mine processes, or treated (if necessary) and discharged.

The 'minimum volume' as presented in Table 4-3 is based purely on a single 1:50 year storm event while the 'recommended volume' includes the influence of the wettest months rainfall. The aforementioned do not account for any seepage losses, additions of process water, dewatering, spillages, wash water or the like. The storm water dams will therefore need to be operated empty to comply with GN 704.
Table 4.3 should be evaluated and revised (if necessary) as part of the detailed design phase of the project to include additional process water requirements.

Containment has been sized according to the layout provided, with a depth of 2.0m assumed (excluding freeboard allowance). Opencast areas (which are self-contained) do not require formal containment facilities, however, a minimum volume has been calculated. This volume should be effectively routed to a sump area to prevent flooding. Table 4-3 presents the volume requirements for the dirty water containment facilities and opencast areas.

TABLE 4-3: DIRTY WATER CONTAINMENT FACILITY VOLUME REQUIREMENTS FOR 1:50 YEAR FLOOD EVENT

Catchment	Surface Area (m^2)	Minimum Volume (m^3)	Recommended Volume (m^3)
S1	10,000	12,000	20,000
S2	7,000	8,000	15,000
O1		9,900	
O2		12,300	
O3		3,400	
O4		8,800	
O5		46,800	
O6		22,000	
O7		7,200	

5 WATER QUALITY MONITORING

In terms of surface water quality monitoring, three samples were taken during the site visit on 6 October 2015. The locations of samples taken are presented in Figure 5-1 with laboratory results presented in Appendix C.

Surface water on the site was limited due to the nature of the non-perennials, which are assumed to only flow for short durations following significant rainfall events or during the wet season. Two samples were taken on the Steelpoort river (HH2 and HH3) with sample HH1 taken from a dam located immediately downstream of the proposed site. Photos taken of the sample points during the site visit can be found in Appendix C.

The water qualities have been defined in terms of the DWS quality of Domestic Water Supplies Assessment Guide (DWS, 1998). The classes of water presented in this guide relate to the suitability of the water for domestic use, taking into account the health risk at certain concentrations and are based on the second edition of the South African Water Quality Guideline developed by the DWS in 1996.

Table 5-1 defines the different classes of water according to this DWS classification system while Table 5-2 provides a summary of the water quality analysis.

TABLE 5-1: DWS CLASSIFICATION SYSTEM OF SUITABILITY FOR DOMESTIC WATER USE

Class 0	Ideal water quality-suitable for lifetime use.
Class 1	Good water quality-suitable for use, rare instances of negative effects.
Class 2	Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	Poor water quality-unsuitable for use without treatment. Chronic effects may occur.
Class 4	Dangerous water quality-totally unsuitable for use. Acute effects may occur.

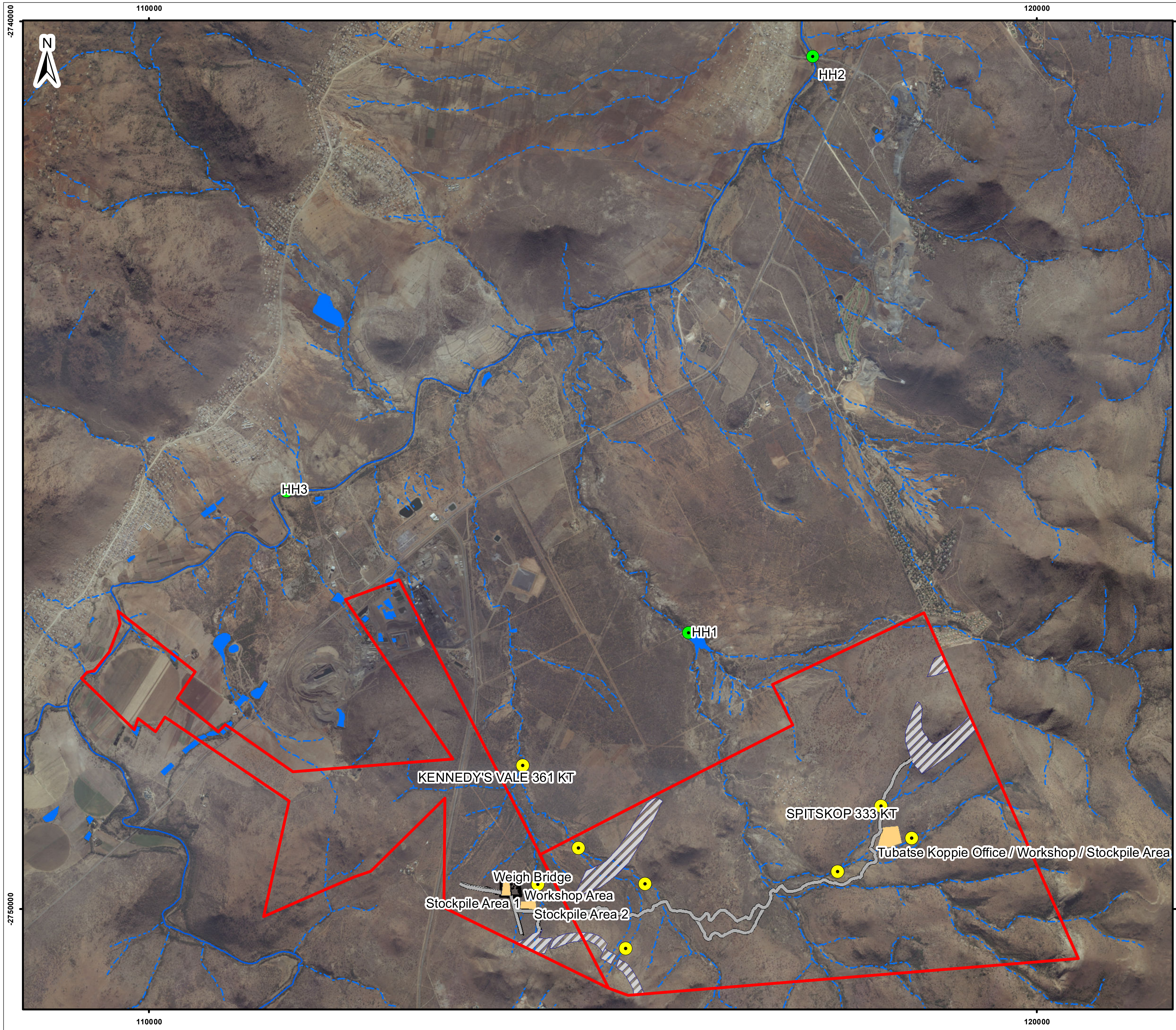
TABLE 5-2: WATER QUALITY ANALYSIS

Constituent	Class 0	Class 1	Class 2	Class 3	Class 4	HH1	HH2	HH3
TDS	< 450	450 - 1000	1000 - 2400	2400 - 3400	> 3400	262	246	208
EC (mS/m)	< 70	70 -150	150 - 370	370 - 520	> 520	42.5	38.5	34.3
Nitrate (as N)	< 6	6 - 10	10 - 20	20 - 40	> 40	<0.2	0.9	0.6
Fluoride	< 0.7	0.7 - 1	1 -1.5	1.5 - 3.5	> 3.5	<0.2	<0.2	<0.2
Sulphate	< 200	200 - 400	400 - 600	600 - 1000	> 1000	21	26	14
Magnesium	< 70	70 - 100	100- 200	200 - 400	> 400	27	18	16
Sodium	< 100	100 - 200	200 - 400	400 - 1000	> 1000	38	24	20
Chloride	< 100	100 - 200	200 - 600	600 - 1200	> 1200	34	24	21
pH	5 - 9.5	4.5 - 5 or 9.5 - 10	4 - 4.5 or 10 - 10.5	3 - 4 or 10.5 - 11	< 3 or > 11	9.7	8.9	8.8
Potassium	< 25	25 - 50	50 - 100	100 - 500	> 500	1.4	1.7	1.7
Calcium	< 80	80 -150	150 -300	> 300		15	28	28
Zinc	< 3	3 - 5	5 - 10	10 - 20	> 20	<0.010	<0.010	<0.010
Arsenic	< 0.1	0.01 - 0.05	0.05 - 0.2	0.2 - 2	> 2	<0.010	<0.010	<0.010
Copper	0 - 1	1 - 1.3	1.3 - 2	2 - 15	> 15	<0.010	<0.010	<0.010
Cadmium	< .003	0.003 - .005	0.005 - .02	0.02 - 0.05	> 0.05	<0.010	<0.010	<0.010
Manganese	< 0.05 - 0.1	0.1 - 0.4	0.4 - 4.0	4.0 - 10.0	> 10.0	0.025	<0.025	<0.025
Iron	< 0.5	0.5 - 1	1 - 5	5 - 10	> 10	0.125	0.083	0.092
Total hardness	0 -200	200 - 300	300 - 600	> 600		n/a	n/a	n/a
Turbidity (NTU)	< 0.1	0.1 - 1	1 - 20	20 - 50	> 50	5	33	34
Faecal coliforms	0	0 - 1	1 - 10	10 - 100	> 100	n/a	n/a	n/a
Total coliforms	0	0 - 10	10 -100	100 - 1000	> 1000	n/a	n/a	n/a
Free available chlorine	0.3 - 0.6	0.2 - 0.3 or 0.6 - 0.8	0.1 - 0.2 or 0.8 - 1.0	0.05 - 0.1 or 1.0 - 1.5	< 0.05 or > 1.5	n/a	n/a	n/a

It is evident that based on the undertaken analysis, turbidity seems to be of primary detriment to the quality of drinking water. Nephelometric Turbidity Units (NTU) of 33 and 34 were found in the Steelpoort river (HH2 and HH3) which results in the classification of the water as “Class 3” or “Poor water quality, unsuitable for use without treatment”. The remainder of the analysis for the water in the Steelpoort river showed “Ideal water quality”. The farm dam (HH1) also showed elevated units of turbidity (5 NTU) as well as a slightly elevated pH value of 9.7. This resulted in the classification of this water as “Class 2” or “Marginal water quality- conditionally acceptable”.

It is important to consider a surface water monitoring program which should be aimed firstly at developing an accurate baseline water quality baseline prior to mining so that secondly, any impact resulting from the mining operation can be identified and managed. To this end, it is recommended that the 3 locations continue to be monitored, together with additional samples as illustrated in Figure 5-1. It is understood that some of the additional sample locations will only flow for short durations following rainfall event.

It is recommended that samples be taken monthly for at least the first year of operation as part of the monitoring program. This can be revised to quarterly monitoring if no concerns are highlighted. This will however need to be discussed with the DWS as they are the ultimate custodians of the water resources. The monitoring should include the standard analysis of major cations/anions as well as ICP scan for metals. Waterlab in Pretoria has appropriate accreditation for such analysis to be undertaken.



Legend

- Site Boundary
- Roads
- Opencast
- Stockpile
- Additional Infrastructure
- Non-Perennial River (50K)
- Perennial River (50K)
- Dams (50K)
- Monitoring Points (Current)
- Monitoring Points (Additional)

0 1,000 2,000 Meters

Scale: 1:42,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, LO31

Figure 5-1

Monitoring Points

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January 2016

6 MEAN ANNUAL RUNOFF

6.1 MEAN ANNUAL AND MONTHLY RUNOFF

The Mean Annual Runoff (MAR) for the catchment associated with the site was estimated using the mean monthly WR2012 naturalised flow 30-year response from 1980 to 2009, which is an update to the Water Resources of South Africa 2005 study (WR2005, 2009). 30 years is considered a period over which a climatic 'normal' can be derived as described by the World Meteorological Agency (WMO, 2015). Naturalised flow is obtained by removing man-made influences such as dams, irrigation schemes and abstractions. In the case of the site, there is little development in the areas about the site and in upslope area from the site. Naturalised flow is consequently a suitable predictor of actual flow on site. In assessing the mean annual and monthly runoff of the site, the rainfall-runoff response was assumed to be the same as the regional rainfall-runoff response as determined for the quaternary catchment B41J in which the site falls.

6.1.1 WR2012

The WR2012 mean annual estimate of runoff for the site was estimated according to the dirty area contained (comprised of stockpiles, opencast areas and containment facilities) and totalled 1.097km^2. The mean annual runoff for quaternary catchment B41J was then factored according to this total contained dirty area. The mean annual runoff over this period is 0.022 million m^3 equating to 0.15% of quaternary catchment B41J. An average monthly variation in MAR for the site, is illustrated in Figure 6-1 (for the 30-year period of interest).

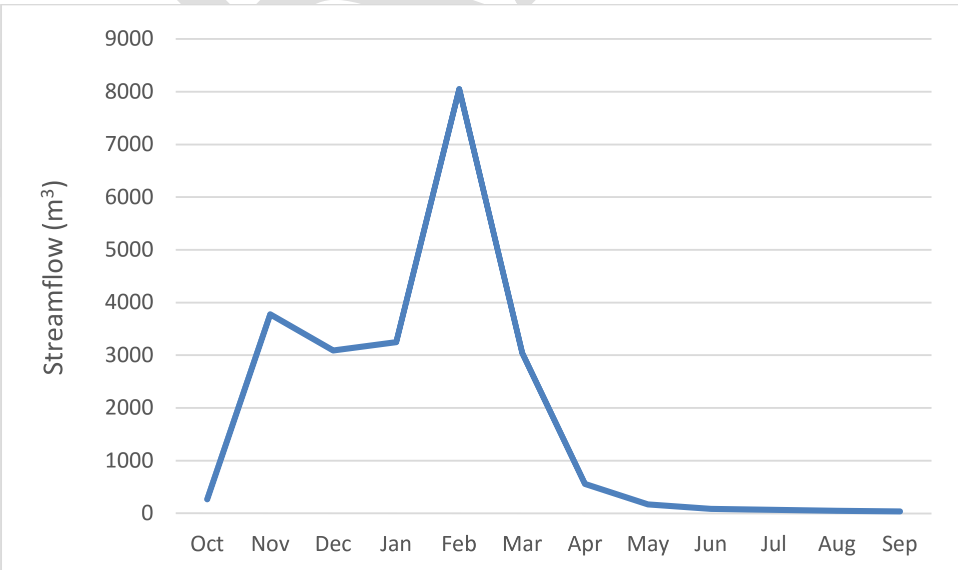

FIGURE 6.1: MEAN MONTHLY RUNOFF FOR THE SITE USING WR2012 (1980 TO 2009).

7 WATER BALANCE

A site wide static monthly climatic water balance model for both the wet and dry seasons has been developed for the project.

7.1 MODEL DESCRIPTION

The static water balance presented in this report represents typical wet and dry seasons based on monthly flows for the proposed operation. The wet season was calculated using the six wettest months (October - March) with the dry season calculated using the six driest months (April to September). The purpose of the report is to assess the site wide water balance from an environmental or overall water use perspective. To this end, the water balance makes a number of simplifying assumptions and is not intended for use in sizing and detailed design requirements.

7.2 INPUT DATA

Various climatic data and specialist information was required as inputs to the water balance model.

7.2.1 CLIMATE

Monthly rainfall and evaporation data for the water balance were sourced from the appropriate monitoring gauges as presented in this report.

7.2.2 SPECIALISTS

Input from a number of specialists was required for the development of this water balance. This input included the following:

- Abstraction volumes of water from underground (groundwater specialist); and
- Hydrology and associated conceptual stormwater management plan (this report).

Other information pertaining to the proposed operation such domestic water supply, associated use, as well as detailed information on the process water circuit was not obtained from the client before this water balance was produced.

7.3 MODEL SUMMARY

The water balance model schematics for the average wet and average dry seasons for the operation are presented in Figure 7-1 and Figure 7-2 respectively.

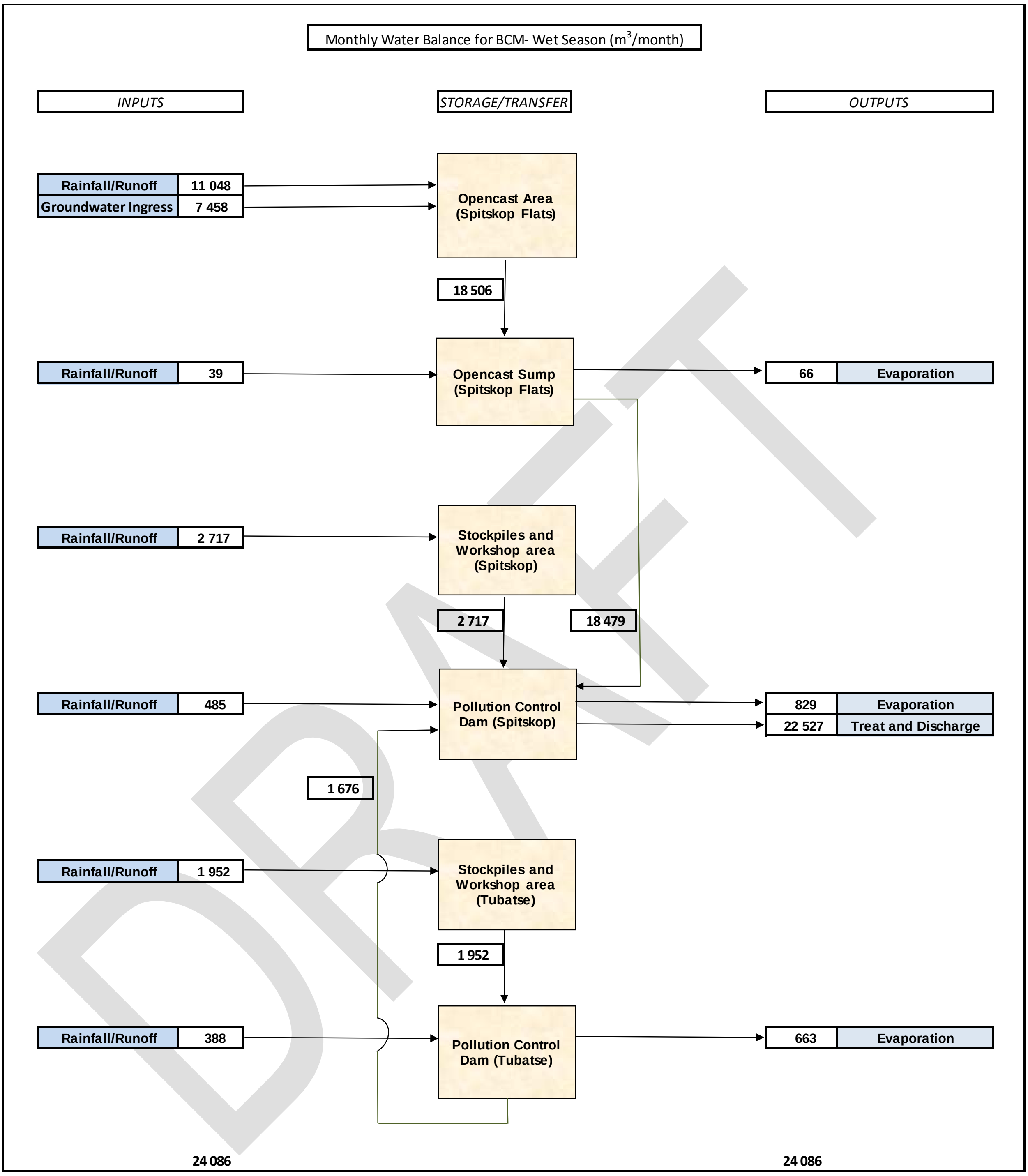

FIGURE 7-1: STATIC MONTHLY WATER BALANCE- WET SEASON

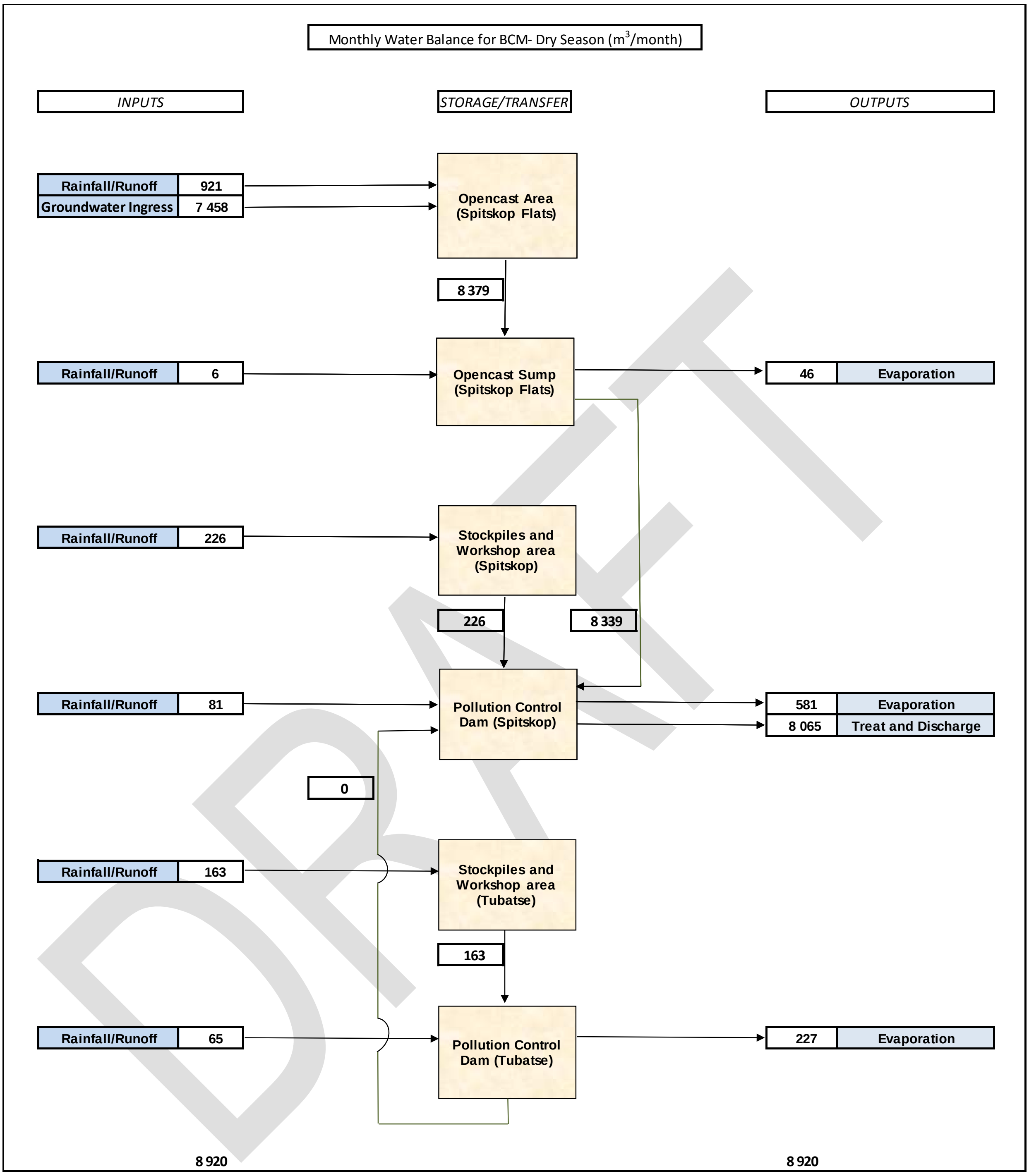

FIGURE 7-2: STATIC MONTHLY WATER BALANCE- DRY SEASON

7.4 Model Assumptions

The following assumptions we made during model development:

- The groundwater ingress volumes were taken from the groundwater report. This indicates that dewatering will only be required from the Spitskop opencast area. The Klarinet and Tubatse Koppies opencast areas will not intercept groundwater. As such, it is assumed that incident rainfall on these opencast areas (Klarinet and Tubatse) will infiltrate with limited water routing to a sump with associated pumping to surface.
- The infrastructure footprints such as opencast areas, stockpiles, workshops etc used for the calculation of runoff contributions were taken from the site layout received by the client.
- Rainfall runoff generated within the Spitskop opencast will be effectively routed to a lower sump area of approximately 400m^2 from where it will be pumped to the stormwater dam.
- The operational footprints of the stormwater dams were assumed to have surface areas of 5000m^2 and 4000m^2 for Spitskop and Tubatse respectively. Incident rainfall and evaporation from these stormwater dams is based upon these surface areas and does not consider dynamic fluctuations.
- The runoff coefficients are representative. These were selected as 0.4 and 0.2 for dirty water areas for average wet and dry seasons respectively.
- Clean and dirty water generating areas were taken as per SWMP presented in this report.
- Should further domestic or make-up water be required, this will be sourced from boreholes or a municipal pipeline.
- Excess water can be adequately managed and if necessary to discharge, meet the appropriate discharge quality guidelines with associated IWULA requirements.
- The model is based upon monthly static input information, is not dynamic in nature, and does not consider additional water requirements at start up.

8 CONCLUSIONS AND RECOMMENDATIONS

Appropriate baseline information including rainfall data, depth-duration-frequency design rainfall estimates, evaporation data as well as both regional and local hydrological characteristics have been considered for the proposed Bushveld Chrome Mine project near Steelpoort. It is recommended that an Automatic Weather Station be installed at the site.

Flooding at the site was investigated but limitations in available site elevation data meant that a reliable flood model (for floodline modelling) could not be built. Instead, a buffer approach (100m) for all non-perennials within the site boundary was adopted. There is a significant amount of infrastructure located within these buffers and intersecting watercourse. These instances will need to be considered during the water use license process (Section 21 c and i). It is recommended that floodlines are modelled (when detailed elevation data becomes available) for streams where flooding of infrastructure is a concern in order to ensure complete compliance with GN704. Peak flows and hydrographs were developed as part of this study for various subcatchments over the site. These outputs are intended to inform any future flood modelling.

Stream crossings and associated bridge and culvert designs have not been considered in this assessment but in principle, these crossing need to be sufficiently sized to provide capacity to convey the 1:100 year flood event over the expected life of the structure to minimise impacts and ensure that the natural flow regime can be maintained as far as possible.

The conceptual storm water management plan has been developed based on the requirements of GN 704. This was done by identifying clean and dirty areas and managing them accordingly. Dirty water producing areas have been isolated by diverting upstream clean water around them via clean water diversions and dirty water produced in dirty areas has been routed to dirty containment facilities via diversions. Stormwater infrastructure has been developed based on the contributing catchment areas and catchment characteristics, and has been sized to contain the 1:50 year flood event. It is recommended that discussions are held with the DWA regarding the lining requirements for storm water management infrastructure, to ensure that the flood hydrology calculations can be revised accordingly during detailed design and prior to construction of infrastructure. The “recommended volumes” of the proposed dirty storm water dams should be investigated further during the detail design phase to accommodate operational storage volumes, without compromising the ability of the dams to contain the “minimum volumes” as per GN 704 compliance. It is recommended that priority is given to the reuse of dirty water within the process water circuit.

Three surface water samples were taken during the site visit. This water quality monitoring is aimed at ensuring baseline water quality can be quantified prior to mining with potential impact subsequently monitored and quantified over time. To this end, additional sampling point have also been recommended. As part of the monitoring program going forward, samples should be taken monthly for at least the first year of operation. This can be revised to quarterly monitoring if no concerns are highlighted. This will however need to be discussed with the DWS as they are the ultimate custodians of the water resources. The monitoring should include the standard analysis of major cations/anions as well as ICP scan for metals. Waterlab in Pretoria has appropriate accreditation for such analysis to be undertaken.

An analysis of mean annual runoff was undertaken as part of the study using the WR2012 dataset. The WR2012 mean annual estimate of runoff for the site was estimated according to the dirty area contained (comprised of stockpiles, opencast areas and containment facilities) and totalled 1.097km^2. This accounts for 0.022 million m^3 of MAR that will be contained by the site (0.15% of quaternary catchment B41J MAR)

Wet and dry season static water balances have been developed for the project based on monthly input data from various specialists. Based on the model results, there seems to be an excess of approximately 22 527m^3/month and 8 065m^3/month for the wet and dry seasons respectively. This excess water will need to be appropriately managed and if deemed necessary to discharge, meet the appropriate discharge quality guidelines and associated discharge IWULA conditions. It is recommended that the water balance be updated once more specific domestic and process water reticulation volumes are known and refined annually during the life of the project. Flow meters should be installed in the domestic and process water circuits to provide actual data on water flows so that the water balance can be updated accordingly. A suitable dynamic water balance simulation model could also be developed and used as a decision support tool as mining progresses.

L Wiles PrSciNat	M Bollaert PrSciNat	Dr F Botha PrSciNat
(Project Manager/Author)	(Project Author)	(Project Reviewer)

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APPENDIX A: PEAK FLOWS AND HYDROGRAPHS

A.1 MODEL INPUTS

PCSWMM is a model package that makes use of the USEPA Storm Water Management Model (SWMM), which is a computer program that computes dynamic rainfall-runoff from developed urban and undeveloped or rural areas (Rossman, 2008).

The SWMM model suits application to this project since it is able to account for:

- Time-varying rainfall;
- Rainfall interception in depression storage;
- Infiltration of rainfall into unsaturated soil layers;
- Routing of overland flow;

A.2 DESIGN HYDROGRAPHS

A.2.1 DESIGN STORM

The SCS Type 3 design storm for South Africa was used to define the rainfall distribution according to the RLMA (Smithers /Schulze) 24-hour design rainfall depth for the 1 in 50 events (see Table 2.2).

A.2.2 MODEL PARAMETERISATION

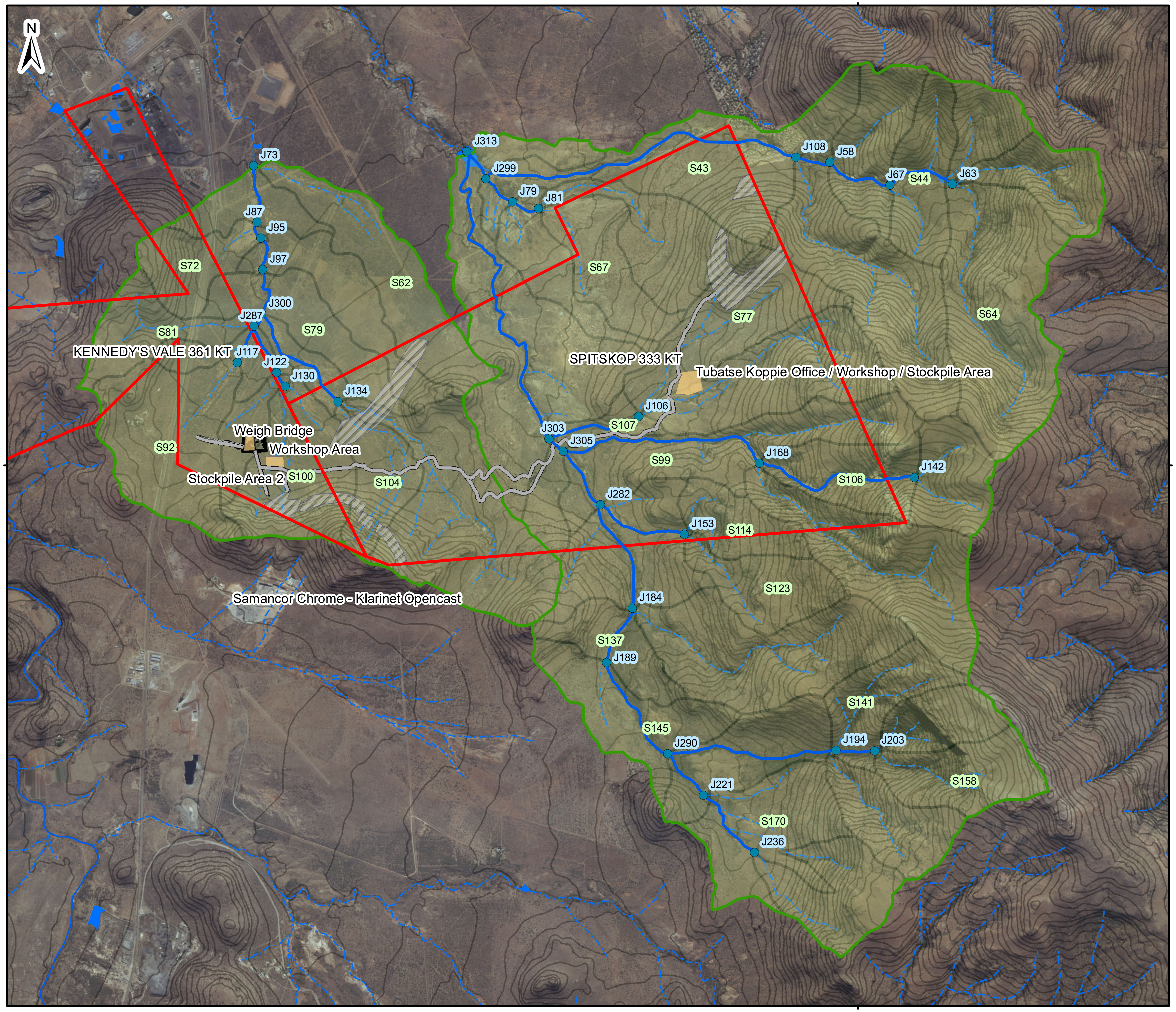
The 30m SRTM30 data for the site was used to separate dirty and clean areas (draining by gravity). Land cover parameters were estimated according to the surface infrastructure layout, aerial photography and site photos. In accordance with the WR2005 (WR2005, 2009) soils dataset, soils for the area were set as *sandy loams* with subsequent hydraulic parameters being derived from supporting literature[2]. Infiltration losses were estimated through the use of the Green-Ampt infiltration model.

The resulting hydrological model development is illustrated in Figure A.1

A.2.3 MODEL RUN

Kinematic wave routing was set for the model run along with a time step of 5 seconds. The resulting routing and runoff continuity error was -0.2% which is the close to optimum.

[2] http://www.dynsystem.com/NetSTORM/docs/GreenAmptParameters.html



Legend

- Site Boundary
- Dams (50K)
- Non-Perennial River (50K)
- Perennial River (50K)
- Contours (20m)
- Roads
- Opencast
- Stockpile
- Additional Infrastructure
- Junctions
- Conduits
- Subcatchments
- Primary Catchments

0 500 1,000 Meters

Scale: 1:22,000 @ A3

Projection: Transverse Mercator
Datum: Hartebeeshoek, Lo31

Figure A-1

Hydrologic Model Setup

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January 2016

A.2.3 PEAK FLOWS AND HYDROGRAPHS

Since time varying rainfall was used, it was possible to develop both peak flows and hydrographs (consequently enabling an unsteady (dynamic) hydraulic model to be developed in the future).

Two hydrographs representing the 1 in 100 year design events for the two primary catchments modelled are presented in Figure 3-2. Additional hydrographs were derived for the subcatchments and junctions as presented in Figure A.1. Table A.1 presents peak flows for key junctions.

It is important to note, that no allowances for climate change have not been made. A risk analysis using the expected life of a structure or process will indicate the relevance of considering climate change (i.e. as the expected life increases the influence of climate change increases).

TABLE A-1: DESIGN PEAK FLOWS FOR KEY JUNCTIONS

Model Label	Peak Flow (m^3/s)	
	50-Year Event	100-Year Event
J313	302	316
J73	178	193
J130	23	28
J134	55	70
J106	55	72

A.2.4 COMPARISON TO THE REGIONAL MAXIMUM FLOOD

In deriving peak flows using PCSWMM, the RMF estimate for the 100-year event was used for calibration. This was achieved through alteration of the Mannings roughness value for the modelled rivers, with a final roughness value of 0.013 being used, which is within the expected range of between 0.01 and 0.02.

The Regional Maximum Flood (RMF) (as outlined in the SANRAL Drainage Manual (SANRAL, 2006) was applied to junction J313, using the Kovacs region 'K5' in order to maintain a conservative approach (where greater flows are more conservative). This is despite the site possibly falling within Kovacs region 'K4.6' which resulted in lower flows when used. The results of this comparison between the PCSWMM estimates and the RMF using Kovacs region 'K5' are presented in Table A2.

TABLE A-2: COMPARISON OF PEAK FLOW TO RMF

Model Label	Peak Flow (m^3/s)	
	50-Year Event	100-Year Event
J313 (PCSWMM)	302	316
J313 (RMF)	250	314

APPENDIX B: STORMWATER MODEL SETUP

B.1 MODEL CHOICE

PCSWMM is a model package that makes use of the USEPA Storm Water Management Model (SWMM), which is a computer program that computes dynamic rainfall-runoff from developed urban and undeveloped or rural areas (Rossman, 2008).

The SWMM model suits application to this project since it is able to account for:

- Time-varying rainfall;
- Rainfall interception in depression storage;
- Infiltration of rainfall into unsaturated soil layers;
- Evaporation of standing surface water;
- Routing of overland flow; and
- Capture and retention of rainfall/runoff.

The development of SWMP's using SWMM have been undertaken for many thousands of studies through the world including (Rossman, 2008) South Africa.

B.2 PEAK FLOWS

B.2.1 DESIGN STORM

The SCS Type 3 design storm for South Africa was used to define the rainfall distribution according to the RLMA (Smithers /Schulze) 24-hour design rainfall depth for the 1 in 50 events (see Table 2.2).

B.2.2 MODEL PARAMETERISATION

The 30m SRTM30 data for the site was used to separate dirty and clean areas (draining by gravity). Land cover parameters were estimated according to the surface infrastructure layout, aerial photography and site photos. In accordance with the WR2005 (WR2005, 2009) soils dataset, soils for the area were set as *sandy loams* with subsequent hydraulic parameters being derived from supporting literature[3]. Infiltration losses were estimated through the use of the Green-Ampt infiltration model.

B.2.3 MODEL RUN

Kinematic wave routing was set for the model run along with a time step of 5 seconds. The resulting routing continuity error was 0% which is the optimum result, while the runoff continuity error was -0.3%

[3] http://www.dynsystem.com/NetSTORM/docs/GreenAmptParameters.html

which is close to optimum. The resulting peak flows and characteristics for the dirty and clean areas is presented in Table B-1. These results do not include the accumulation of flow between subcatchments (runon) but only individual subcatchment flows (runoff).

TABLE B-1: CLEAN AND DIRTY AREA CHARACTERISTICS FOR THE 1:50 YEAR EVENT

Catchment	Area (ha)	Slope (%)	Infiltration (mm)	Runoff Coefficient	Peak Flow (m^3/s)
C1	10.69	22.4	115	0.25	2.3
C2	0.44	5.0	104	0.32	0.2
C3	14.23	26.0	122	0.29	3.3
C4	6.58	34.9	108	0.29	2.2
C5	1.44	34.9	106	0.31	0.6
C6	0.04	16.9	92	0.40	0.0
C7	16.42	38.6	110	0.28	4.8
C8	7.47	44.0	107	0.30	2.8
C9	0.52	0.5	116	0.24	0.1
C10	5.18	35.3	109	0.29	1.6
C11	1.11	37.9	105	0.32	0.5
C12	19.08	11.0	113	0.26	4.4
C13	30.65	23.9	123	0.29	6.7
C14	152.10	15.0	39	0.00	34.1
C15	44.96	10.0	36	0.00	8.7
C16	12.36	23.6	109	0.29	3.9
C17	7.27	21.9	105	0.32	3.4
C18	23.98	30.0	110	0.28	7.0
C19	1.94	20.0	110	0.28	0.6
C20	2.03	22.0	107	0.30	0.7
C21	2.94	40.0	102	0.34	1.8
C22	7.23	40.0	111	0.27	1.9
C23	1.47	41.4	92	0.40	0.8
C24	5.74	40.0	110	0.28	1.7
D1	4.70	5.0	12	0.92	3.9
D2	2.30	5.0	12	0.92	2.0
D3	5.03	5.0	12	0.92	4.1

APPENDIX C – WATER QUALITY LABORATORY RESULTS AND PHOTOS

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification		
		HH1	HH2	HH3
Sample Number		17620	17621	17622
pH – Value at 25°C *	WLAB001	9.7	8.9	8.8
Electrical Conductivity in mS/m at 25°C *	WLAB002	42.5	38.5	34.3
Total Dissolved Solids at 180°C *	WLAB003	262	246	208
Turbidity in N.T.U *	WLAB005	5.0	33	34
Total Alkalinity as $CaCO_3$ *	WLAB007	180	148	152
Chloride as Cl	WLAB046	34	24	21
Sulphate as SO_4	WLAB046	21	26	14
Fluoride as F	WLAB014	<0.2	<0.2	<0.2
Nitrate as N	WLAB046	<0.2	0.9	0.6
Ortho Phosphate as P	WLAB046	<0.2	<0.2	<0.2
Free & Saline Ammonia as N	WLAB046	0.3	0.4	0.6
ICP-MS Scan *	WLAB050	See Attached Report: 54989-A		
% Balancing *	---	95.6	96.7	95.6

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : 1000
Client : Highlands Hydrology
Report Number : 54989-A

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
HH1	17620	<0.010	0.130	<0.010	<0.010	<0.010	0.019	<0.010	<0.010	15	<0.010	<0.010	<0.010
HH2	17621	<0.010	0.115	<0.010	<0.010	0.016	0.029	<0.010	<0.010	28	<0.010	<0.010	<0.010
HH3	17622	<0.010	0.106	<0.010	<0.010	0.010	0.024	<0.010	<0.010	28	<0.010	<0.010	<0.010

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
HH1	17620	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.125	<0.010	<0.010	<0.010	<0.010	<0.010
HH2	17621	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.083	<0.010	<0.010	<0.010	<0.010	<0.010
HH3	17622	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.092	<0.010	<0.010	<0.010	<0.010	<0.010

Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
HH1	17620	<0.010	<0.010	<0.010	1.4	<0.010	<0.010	<0.010	27	0.025	<0.010	38	<0.010
HH2	17621	<0.010	<0.010	<0.010	1.7	<0.010	<0.010	<0.010	18	<0.025	<0.010	24	<0.010
HH3	17622	<0.010	<0.010	<0.010	1.7	<0.010	<0.010	<0.010	16	<0.025	<0.010	20	<0.010

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)	Sc (mg/L)
HH1	17620	<0.010	0.015	<0.010	0.032	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HH2	17621	<0.010	0.011	<0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HH3	17622	<0.010	0.010	<0.010	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Sample Origin	Sample ID	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)	Tm (mg/L)
HH1	17620	<0.010	0.9	<0.010	<0.010	0.056	<0.010	<0.010	<0.010	<0.010	0.023	<0.010	<0.010
HH2	17621	<0.010	2.4	<0.010	<0.010	0.125	<0.010	<0.010	<0.010	<0.010	0.047	<0.010	<0.010
HH3	17622	<0.010	2.0	<0.010	<0.010	0.101	<0.010	<0.010	<0.010	<0.010	0.037	<0.010	<0.010

Sample Origin	Sample ID	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
HH1	17620	<0.010	0.017	<0.010	<0.010	<0.010	<0.010	<0.010
HH2	17621	<0.010	0.027	<0.010	<0.010	<0.010	<0.010	<0.010
HH3	17622	<0.010	0.004	<0.010	<0.010	<0.010	<0.010	<0.010

Sample Locations (HH1, HH2, HH3) respectively

APPENDIX D – DECLARATION

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

PROJECT TITLE

Hydrology Assessment for the Bushveld Chrome Mine- Steelpoort

Specialist:	Highlands Hydrology (Pty) Ltd		
Contact person:	Luke Wiles		
Postal address:	P O Box 51 Paddock		
Postal code:	4244	Cell:	0721294202
Telephone:		Fax:	
E-mail:	Luke.wiles@w2k.co.za		
Professional affiliation(s) (if any)	PrSciNat		

Project Consultant:	Environmental Management Assistance (Pty) Ltd		
Contact person:	Anandi Alers		
Postal address:	Po Box 386 Sundra		
Postal code:	2200	Cell:	084 5155 840
Telephone:		Fax:	086 226 7324
E-mail:	Anandi.alers@emassistance.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Luke Wiles , 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

Signature of the specialist:

Highlands Hydrology (Pty) Ltd

Name of company (if applicable):

29/01/2016

Date: