DMR Reference Number:

MP30/5/1/2/2/10129MR

Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province

Hydrological Assessment Report

Project Number:

XST3791

Prepared for:

Umcebo Mining (Pty) Ltd

October 2016

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Report Type:	**Hydrological Assessment Report**
Project Name:	**Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province**
Project Code:	**XST3791**

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Chenai Makamure	Water Balance & SWMP		August 2016
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DECLARATION OF INDEPENDENCE

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I, Mashudu Rafundisani as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Umcebo Mining (Pty) Ltd, other than fair remuneration for work performed, specifically in connection with the proposed development of an underground coal mine and associated infrastructure, located near Hendrina, Mpumalanga Province.

Mashudu Rafundisani

12/08/2016

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EXECUTIVE SUMMARY

Umcebo Mining (Pty) Ltd (Umcebo) proposes the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10-22 kilometres (km) south east of Hendrina in the Mpumalanga Province of South Africa. The project area is located in the Olifants Water Management Area no: 04 in quaternary catchment B12A.

The Klein Olifants is the only perennial stream within this quaternary catchment; it traverses the Hendrina South and Mooivley East Mining Right Area (MRA). There are other few non-perennial streams within these MRA's and are tributary to the Klein Olifants. Mooivley West MRA is drained by an unnamed stream that is also a tributary to the Klein Olifants.

Runoff emanating from the mentioned MRA's reports into the Klein Olifants which eventually joins the Olifants River.

Samples were collected during the dry (June) and wet seasons (March) within the project area and the surrounding streams to determine the baseline water quality status, although the Klein Olifants river was not flowing at the time of sampling. Samples were taken at stagnant pools of water along the river channel to determine an indicative baseline water quality. Parameters such as Total Dissolved Solids (TDS), Chloride and Sodium were exceeding the target water quality range for the irrigational use as set in the South African Water Quality Guidelines (DWAF, 1996).

The proposed development and operation of a new underground coal mine and associated activities have the potential to impact on the water resources within and around the project area. The identified potential surface water impacts possibly include but not limited to:

- Siltation of surface water resources leading to deteriorated water quality as a result of eroded material reporting into the streams;
- Contamination of surface water resources when contaminated water runoff form the mine reports into the nearby streams;
- Reduction in runoff catchment yield in to the natural streams when all the dirty water runoff is captured and contained within the mine;
- Potential subsidence on the undermined areas that may lead to impoundment of water there by reducing surface runoff reporting into the Klein Olifants; and
- Potential decant of Acid Mine Drainage during the post-closure phase resulting in significant water quality modification of the Klein Olifants river.

A mine wide water balance was developed and the summary of the average wet period water balance and the average dry period water balance were calculated. The results of the water balance are summarised as follows:

- The water requirements for the three sites were calculated based on the maximum water use of 2 000 m^3/day and these resulted in water demand of 20 333 m^3/month;
- The water balance calculations indicate that the water requirements (2000 m^3/day) at the mine will not be met by the water make as underground water make ranges between 0 and 1000 m^3/day and the runoff which was within the ranges of 0 and 84 m^3/day;
- The deficit will therefore be in the order of magnitude of 1 000 m^3/day in total; and
- More specifically, the deficits were calculated to be in the dry season between 8 000 and 18 000 m^3/month per site; and in the wet season between 7 000 and 14 000 m^3/month per site.

Limited information was available during this study and a number of assumptions were made for the water balance calculations (Refer to Section 7.1.2). This study is therefore recommended to be updated once the information becomes available.

A storm water management plan was compiled for the project area, which covered the clean and dirty water control requirements based on the placement of the proposed infrastructure as per Government Notice (GN) Regulation 704 requirements of the National Water Act, 1998 (Act No. 36 of 1998). The summary of findings from the storm water management plan includes but not limited to:

- The Pollution Control Dams (PCD) should have elevated downstream embankment/ walls on flat ground so that water can be contained within and not overflow to the downstream clean water receiving environment and the nearby watercourse;
- At normal operational volume, the PCD should be able to hold the runoff generated during a 1:50 year storm event and have a 0.8 m free board
- Silt traps should be in place in the dirty water channels before it enters into the PCDs. This should be placed in a manner that allows desilting clean up when the channels are silted up;
- The volumes of water pumped to and abstracted from the PCDs and water levels should be recorded on a daily basis; and
- The water quality in the PCDs should be monitored monthly to assist in the management/ maintenance of the water and salt balance.

A floodline delineation study was conducted to understand the risk of flooding on the proposed mine infrastructure, and in accordance with GN 704 Regulations. According to the Regulations infrastructure should not be placed within the 1:100 year floodline, or a horizontal distance of 100 m from a watercourse (whichever is greater). The 1:100 year floodlines were delineated for the streams and drainage lines within close proximity to surface infrastructure areas. The following surface infrastructure was found to be within the 1:100 year floodline and/or the 100 m buffer of watercourses:

- Fence around Mooivley East infrastructure;
- Conveyor, access road and fence connecting Hendrina South and Mooivley West sites; and
- Fence, haul road and access road at Mooivley West.

However, appropriate management measures were provided to prevent and/or reduce the risk of flooding of these infrastructures as well as risk of contamination of surface water resources due to mobilisation of pollutants (hydrocarbon chemicals, heavy metals from mined out areas, etc.) during flooding. Appropriate mitigation/ management measures to prevent, and/or minimise all other identified potential surface water impacts includes but not limited to:

- Limiting the vegetation clearing to the development footprint;
- Implement dust suppression measures during construction;
- Provision and adequate maintenance of mobile ablutions and waste bins for construction workers;
- All bulk fuel storage areas should be appropriately bunded and spill kits should be in place to contain and immediately clean up any potential leakages of fuels and oils;
- To ensure that all the dirty water emanating from the dirty water areas is collected via silt traps before entering the PCD for re-use within the mine so as to prevent unnecessary discharge into the environment;
- The clean and dirty water collection systems should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows;
- All overburden and topsoil stockpiles should be vegetated as soon as possible. These stockpiles should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels;
- Water quality monitoring on the surrounding streams to enable detection of impacts as they arise and ensure that the necessary mitigation measures implemented. Also, monitoring should be implemented within the mine water system (PCD’s) to ensure that pollution sources are monitored during mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated;

- A geotechnical study must be conducted to assess the risk for subsidence in areas associated with the Klein Olifants River. These delineated high risk areas should then be avoided; the mine should undermine the river in one location when entering the resource on the other side of the river; and
- Appointment of an Environmental Control Officer (ECO) to ensure implementation of all the recommended mitigation/ management measures.

Thus, the project can go ahead if the recommended mitigation measures are in place to ensure the prevention and/or reduction of the identified potential surface water impacts on the Klein Olifants and other unnamed streams.

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LIST OF ACRONYMS AND ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GN704	Government Notice 704 in Government Gazette 20119
ha	hectares
km	Kilometre
LIDAR	Light Detection And Ranging
NWA	National Water Act, 1998 (Act No. 36 of 1998)
m	Metre
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
Mg/l	Milligrams per litre
MRA	Mining Right Application
mg/L	milligrams per litre
mm	Millimetre
mS/m	Milli Siemens per metre
m^3	Cubic metre
PCD	Pollution Control Dam
RoM	Run of Mine
SANAS	South African National Accreditation System
SAWQG	South African Water Quality Guidelines
SDF	Standard Design Flood
TDS	Total Dissolved Solids
UPD	Utilities Programme for Drainage
WARMS	Water Authorisation and Registration Management System
WRC	Water Research Commission
WMA	Water Management Area

1 Introduction

Umcebo Mining (Pty) Ltd (Umcebo), a subsidiary of Glencore Operations South Africa (Pty) Ltd (Glencore) is proposing the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10 to 22 kilometres (km) south east of Hendrina in the Mpumalanga Province of South Africa (the Project).

Umcebo currently holds two Prospecting Rights (PRs), namely MP 1265 PR and MP 1266 PR, located within the Ermelo Coalfield. The total extent of MP 1265 PR (referred to as Mooivley East and Mooivley West) is 3 923 hectares (ha) and comprise the following farms and portions:

- Mooivley 219 IS – Potions 2, 4, 5 and Remaining Extent (RE) of the farm;
- Tweefontein 203 IS – Portions 2, 15, 16, 17 and Portion of Portion 14;
- Uitkyk 220 IS – Portions 2 and 3; and
- Orange Vallei 201 IS – Portions 1 and Remaining Extent (RE) of the farm.

The total extent of MP 1266 PR (referred to as Hendrina South) is 2 787 ha and comprises the following farm and portions:

- Elim 247 IS - RE of the farm;
- Geluksdraai 240 IS – 1 and 2;
- Orpenskraal 238 IS – RE of the farm; and
- Bosmanskrans 217 IS – Potions 1, 3, 4, 6, 8, 9 and RE of the farm.

The project area proposed to be mined (underground) has a combined footprint of 6 714 ha and is located within the Steve Tshwete Local Municipality (STLM) and Msukaligwa Local Municipality (MLM).

1.1 Project Overview

The project area comprises three underground reserve blocks namely Mooivley East, Mooivley West and Hendrina South. The two Mooivley reserves comprise two shaft areas which will be developed to gain access to the two underground areas, whilst the Hendrina South reserve comprises one shaft area. Mooivley West and Hendrina South will be mined at the same time. Once completed, Mooivley East mining activities will commence.

The estimated Life of Mine (LoM) will be 30 years[1] for all mining areas with a production rate of 2.4 million tonnes per annum at full capacity, with a total of approximately 78 million tonnes of Run of Mine (ROM). The mine will reach full production within the first four years.

The grade of coal is poor and therefore not suitable for export. The coal product will be transported to a nearby Eskom power station (i.e. Kusile, Kendal, Kriel and Grootvlei) via the existing road network.

The project is proposed to commence with construction and development when all required licences and authorisations have been granted.

Due to the depth of the resource (i.e. 32 m to 128 m below surface), underground mining will be used to access the ore body. The proposed mining method for the extraction of coal will be bord and pillar. In mechanised bord and pillar mining, extraction is achieved by developing a series of roadways (bords) in the coal seam connected by splits (cut-throughs) to form pillars and is done through the use of machinery referred to as a continuous miner. Any overburden material extracted will be stockpiled and used to backfill and rehabilitate the incline shafts once mining is completed.

All proposed mine infrastructure are presented on Figure 1-1 and includes the following:

- Crushing and Screening Plant;
- Overburden and Product Stockpiles;
- Access and Service Roads (with weighbridge);
- Overland Conveyors;
- Three Access Points to the Underground Reserve;
- Three Ventilation Shafts;
- Office Complex (change house, workshop, offices);
- Three Pollution Control Dams (PCDs) and water pipelines;
- Five Aboveground Storage Tanks for the storage of diesel;
- Three Waste Bins per Shaft;
- Site fencing located around the Conveyer Belt and each Mining Complex;
- Diesel Generator and Sub-station;
- Water Treatment Plant; and
- Package Sewage Treatment Plant (STP).

[1] The MRA will be made for an initial period of 30 years, the maximum allowed in terms of the provisions of Section 23 of the MPRDA. At the end of this period an application for renewal of the mining right will be made for any remaining reserves.

1.2 Terms of Reference

This report serves to provide the details of the surface water assessment on the receiving water environment prior to commencement of the proposed mining project, and assess and identify the potential impacts on the surface water resources that could emanate from the project and its associated activities. It will also provide the appropriate mitigation measures to prevent minimise and/or reduce the identified potential impacts. This will be limited to the proposed infrastructure provided in the Infrastructure Plan (Figure 1-1).

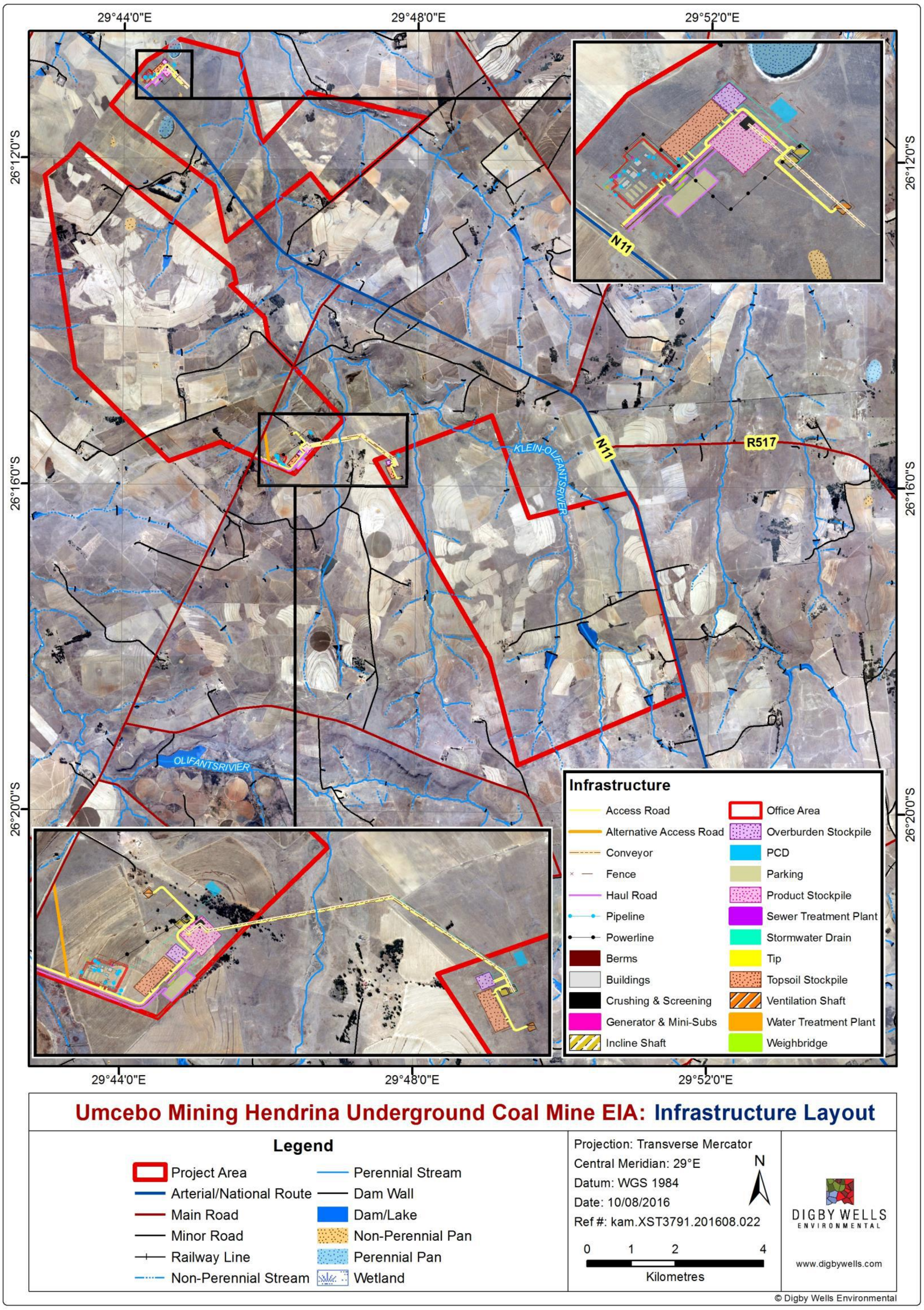

Figure 1-1: Proposed Infrastructure

2 Details of the Specialist

The relevant expertise of the specialist involved in the surface water assessments are summarised in Table 2-1.

Table 2-1: Expertise of specialists[2]

Chenai E. Makamure (Pr. Sci. Nat) 400150/16 Water Institute of Southern Africa WISA (No. 25046)	A holder of an MSc in Geo-Information Science and Earth Observation for Watershed Modelling and Management (Surface Hydrology). Chenai is a seasoned Surface Water Consultant (Hydrologist) with over nine years work experience. Her experience ranges from Mining, quasi-government and consulting environment; focused specifically in the mining industry. Chenai had completed numerous hydrology specialist studies including, baseline hydrology assessments, water quality assessments, data collection and analysis for surface water quality and quantity, surface water quality input into EIA/EMP, integrated water and waste management plans, water balances, storm water management plans assessments and development and flood modelling and floodlines determination within Iron Ore, Coal, Gold and Platinum mining, power stations and infrastructure development projects in Africa (South Africa, Ghana, Mali, Liberia, Sierra Leone, Cameroon, Malawi and Democratic Republic of Congo).
Mashudu Rafundisani Cand Sci Nat (115066)	Mashudu Rafundisani is a Hydrologist with three years working experience in the Water Geo-Sciences Department in Digby Wells Environmental. He holds an Honours Degree in Environmental Management from the University of Venda (South Africa). Mashudu has completed numerous surface specialist studies which includes, but is not limited to; data collection and analysis of surface water quality, integrated water and waste management plans, water use licence applications and auditing, water and salt balances, storm water management plans, basic hydraulics and flood modelling in south Africa and other parts of Africa.
Andy Pirie	Andy Pirie a Surface Water Consultant (Hydrologist) in the Hydrology Unit at Digby Wells Environmental. Andy graduated with a M.Sc. Water Resource Management from the University of Pretoria. Work experience includes floodline modelling using HEC-RAS software, development of Storm Water Management Plans, data collection and analysis of surface water quality and quantity, surface water specialist studies for EIA/EMPs, and Integrated Water and Waste Management Plans (IWWMP). Andy also has extensive knowledge using GIS and CAD software’s such as ArcGIS, Global Mapper, Quantum GIS, Surfer, AutoCAD and Microstation.

[2] Please refer to Appendix A for the Curriculum Vitae of the relevant specialists.

3 Aims and Objectives

The aims and objectives of this study are summarised below:

- Provide a description of the baseline surface water quantity and quality of the project area;
- Determination of the 1:50 year and 1:100 year floodlines along the section of river or any identified watercourse located within close proximity of the project infrastructure (for environmental purposes only);
- Development of a conceptual Storm Water Management Plan (SWMP) in line with the location of infrastructure. All recommendations will be in line with GN 704;
- Development of a Water Balance in line with DWS BPG: G2 Water and Salt Balance (DWS, 2006);
- Identification of impacts on the surface water resources from the proposed activities. Once impacts have been identified, a numerical environmental significance rating process that utilises the probability of an event occurring and the severity of the impact will be undertaken to determine the significance of a particular environmental impact; and
- Provide mitigation measures for implementation to prevent and/or reduce the identified potential surface water impacts together with a monitoring plan.

4 Methodology

4.1 Literature Review and Desktop Assessment

The documents that were reviewed include, but are not limited to (refer to section 18):

- Digby Wells Environmental, August 2016. Groundwater Assessment Report. Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga. Umcebo Mining (Pty) Ltd.
- Department of Water Affairs and Forestry (DWAF), 1996. South African Water Quality Guidelines (second edition). Volume 1: Agriculture: Irrigational Use; and
- WR2012, “Water Resources of South Africa, 2012 Study (WR2012)”, Water Research Commission, Pretoria.

Information within these reports was reviewed to obtain background information for the project area and/or utilise the relevant information when compiling the Hydrological Assessment Report.

4.2 Fieldwork and Seasonal Influence

A site visit was conducted on 16 and 17 March 2016 (wet season) to collect water samples on the Klein Olifants River and other streams around the project area. The Klein Olifants River was mostly dry with some sections having stagnant water along the river channel and therefore only five samples were collected.

During the dry season only two samples were collected whilst the other monitoring points were dry; this sampling round was completed in June 2016.

The Klein Olifants was not flowing during the wet and dry sampling periods. During the dry season or low flow periods, the dilution effect usually observed is reduced and high concentrations of certain parameters (salts and biological parameters) are likely to be observed.

4.3 Detailed Baseline Hydrology

The baseline hydrology characterisation included:

- An analysis of surface water quality of samples obtained from site visits was undertaken. Water samples were collected and sent to a SANAS accredited laboratory for analysis and were benchmarked against the Olifants River Water Quality Objectives (RWQO) and the South African Water Quality Guidelines (SAWQG) for Agricultural Use: Irrigation (DWAF, 1996); as the area is surrounded by cultivated farms; and
- The catchment peak flows has been simulated from the Utilities Programme for Drainage (UPD) for use when modelling the floodlines.

4.4 Water Balance

A water balance was prepared according to the DWS Best Practice Guideline G2: Water and Salt Balances, to account for inflows and water make and transfers during operations. This will depict water inflows, losses and outflows within the mine.

The project description was studied to gain an understanding on the operation of the mine and develop a water circuit diagram that illustrated the water pathways in the mine water balance. The water balance was developed using an excel spreadsheet model, taking into consideration average dry and average wet conditions. The methodology detailed in the BPG: G2 was undertaken in preparation of the water balance, and includes:

- Determination of the water balance objectives;
- Determination of the water balance boundaries;
- Construction of a process flow diagram using the input and output flows; and
- Calculation of the water balance.

4.5 Storm Water Management Plan

A SWMP has been developed in accordance to the Best Practice Guideline G1: Storm Water Management by DWS, 2006. All recommendations will be in line with GN 704. The following is required:

- The Mine plan design indicating the location and size of storm water management structures and a SWMP will be drafted to complement these designs;
- Identify and delineate the clean and dirty water areas on a map; and
- Conceptual placement of clean and dirty water structures indicated on a plan; and make recommendations of SWMP measures.

4.6 Floodline Determination

The initial desktop assessment shows that the Klein Olifants River traverses the project area. The GN 704 requires that mining activities should not take place within the 1:100 year floodlines or within a distance of 100 metres (m) from the water course; whichever is greater. The 1:100 year floodlines was determined for a section of the Klein Olifants River where the project area will be located. Floodline modelling included the following main tasks:

- A hydrological assessment to determine the 1:100 year peak flows;
- Preparation of geometric data for input into the HEC-RAS 4.1.0 model using HEC-GeoRAS 10.2;
- Hydraulic modelling using the HEC-RAS 4.1.0 to determine the 1:100 floodlines;
- Importing HEC-RAS results into HEC-GeoRAS 10.2 and performed flood inundation mapping to produce the 1:100 year floodlines; and
- A report with a plan indicating the 1:100 year floodlines and a 100 m buffer from the river, as well as a discussion of the results together with the recommendations.

4.7 Impact Assessment

An impact assessment was undertaken to:

- Identify the potential surface water (quality and quantity) impacts that may result from the proposed project activities; based on the established baseline conditions. Digby Wells adopted numerical environmental significance rating process that utilises the probability of an event occurring and the severity of the impact has been utilised to determine the significance of a particular environmental impact; and
- Develop mitigation measures for implementation to prevent and/or reduce the identified potential surface water impacts. Monitoring plan has also been provided.

5 Assumptions and Limitations

The following defines the assumptions and limitations applicable to the Hydrological Assessment:

- The surface water impact assessment was done based on the provided mine layout (Figure 1-1) plans and the proposed mining activities. Any changes to the mine plans after completion of this report may require an update of this report;
- Limited information relating to water demand and requirements was available during this study and a number of assumptions were made for the water balance calculation. It is therefore recommended to update the water balance when more information becomes available;
- The determined floodlines should only be used for indicative and environmental purposes, and not for detailed engineering design;
- The 5 m contours used to model the floodlines did not capture the channel dimensions and adjacent floodplains adequately, resulting in flood elevations that are less accurate than if detailed elevation survey data (1 m contour interval or less) had been used;
- A steady state hydraulic model was run which assumes that flow is continuous at the determined peak flow rates. This is a conservative approach which results in higher flood levels than if unsteady state modelling was performed;
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model;
- No abstractions from the river sections or discharges into the river sections were taken into account;
- No dam attenuation was considered in the model;
- The SWMP has been drafted at conceptual level for environmental purposes, thus only placements of infrastructure for SWMP control have been identified from the mine plan with few additional recommendation in terms of extension of infrastructure and recommended management measures;
- There has been no detailed conceptual sizing of storm water infrastructure i.e. the PCDs, silt trap and the clean and dirty water channels as these are already available from Umcebo Mining; and
- The SWMP is based on the existing mine plan (dated 26/06/27) developed for this project and was assumed to be the final mine plan.

6 Baseline Environment

6.1 Hydrological Setting

This section provides the hydrological baseline description and includes a description of the Water Management Areas (WMAs), rivers and drainages, climate (rainfall and evaporation), and water quality status within or around the project area.

6.1.1 Regional Hydrology

The project area or the mining right areas are predominantly located in the Olifants Water Management Area (WMA 04), in quaternary catchment B12A (Figure 6-1). The surface water attributes of the affected catchments namely Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) were obtained from the Water Resources of South Africa 2005 Study (WR2005) and are summarised in Table 6-1.

Table 6-1: Summary of the surface water attributes of the B12A quaternary catchment

Catchment	Area (km^2)	MAP (mm)	MAR $m^3 * 10^6$	MAE (mm)
B12A	405	672	12.69	1501

The B12A quaternary catchment has a net area of 405 km^2 and has a MAR of 12.69 million cubic meters (Mm^3). Runoff emanating from this quaternary catchment drains in a northern direction via the Klein Olifants River which then feeds into the Olifants River.

The Klein Olifants River is the only major perennial river which drains the B12A quaternary catchment. Several non-perennial streams exist within the quaternary and those flow to the Klein Olifants. The quaternary is also characterised by several dams and pans that form part of these non-perennial streams.

The Klein Olifants traverses the Hendrina South MRA in the middle; other four streams which are tributaries to the Klein Olifants also exist in this MRA with two of them on the eastern side of the Klein Olifants and the other two on the western side. Several farm dams exist within this MRA.

The Mooivley West MRA consists of three streams, and few dams and pans. The identified streams within the Mooivley West MRA drains in a north-easterly direction and feed into the Klein Olifants.

The Mooivley East MRA is also traversed by the Klein Olifants with two unnamed streams on both sides of the Klein Olifants. The unnamed stream on the western side confluence with the Klein Olifants at the northern boundary of the Mooivley East MRA, whilst the other one confluence at a downstream point which is outside of MRA.

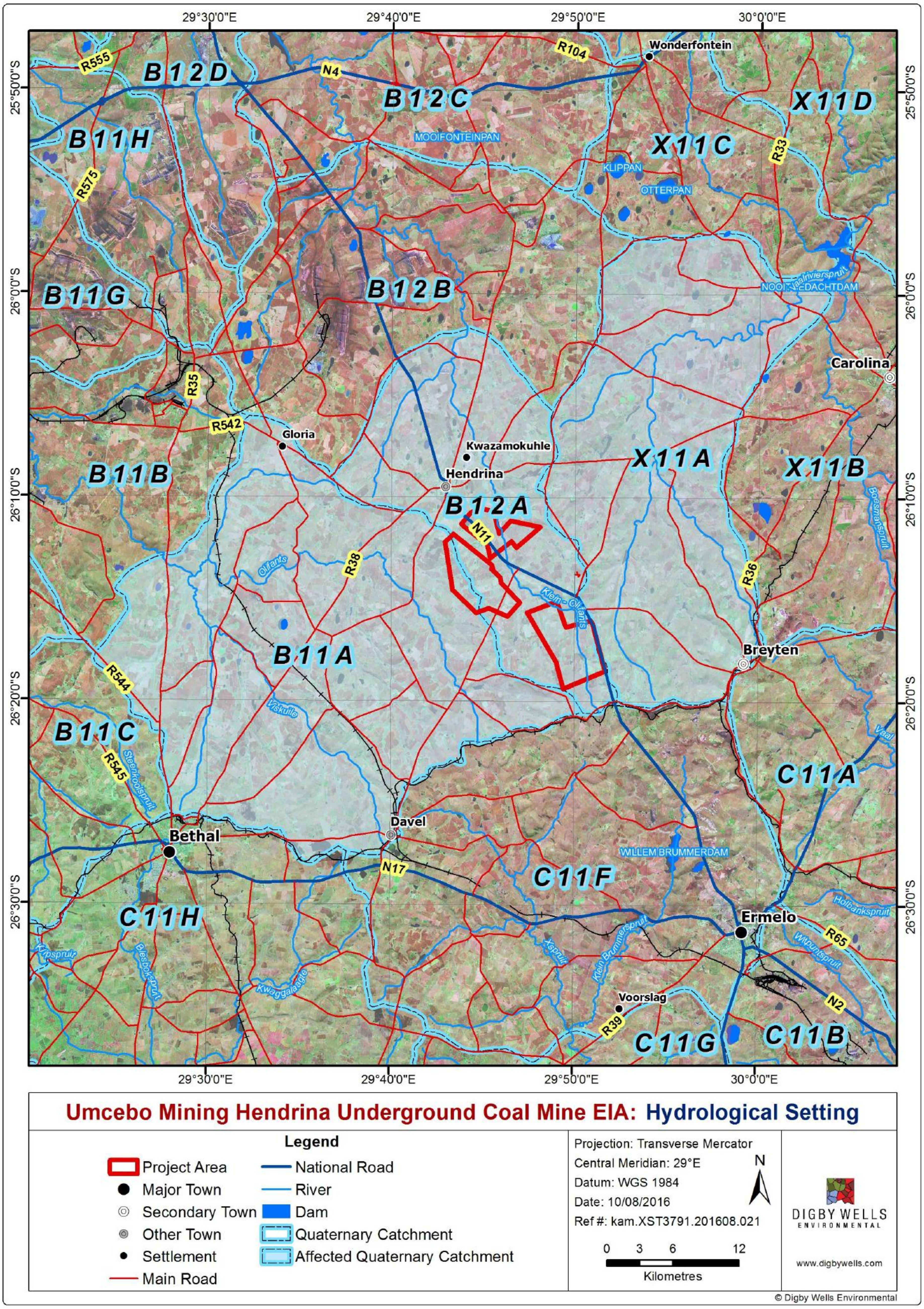

Figure 6-1: Hydrological Setting

6.1.2 Climate

This section provides the climatic conditions (temperature, rainfall and evaporation) of the project area.

6.1.2.1 *Rainfall*

The MAP (obtained from the WR2005 manual) for quaternary catchment B12A is 672 mm, as indicated in Table 6-2.

Table 6-2: Summary of Rainfall Data extracted from the WR2005

Month	MAP (mm)
January	116.9
February	85.3
March	76.7
April	39.2
May	14.6
June	7.6
July	5.8
August	7.1
September	22.3
October	70.4
November	110.4
December	115.6
MAP	**672**

6.1.2.2 *Evaporation*

Monthly evaporation data was obtained from the WR2005 manual (WR2005, 2009). The project area lies within quaternary catchments B12A, which has a MAE of 1 262 mm. The evaporation obtained is based on Symons Pan evaporation measurements and needs to be converted to lake evaporation. This is due to the Symons Pan being located below the ground surface and painted black which results in the temperature in the water being higher than that of a natural open water body. The Symons Pan figure is then multiplied by a lake evaporation factor[3] to obtain the adopted lake evaporation which presents the monthly evaporation rates of a natural open water body. Table 6-3 is a summary of the evaporation from the WR2005 for the B12A quaternary.

[3] Evaporation factor obtained from WR2005

Table 6-3: Summary of Evaporation Data

Months	Symons Pan Evaporation (mm)	Lake Evaporation Factor	Lake Evaporation (mm)
January	165.1	11.0	138.7
February	137.6	9.2	121.1
March	135.8	9.1	119.5
April	104.5	7.0	91.9
May	88.0	5.9	76.5
June	71.4	4.8	60.7
July	78.2	5.2	64.9
August	103.6	6.9	83.9
September	134.2	8.9	108.7
October	161.8	10.8	131.1
November	152.7	10.2	125.2
December	168.1	11.2	139.5
Total	**1 501**	**N/A**	**1 262**

The evaporation rates presented in Table 6-3 show that the highest evaporation of 139.5 mm, 138.7 mm and 131.1 mm was recorded in December, January and October respectively. The monthly minimum evaporation ranges between 60.7 mm in June and 64.9 mm in July.

6.2 Mean Annual Runoff

The B12A quaternary catchment has a net area of 405 km^2 and has an MAR of 12.69 million Mm^3, WR2005. Runoff emanating from this quaternary catchment drains in a north-westerly direction via the Klein Olifants River, towards the Olifants River.

Based on GN 704[4] requirements, all runoff emanating from dirty water areas such as mine infrastructures, operational areas and ROM stockpiles need to be contained within these areas, so as not to mix with the downstream clean water.

[4] Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources; GN R704 in Government Gazette 20119 of 4 June 1999

The proposed project will be an underground mine. However, there will be surface infrastructure including a crushing and screening plant, PCD and offices. The identified infrastructure areas amount to approximately 1.5 km2. The percentage loss in MAR for the B12A quaternary catchment and the subcatchments at each of the 3 sites due to the project are depicted in Table 6-4 and are relatively small, all below 5%.

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Table 6-4 Loss in MAR due to Proposed Infrastructure

Catchment	Total Area (km^2)	Catchment MAR (m^3* 10^6)	Infrastructure Area (km^2)	Percentage decrease in MAR (%)	Loss in MAR (m^3* 10^6)
B12A	405	12.69	0.42	0.10	0.013
Hendrina South	1.61	0.05	0.06	3.72	0.002
Mooivley West	9.36	0.29	0.18	1.92	0.006
Mooivley East	7.71	0.24	0.18	2.33	0.006

6.2.1 Storm Rainfall Depths

The closest weather stations to the Project area are presented in Table 6-5. The data was used to estimate the 24-hour design rainfall depth (Table 6-6) using the Design Rainfall Estimation (DRE) in South Africa (Smithers and Schulze, 2003).

Table 6-5: Summary of the Closest Rainfall Stations

Station Name	SAWS Number	Distance from Project Centre (km)	Record Length (years)	Lat (°) (')	Long (°) (')	MAP (mm)	Altitude (m)
MORGENSTER	0479552_W	5.7	72	26° 12'	29° 49'	624	1690
TEVREDEN	0479348_W	12.1	47	26° 18'	29° 42'	693	1685
HENDRINA (MUM)	0479369_W	14.1	49	26° 9'	29° 43'	681	1682
KLIPFONTEIN	0479739_W	16.1	62	26° 19'	29° 56'	720	1724
VLAKLAAGTE	0479225_W	18.1	70	26° 14'	29° 38'	680	1640
KARINA	0479545_W	18.1	70	26° 5'	29° 49'	663	1642

Table 6-6 presents the estimated rainfall depths for a 24-hour rainfall event for various return periods for the stations mentioned in Table 6-5.

Table 6-6: Estimated 24 Hour Design Rainfall Depth

Design rainfall return period (yrs)	1:2	1:5	1:10	1:20	1:50	1:100	1:200
24 Hr design peak rainfall (mm)	58.5	77.6	91.2	104.8	123.6	138.4	154.0

6.2.2 Flows

A DWS flow gauging station (B1H026) is located approximately 20 km downstream of the project site on the Klein Olifants River. However, there is no recorded flow data available on the DWS data archive for this gauge station. During the site visit conducted on the 16th and 17th of March 2016, the Klein Olifants was mostly dry with no flow whilst at some points there were stagnant water, but not enough to flow along the river.

The catchment peak flows has been simulated from the Utilities Programme for Drainage (UPD). This peak flow will has been utilised when modelling the flood extent during the 1:100 year rainfall event.

6.3 Land and Water Uses

The predominant land and surface water use in the study area is agricultural (livestock watering and crop irrigation); according to the Water Authorisation and Registration Management System (WARMS) database.

Based on the site survey, several cultivated land exist within all the mining right areas, while other parts consist of grassland and farm houses.

6.4 Water Quality

A site visit was conducted on the 16th and 17th of March 2016 to collect water samples from the Klein Olifants River and other streams around the project area. The Klein Olifants was mostly dry with sections having stagnant water. Five water samples were collected.

March is considered wet season in South Africa hence the water quality results for March represent the baseline water quality during wet season. During the dry season, only two samples were collected at the same locations as the other monitoring points were dry; this sampling round was completed in June 2016.

Samples were submitted to Aquatico Laboratory (Pty) Ltd, a SANAS accredited laboratory, in Pretoria for analyses of physical and chemical water quality parameters. Table 6-7 presents the coordinates for the surface water sampling points and these are also shown on Figure 6-3. The results of the surface water quality analysis are presented in Table 6-8.

The predominant water use around the project area is agriculture (irrigation) and for that reason the results were also benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996). The Resource Water Quality Objectives (RWQOs) are defined by the DWS, based on the National Water Act, 1998 (Act No. 36 of 1998) (NWA) as “clear goals relating to the quality of the relevant water resources” (DWAF, 2006a). In South Africa, SAWQG have been developed as discrete values that depict the change from one category of fitness for use to another (DWAF, 1996).

The Klein Olifants water quality has also been benchmarked with the RWQO for the Upper and Middle Olifants catchments. To understand the baseline water quality of the project area, analysis of the variation in the water quality during the wet and dry season was undertaken.

The water quality guidelines describe the “fitness for use” of a water resource, while the Water Quality Objectives defines “what management action is required” for a water resource. The fitness for use of water defines how suitable the quality of water is for its intended use.

Table 6-7: Surface Water Monitoring Points

Point Name	Latitude*	Longitude*
SW01	26°13'58.88"S	29°46'35.67"E
SW02	26°14'40.47"S	29°46'56.78"E
SW03	26°13'6.39"S	29°46'7.33"E
SW05	26°17'30.89"S	29°50'14.73"E
SW06	26°8'49.83"S	29°45'8.31"E

*Geographic Coordinate System WGS84 Datum

6.4.1 Description of the Sampling Locations

Samples were collected at six different monitoring locations. These locations can be described as follows:

- SW01 is the first sample point on the Klein Olifants River and is situated downstream of the Mooivlei East MRA, along the gravel road which joins the N11 on the North East side from the sampling point;
- SW02 is a sampling point located on an unnamed stream between the Mooivlei East and the Mooivley West MRAs. This unnamed stream is a tributary to the Klein Olifants;
- SW03 is a sampling point downstream of the Mooivlei East MRA on the Klein Olifants. This is at the bridge along the N11 road. There is an unnamed tributary which originates from the Mooivlei West MRA and confluence with the Klein Olifants approximately one kilometre upstream of SW03 sampling point. Thereby it will enable monitoring or detection of impacts arising from the Mooivlei West MRA;

- SW04 is a point on an unnamed stream which is upstream of Hendrina South MRA. This point was dry and sampling was not possible during the visit;
- SW05 is an upstream sampling point on the Klein Olifants. This sampling point is below a dam and is located within the Mooivlei East MRA; and
- SW06 is a downstream sampling point on the Klein Olifants at a bridge along the R38 road.

At these sampling locations, there were patches of stagnant water in which the samples were taken; no flow was observed, therefore the samples are likely not to be representative of stream water quality. Figure 6-2 presents some of the sampling locations.

Figure 6-2: Images of the Sampling Locations

Table 6-8: Water Quality Results benchmarked against the Olifants RWQO and SWQG: Irrigation use guidelines

Sample ID		pH	EC (mS/m)	TDS (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	NH_4 (mg/l)	PO_4	F (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	Fe (mg/l)
Olifants RWQO		**6.5 - 8.4**	**111**	**N/A**	**5**	**500**	**4**	**0.1**	**0.125**	**3**	**N/A**	**N/A**	**N/A**	**N/A**
SWQG: Agriculture Use: Irrigation (Target water quality)		**<6.5 - >8.4**	**N/A**	**40**	**140**	**N/A**	**N/A**	**N/A**	**N/A**	**2**	**N/A**	**N/A**	**70**	**5**
Wet Season														
SW01	18/03/2016	7.4	19.0	116.0	7.7	20.6	0.40	0.27	0.00	0.4	14.0	8.0	13.7	-0.004
SW02	18/03/2016	8.2	36.1	213.0	23.7	19.0	0.32	0.15	0.00	0.6	24.2	14.9	35.0	-0.004
SW03	18/03/2016	8.2	38.3	229.0	21.2	16.5	-0.13	0.18	0.00	0.6	18.3	12.8	52.7	-0.004
SW05	18/03/2016	8.1	31.1	194.0	18.4	22.5	-0.13	0.19	0.00	0.5	21.9	16.8	21.5	-0.004
SW06	18/03/2016	7.8	46.1	280.0	15.3	24.1	-0.13	0.73	0.00	0.5	30.6	17.0	56.4	-0.004
Dry Season														
SW05	17/06/2016	8.6	57.9	316.0	23.0	2.1	-0.13	0.3	0.0	0.5	43.6	18.4	62.9	-0.004
SW06	17/06/2016	9.0	94.5	520.0	59.0	74.3	-0.13	0.3	0.0	0.6	47.2	58.2	77.2	-0.004

Negative figure = below detection limit

N/A = No specified Guidelines value

6.4.2 Water Quality Results

In Table 6-8, the Olifants River Water Quality Objectives defines “what management action is required” while the Target Water Quality Range/ No Effect Range specifies good or ideal water quality, instead of water quality which is merely acceptable. Water quality results can be summarised as follows:

- pH at SW05 and SW06 exceeded (>8.4) the Olifants RWQO and the target water quality for agricultural use: irrigation, but only during the dry season;
- All samples have elevated TDS levels that exceed the SWQG limits (40 mg/l) for Agriculture/ Irrigational use. The Olifants RWQO does not specify guideline limits for TDS;
- Chloride (Cl) concentrations exceeded the Olifants RWQO (5 mg/l) during wet and dry seasons. However, the concentrations were still within the SWQG: Irrigational limit of 140 mg/l;
- Ammonia (NH_4) concentrations exceeded the Olifants RWQO limit (0.1 mg/l) in both wet and dry seasons; and
- Sodium (Na) at SW06 exceeded the SWQG: Irrigational limit of (70 mg/l) during the dry season.

The Klein Olifants River was not flowing during the wet and dry season surveys. During the dry season or low flows, the lower volume of water reduces the dilution effect on several parameters and high parameters concentrations are likely to be observed.

The water quality presented does not provide a precise river water quality as there was no flow during the site assessment. Samples were taken on stagnant pools of water along the river and this only provides an indicative baseline water quality which will still need to be updated during high flows.

Figure 6-3: Surface Water Monitoring Points

7 Water Balance

A site-wide water balance model has been prepared to understand flows within the Hendrina underground coal mine operational water circuit, during average dry season and average wet season scenarios. This section details the water balance which is done in accordance with the Best Practice Guideline G2 – Water and Salt Balances (DWS, 2010).

7.1 Objectives

The water balance will be used by the mine in support of the Water Use Licence (WUL) application as well as a water management tool to achieve the following key principles of water management:

- Understand the water circuit at the mine;
- Estimate makeup water volumes required during periods of deficit;
- Estimate volumes of excess water during periods of surplus; and
- Assess areas within the mine water circuit, where opportunities to conserve and re-use water can be implemented.

7.1.1 Water Balance Components

A summary of the information used in the water balance include:

- Climate data which includes rainfall and evaporation; and
- Mine water requirements obtained from the applicant, which include potable water and water uses at operational phase.

Water sources (inflows) were taken as:

- Groundwater ingress into the underground mine;
- Storm water collected from dirty catchments and conveyed to PCD;
- Runoff from the stockpiles; and
- Potable water supply from boreholes until such time that these can be obtained from underground sumps for treatment during operation.

Water sinks (losses) were taken as:

- Evaporation from PCD;
- Dust suppression;
- Sumps within the open underground for water recycling and reuse; and
- Water consumption.

7.1.2 Assumptions

The water balance assumed the following:

- Sewage water from the offices and workshops is not reused in the system, but disposed of into a soak away system after treatment at the Package STP;
- Rainfall related inflows and evaporation related losses for the wet and dry conditions were estimated for each month;
- Monthly rainfall and evaporation used in the water balance are based on WR2005 data which is representative of the entire quaternary catchment area. This is therefore a generalised description of the climate and does not necessarily depict onsite rainfall and evaporation rates, which currently are not available;
- Runoff and evaporation coefficients for each surface were fixed and not influenced by antecedent climatic conditions;
- The wet season is defined by the three wettest months (November, December and January) and the dry season as the three driest months (June, July and August);
- The yearly water balance summary is based on a full 12 operational months in each year;
- The groundwater ingress was available for the entire Life of Mine from the estimated inflows in the Groundwater Report (Digby Wells, 2016), for the purpose of this water balance, average values were used for each of the underground mining areas;
- All footprint areas used in the water balance calculation are based on the provided infrastructure plan;
- The water used at the offices, workshops and underground will be sourced from treatment plant distributed from the Jojo tanks. An allocation of 100 L/day per person for the employees has been assumed;
- As per the project description, it is assumed that water that will be required for all activities will be less than 2000 m^3/day during the operational phase in addition to the 100L/day allocated to employees;
- The total water requirement of 2000 m^3/day for all underground areas is assumed to be for the underground water and haul road dust suppression uses with a one third (1/3) distribution amongst the three mines;
- Dust suppression requirement was determined from the assumption that 3 mm of water will be used daily for the total area of the haul roads as well as the conveyor discharge and transfer points;
- The Continuous Miner and the Roof bolter water requirements are included in the 2000 m^3/day water requirements considered in the calculations; and
- The water from the PCD will be used for the on surface dust suppression.

7.2 Model Input Parameters

The input parameters used for the water balance are presented in Table 7-1:

Table 7-1: Hendrina Water Balance Input Parameters

Description	Value/Quantity	Units	Notations
Areas			
Office Area	43 893.3	m^2	Based on Mine plan
Change House	842.06	m^2	Based on Mine plan
Fuel Stations	366.19	m^2	Based on Mine plan
Main Offices	875.42	m^2	Based on Mine plan
Security Office	68.42	m^2	Based on Mine plan
Shift Change Office	390.47	m^2	Based on Mine plan
Stores / Offices (Spares)	319.77	m^2	Based on Mine plan
Wash Bay	283.25	m^2	Based on Mine plan
Workshop	742.86	m^2	Based on Mine plan
Sewer Treatment Plant	22.31	m^2	Based on Mine plan
Water Treatment Plant	22.31	m^2	Based on Mine plan
Generator & Mini Substation	32	m^2	Based on Mine plan
Parking	23 093.69	m^2	Based on Mine plan
Product Stockpile Mooivley West	36 591.05	m^2	Based on Mine plan
Overburden stockpile Mooivley West	10 000	m^2	Based on Mine plan
Overburden stockpile Hendrina South	10 000	m^2	Based on Mine plan
Product stockpile Mooivley East	37 297	m^2	Based on Mine plan
Overburden stockpile Mooivley East	10 000	m^2	Based on Mine plan
Top Soil Mooivley West	30 000	m^2	Based on Mine plan
Topsoil Hendrina South	30 000	m^2	Based on Mine plan
Topsoil Mooivley East	30 000	m^2	Based on Mine plan
PCD Hendrina South	3 300	m^2	Based on Engineering Designs
PCD Mooivley West	8 100	m^2	Based on Engineering Designs
PCD Mooivley East	8 100	m^2	Based on Engineering Designs

Description	Value/Quantity	Units	Notations
Weighbridge Parking Hendrina South	342.9	m^2	Based on Mine plan
Office Complex	875.42	m^2	Based on Mine plan
Haul roads Mooivley West	3 281.15	m^2	Based on Mine plan
Haul roads Hendrina South	1 471.3	m^2	Based on Mine plan
Haul roads Mooivley East	1 183.54	m^2	Based on Mine plan
Mooivley East Board and Pillar	407.4	Ha	Based on Mine plan
Mooivley West Board and Pillar	1 542.9	Ha	Based on Mine plan
Hendrina South Board and Pillar	1 065.5	Ha	Based on Mine plan
Ratios and Coefficients			
Office and workshop area	0.7		Assumed to be compacted areas (using double chip and spray bituminous seals)
Office and workshop area	0.3		Assumed to be grassed areas
Rain onto stockpiles (runoff and seepage)	0.6		Hodgson and Krantz,1998 (Assumed un-rehabilitated spoils)
Rain onto stockpiles (runoff and seepage)	0.1		Hodgson and Krantz,1998 (Assumed rehabilitated spoils)
Number of Employees	86.0		During construction
Number of Employees	371.0		Operational Phase
Number of Employees - Underground	189.0		Operational Phase
Number of Employees-Surface	182.0		Operational Phase
Volumes			
PCD Hendrina South	10 000	m^3	Based on Mine plan ; designed to contain a 1:50-year flood event
PCD Mooivley West	24 000	m^3	Based on Mine plan
PCD Mooivley East	24 000	m^3	Based on Mine plan
Water Make			
Ground Water inflows Hendrina South	11 958.3	m^3/month	Average from the estimated inflows in the Hydrogeological Study for 30.5 days per month

Description	Value/Quantity	Units	Notations
Ground Water inflows Mooivley West	7 908.9	m^3/month	Average from the estimated inflows in the Hydrogeological Study for 30.5 days per month
Ground Water inflows Mooivley East	3 390.6	m^3/month	Average from the estimated inflows in the Hydrogeological Study for 30.5 days per month
Ground Water inflows Total	21 427.4	m^3/month	Average from the estimated inflows in the Hydrogeological Study for 30.5 days per month
Water Demands			
Potable Water treatment plant	150	m^3/day	Maximum from Project description
Sewer treatment plant capacity	150	m^3/day	from Project description
Sewage Effluent generated	30	m^3/day	from Project description
Sewage sludge produced	20	m^3/month	from Project description
Water Uses Construction	500	m^3/day	from Project description-Information Request
Operation Phase	2 000	m^3/day	from Project description for four sections underground) - Information Request
Water Consumption per individual	0.1	m^3/day	Assumed 100L/day from Project Description both during operation and construction
Dust suppression demand	3	mm/day	Assume 3mm water for total area for dust suppression per day
Potable water losses to sewage treatment plant	0.85		Assumed 0.85 of water supplied
Water consumption and system losses	0.15		Assumed 0.15 of water supplied

7.3 Results

The summary of the average wet period water balance and the average dry period water balance are shown in Figure 7-1, Figure 7-2 , Figure 7-3 and Figure 7-4.

The water balance results are summarised as follows:

- The water requirements for the three sites were calculated based on the maximum water use of 2 000 m^3/day and these resulted in water demand of 20 333 m^3/month;
- The water balance calculations indicate that the water requirements (2000 m^3/day) at the mine will not be met by the water make as underground water make ranges between 0 and 1 000 m^3/day and the runoff which was within the ranges of 0 and 84 m^3/day;
- The deficit will therefore be in the order of magnitude of 1 000 m^3/day in total; and
- More specifically, the deficits were calculated to be in the dry season between 8 000 and 18 000 m^3/month per site; and in the wet season between 7 000 and 15 000 m^3/month per site. The mine will have to investigate the source of the make-up water.

The results of the water balance as per recent DWS template are illustrated in Table 7-2.

7.4 Limitations and Further Work

Limited information was available and a number of assumptions were made for the water balance calculations. This study is therefore recommended to be updated as more information becomes available. A summary of limitations and further work required is listed below:

- Generation of runoff will vary substantially season to season and year to year and it is recommended that runoff volume measurements are collected and used to calibrate the water balance model particularity in the water storage structures such as PCDs;
- The model is based on conservative values, assuming the maximum areas for runoff. It will be necessary to update with an operational mine water balance when mining commences;
- Underground water uses have been based on assumptions; actual water requirements should be determined;
- The dust suppression water demand should be recorded and used to calibrate the model; and
- In addition to runoff and groundwater inflow, monitoring of the other key water transfers should be undertaken on monthly basis and used to calibrate the water balance model.

Table 7-2: Water Balance Summary

Facility Name	Water In			Water Out			Balance
	Water Circuit/stream	Quantity (m^3/mon)	Quantity (m^3/a)	Water Circuit/stream	Quantity (m^3/month)	Quantity m^3/a)	Quantity (m^3/month)
Potable Water Treatment Plant				Underground Potable Water Demand	576	6 916	
	Boreholes / Underground Supply	1 130	13 560	Surface Potable Water Demand	554	6 644	
		1 130	**13 560**		**1 130**	**13 560**	**0**
Pollution Control Dam Mooivley West	Rainfall	454	5 442	Dust Suppression	300	3 598	
	Runoff Product Stockpile	1 229	14 751	Evaporation	852	10 220	
	Underground dewatering	6 779	81 347	Underground and other Uses	20 034	240 402	
	Runoff Topsoil Stockpile	168	2 016	Storage	0	0	
	Runoff Overburden Stockpile	336	4 031				
	Runoff Office Area	25	294				
		8 990	**107 881**		**21 185**	**254 220**	**-12 195**
Pollution Control Dam Hendrina South	Rainfall	185	2 217	Dust Suppression	134	1 613	
	Underground dewatering	11 958	143 500	Evaporation	347	4 164	
	Runoff Topsoil Stockpile	168	2 016	Storage	0	0	

Facility Name	Water In			Water Out			Balance
	Water Circuit/stream	**Quantity (m^3/mon)**	**Quantity (m^3/a)**	**Water Circuit/stream**	**Quantity (m^3/month)**	**Quantity m^3/a)**	**Quantity (m^3/month)**
	Runoff Overburden Stockpile	336	4 031	Underground and other Uses	20 199	242 387	
		12 647	**151 765**		**20 680**	**248 164**	**-8 033**
Pollution Control Dam Mooivley East	Rainfall	454	5 442	Dust Suppression	108	1 298	
	Runoff Product Stockpile	1 253	15 036	Evaporation	852	10 220	
	Runoff Topsoil Stockpile	168	2 016	Storage	0	0	
	Runoff Overburden Stockpile	336	4 031	Other Uses	3 536	42 429	
	Runoff Office Area	25	294				
	Underground dewatering	2 261	27 127				
		4 496	**53 946**		**4 496**	**53 946**	**-16 689**
Total Water Balance		**14 616**	**175 388**		**43 500**	**522 000**	**-28 884**

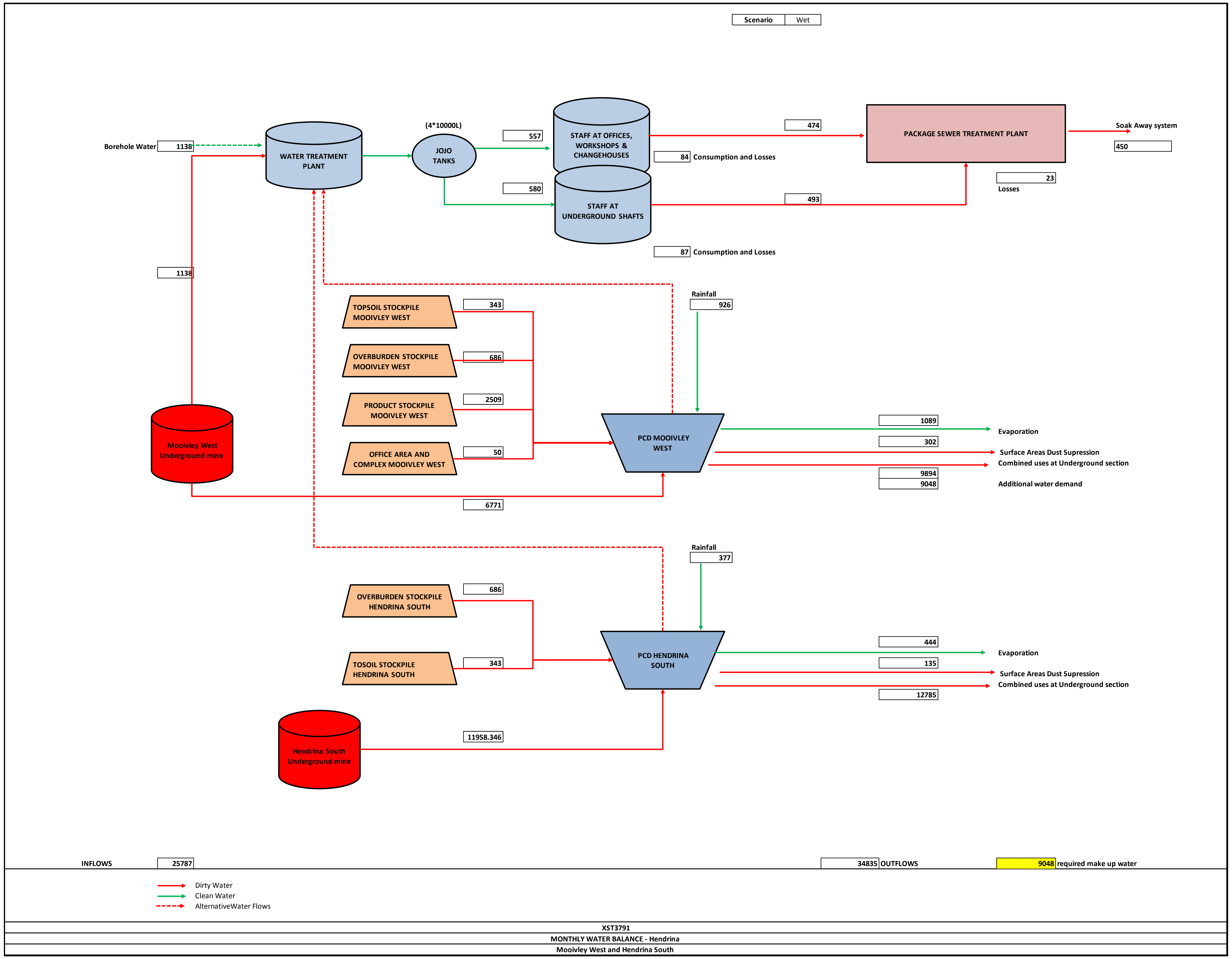

Figure 7-1: Monthly wet season water balance (m^3/month) – Hendrina South and Mooivley West

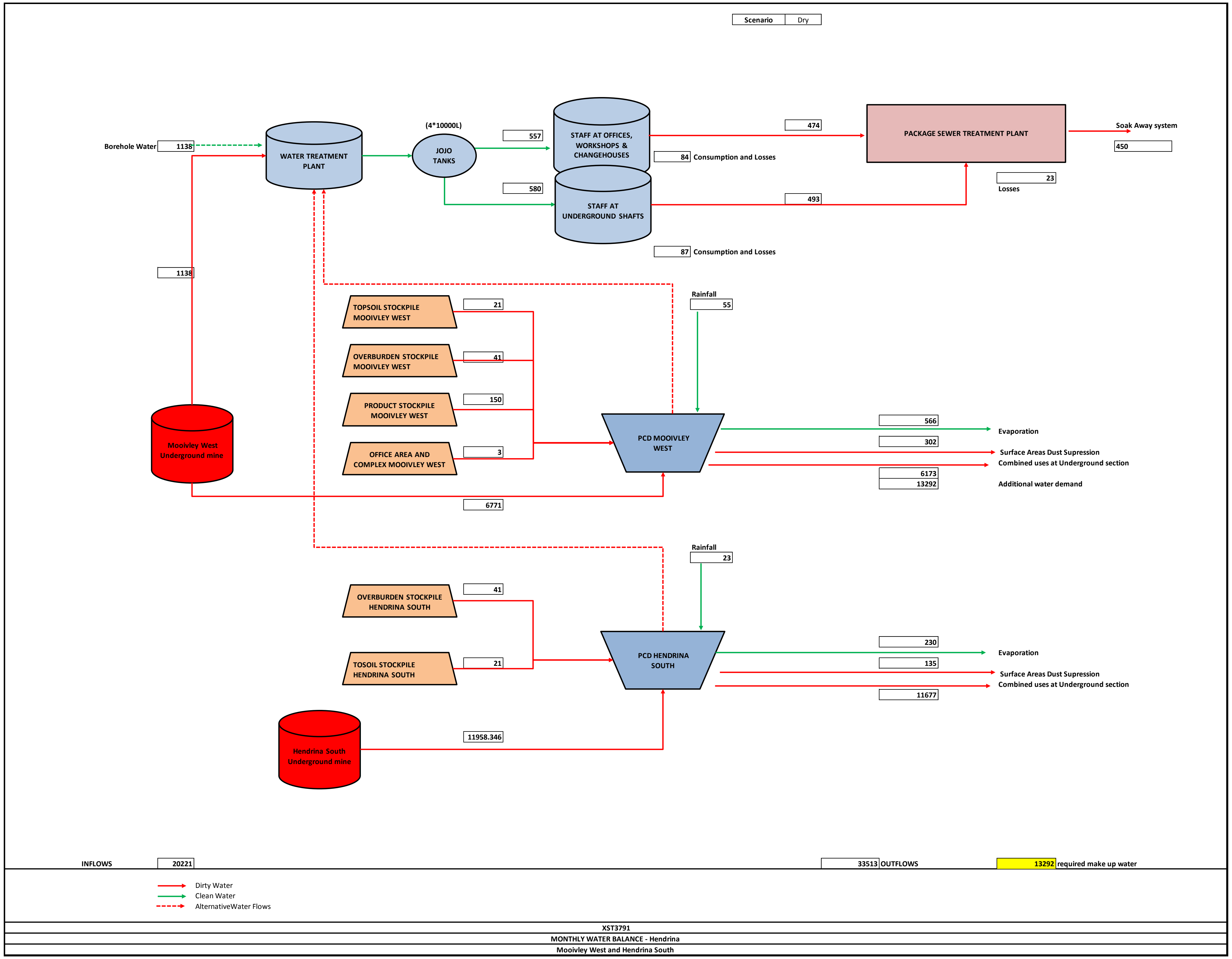

Figure 7-2: Monthly dry season water balance (m^3/month) - Hendrina South and Mooivley

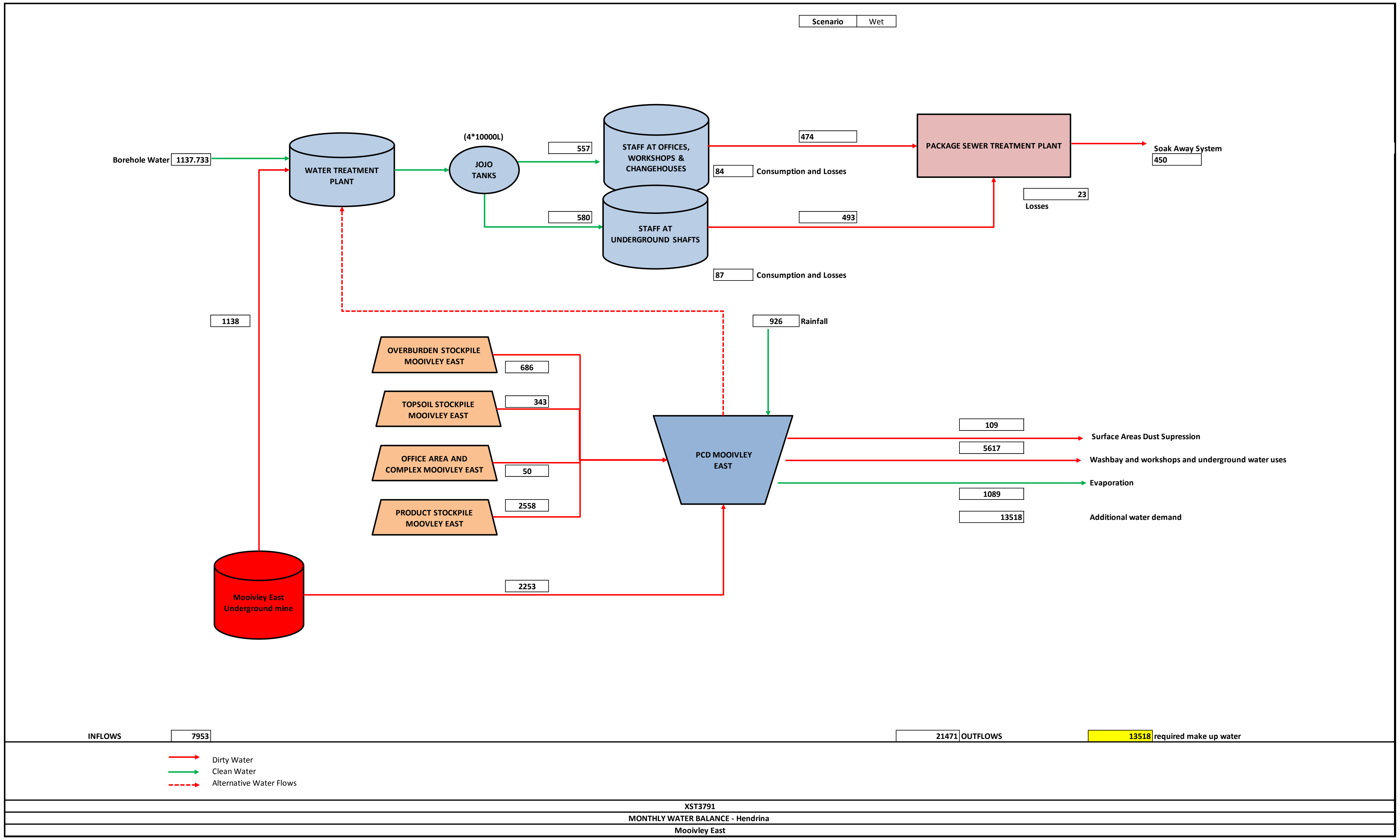

Figure 7-3: Monthly wet season water balance (m^3/month)–Mooivley East

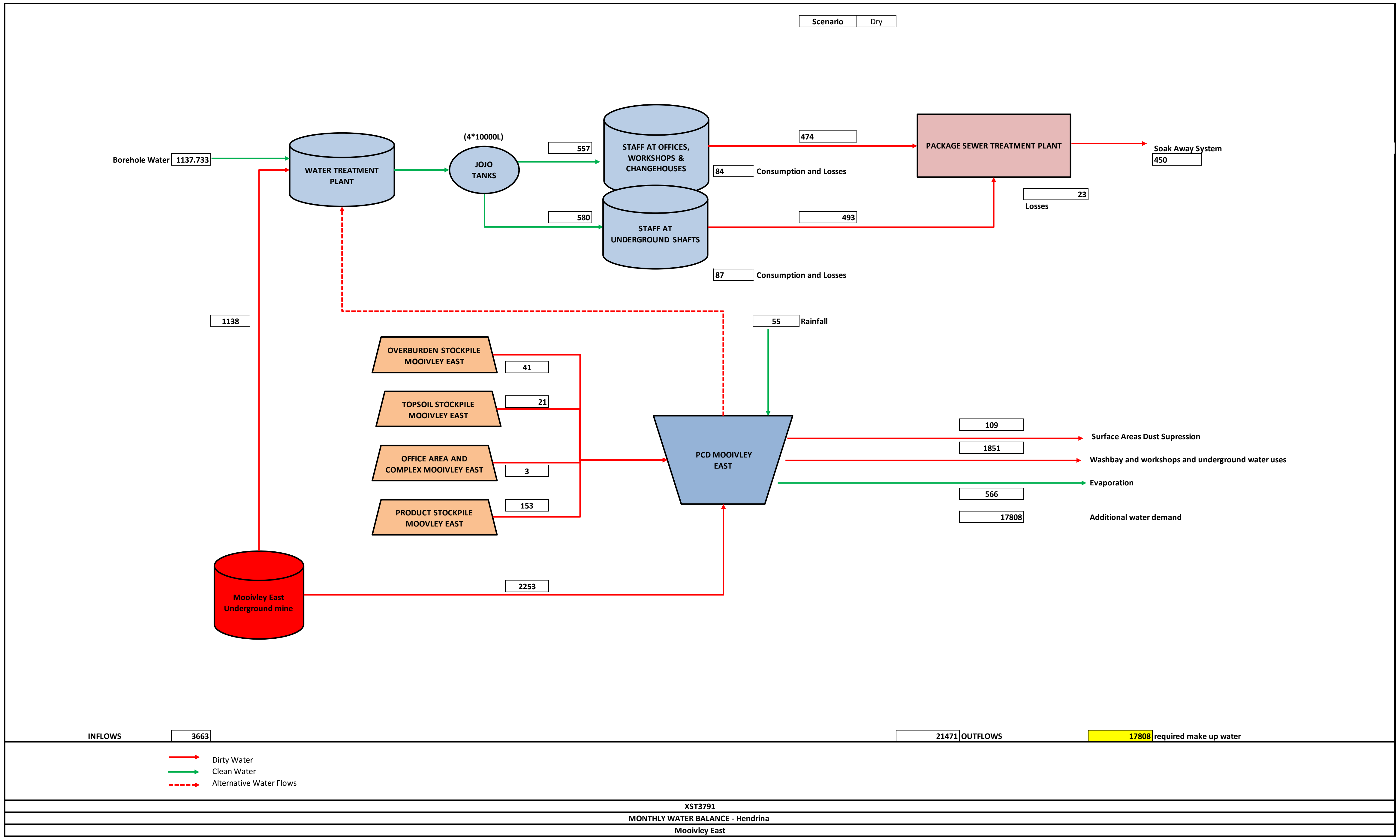

Figure 7-4: Monthly dry season water balance (m^3/month) - Mooivley East

8 Floodlines Determination

8.1 Introduction

In order to understand the risk of flooding to the proposed mine infrastructure, and in accordance with GN 704 regulations, where it is stated that infrastructure should not be placed within the 1:100 year floodline, or a horizontal distance of 100 m from a watercourse (whichever is greater), it is necessary to determine the 1:100 year floodlines. Streams and drainage lines within close proximity to surface infrastructure areas were modelled.

This section details the methods used in the development of the hydraulic model, assumptions and limitations on which the model is based, and the identification of infrastructure located within the 1:100 year floodline and/or 100 m buffer of watercourses. Lastly, recommendations are provided.

8.2 Methodology

8.2.1 Software

Two software programmes were used in the determination of the floodlines and are described below.

HEC-GeoRAS utilises the ArcGIS environment for the preparation of geometric data (cross-sections, river profile, banks and flow paths) for input into the HEC-RAS hydraulic model. It is further used to import HEC-RAS results back into ArcGIS to perform flood inundation mapping.

HEC-RAS 4.1 (Brunner, 2010) was used to perform hydraulic modelling. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has been thoroughly tested through numerous case studies.

8.2.2 Topographical Data

Detailed elevation data was not available for the project area, and therefore, the next best available data was a 5 m contour dataset, which was obtained from the Chief Directorate: National Geo-spatial Information. The topographical data is used to extract elevation data for the river profiles and cross-sections. It is further used to perform flood inundation mapping.

8.3 Catchment Characteristics and Peak Flow Estimation

The catchments used for the floodline determination were delineated from a Digital Elevation Model (DEM) created from the 5 m contour dataset. The delineated catchments are indicated on Figure 8-1.

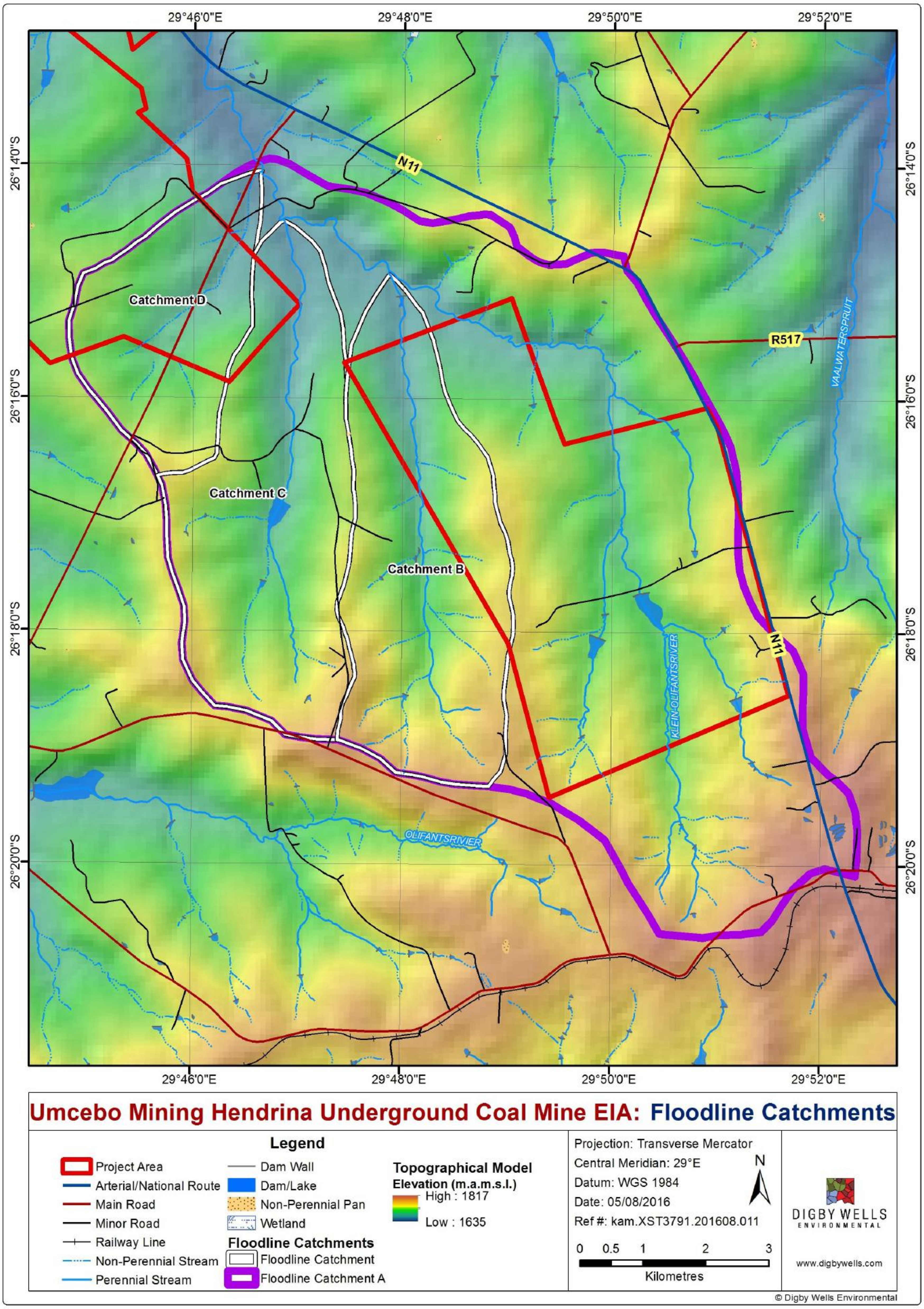

Figure 8-1: Delineated Catchments

The Rational Method and Standard Design Flood (SDF) Method were used to calculate the 1:50 and 1:100 year peak flows and are described below. The Rational Method was used to calculate peak flows for streams with catchments less than 15 km² and the SDF Method was used for catchments greater than 15 km². The (Utilities Programme for Drainage UPD) software which contains the Rational and SDF Methods was used to perform calculations.

The Rational Method is a hydrological method used to predict peak flow. It is based on the equation shown below:

$$Q_T = \frac{C\ I\ A}{3.6}$$

where:

Q_T = Peak flow for a recurrence interval e.g. a 1:100 year flood (m³/s)

C = Runoff coefficient (dimensionless)

I = Average rainfall intensity over the catchment (mm/hour)

A = Catchment contributing to the peak flow (km²)

3.6 = Conversion factor

The runoff coefficient C is based on a number of different physical characteristics of the contributing catchment. These include the vegetation type, slope, drainage properties of the soil, and land use characteristics.

The Rational Method has the following assumptions:

- Rainfall has a uniform area distribution across the total contributing catchment;
- Rainfall has a uniform time distribution for at least a duration equal to the time of concentration;
- The peak discharge occurs when the total catchment contributes to the flow occurring at the end of the critical storm duration, or time of concentration;
- The runoff coefficient C remains constant for the storm duration, or time of concentration; and
- The return period of the peak flow T is the same as that of the rainfall intensity.

The SDF Method is an empirical regionally calibrated version of the Rational Method. The only information required for its application is the area of the catchment, the length and slope of the main stream, and the drainage basin in which it is located. The SDF method is applicable to catchments of between 10 km² to 40 000 km².

A summary of the catchment characteristics and calculated peak flows for each catchment is indicated in Table 8-1 below.

Table 8-1: Summary of Catchment Characteristics and Peak Flows used in the Flood Study

Catchment	Catchment A	Catchment B	Catchment C	Catchment D
MAP (mm)	672	672	672	672
Catchment Area (km^2)	89.52	16.32	16.95	9.27
Longest Watercourse (km)	18.21	8.58	7.84	4.54
Height Difference along 10-85 (m)	59	65	46	44
Average Slope along 10-85 (m/m)	0.00432	0.01010	0.00782	0.01292
Distance to Catchment Centroid (km)	6.64	4.8	4.9	2.95
Peak Flow Method	SDF	SDF	SDF	Rational
1:50 Year Peak Flow (m^3/s)	228.83	93.16	94.44	76.17
1:100 Year Peak Flow (m^3/s)	291.4	118.76	120.39	98.21

8.4 Roughness Coefficients

The Manning's roughness factor 'n' is used to describe the flow resistant characteristics of the channel and floodplain. Based on the site visit and an assessment of aerial imagery, a Manning's 'n' value of 0.040 was assigned to both the floodplain and channel.

8.5 Model Development

Development of the hydraulic model included the following steps:

- Creation of a 5 m spatial resolution DEM from the 5 m contour data in ArcGIS 10.2;
- Digitising the stream centre lines and flow paths using HEC-GeoRAS;
- Digitising cross-sections approximately 100 m apart through the stream centre lines using HEC-GeoRAS;
- Importing geometric data into HEC-RAS;
- Entering the Manning's 'n' values, peak flows, and upstream and downstream slope boundary conditions in HEC-RAS;
- Performing steady, mixed-flow regime hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections; and
- Importing flood levels into HEC-GeoRAS and performing floodplain delineation.

8.6 Flood Modelling Results

The 1:100 year floodlines are illustrated on Figure 8-2 . A floodline determination for surface infrastructure at Mooivley East was not undertaken, as the closest stream was approximately 900 m away, with an elevation difference in excess of 10 m. The following surface infrastructure falls within the floodlines and / or the 100 m buffer of watercourses:

- Fence around Mooivley East infrastructure;
- Conveyor, access road and fence connecting Hendrina South and Mooivley West sites; and
- Fence, haul road and access road at Mooivley West.

8.7 Recommendations

The following is recommended:

- The conveyor and access road connecting Hendrina South and Mooivley West, should be elevated above the floodline at a height of approximately 1 662 mamsl (height subject to more detailed and accurate elevation survey data). A culvert / bridge for the road crossing should be constructed and sized appropriately. The fence should be designed and constructed to withstand a 1:100 year flood;
- The proposed berm running along the haul road at Mooivley West, must be constructed above the floodline at a height of approximately 1 696 mamsl (height subject to more detailed and accurate elevation survey data), to ensure that flooding of infrastructure does not occur; and
- A water authorisation in terms of Section 40 of the NWA for all watercourse crossings should be applied for in the water use license application.

Lastly, as mentioned previously, the 5 m contours which were used to model the floodlines, do not accurately capture the channel dimensions and adjacent floodplains, resulting in less accurate flood elevations. It is recommended that a detailed elevation survey is undertaken and that the floodlines are remodelled using this data, to obtain accurate flood elevations

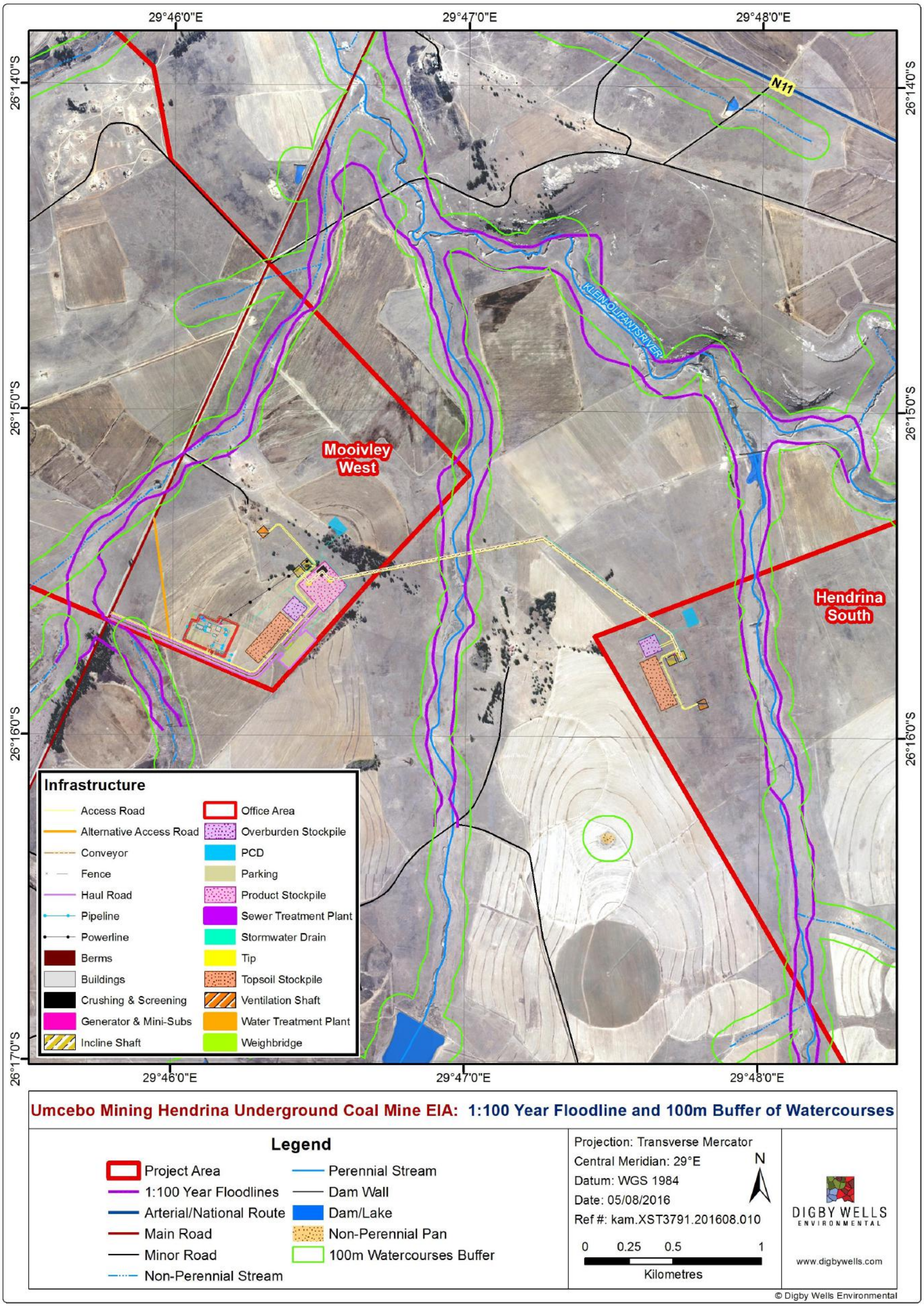

Figure 8-2: Floodlines Map

9 Stormwater Management Plan

Storm water management and drainage planning are critical for the management of water and waste at mining sites and a Storm Water Management Plan (SWMP) needs to be developed under the guidance of the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPG) (DWS, 2006) focusing on storm water management (BPG: G1).

9.1 Storm Water Management Principles

Mining operations have the potential to have a negative impact on the natural water quality of an area in the following ways:

- Bulk earthworks will strip vegetation and expose topsoil and sub-soils. Storm water will contribute to erosion thereby increasing levels of suspended solids within local watercourses and water features;
- Earthworks and mineral processing operations may expose elements naturally occurring within soils and geology, mobilising them into local watercourses and water features;
- Storage and use of process specific chemicals and vehicular related pollutants which, if not properly managed, may be washed by storm water into local watercourses and water features; and
- Discharge of polluted or improperly treated storm water, process water and sewage water into local watercourses or water features may occur.

A negative impact on the baseline water quality by mining operations will likely affect local aquatic ecosystems, and/or the local community who use the water for drinking, washing, irrigating or livestock watering.

In addition to the above, storm water may pose a risk of flooding to a proposed development, if not managed correctly.

The aim of this SWMP is to mitigate the above impacts by fulfilling the requirements of the NWA and more particularly GN 704.

The following definitions from GN 704 are appropriate to the classification of catchments and design of storm water management measures for the proposed project:

- **Clean water system:** includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- **Dam:** includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- **Dirty area:** means any area at a mine or ***activity*** which causes, has caused or is likely to cause pollution of a water resource;

- **Dirty water system:** This includes any dirty water diversions bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- **Activity:** means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

9.2 Objectives

The main objective of surface water management is to ensure that surface water risks within the sub-catchments of the Klein Olifants River, where the projects site surface activities and infrastructure is located, are minimised.

The SWMP will provide conceptual inputs into the management of the proposed storm water structures outlined in the mine plan design and make recommendations for additional erosion and placement of storm water management structures.

The measures provided in the SWMP have been developed in accordance with the principles of BPG G1: Storm water management (DWS, 2006), with the objective of keeping clean and dirty water separate, as defined by the following:

- Collect all storm water that is of poor quality in a dirty water trench and contain it within the storage facilities (dam) for reuse;
- Ensure that all storm water structures that are designed to keep dirty and clean water separate can accommodate a defined precipitation event. The magnitude of the precipitation event used in this assessment is the 1:50 year, 24-hour event;
- Route all clean storm water directly to natural watercourses without increasing the risk of a negative impact on safety and infrastructure, e.g. loss of life or damage to property due to an increase in the peak runoff flow;
- Ensure that the maximum volume of clean water runoff is diverted directly to watercourses;
- The SWMP must be sustainable over the life cycle of the mine and over different hydrological cycles and must incorporate principles of risk management; and
- The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

9.3 Proposed Storm Water Measures

A mine infrastructure layout has been proposed, and consequently the SWMP has been based on the proposed layout with dirty and clean areas as indicated in Table 9-1.

Table 9-1: Clean and Dirty Area Classification

Area Classification	Mine Areas
Clean runoff areas	Area upstream of the Mine
	Areas within the mine but downstream of the dirty areas
Dirty (pollution sources)	Overburden stockpiles and Product Stockpiles
	PCDs
	Underground Mining Areas(although these are not part of the SWMP; they are a source of dirty water)
	Offices and Parking Areas (This area included the sewage treatment plant , mini substations and workshops)
	Haul Road and weigh bridge

The primary risk is the contamination of the surface water environment (including storm water drainage) from the mobilisation of carbonaceous and sandy material, as well as dirty water into the clean catchment.

The sub-catchments that will be affected by the mine activities and surface infrastructure were delineated from the Digital Elevation Model (DEM) in Global Mapper GIS Software V15; and indicated with the proposed site specific measures storm water structures depicted in Figure 9-1, Figure 9-2 and Figure 9-3.

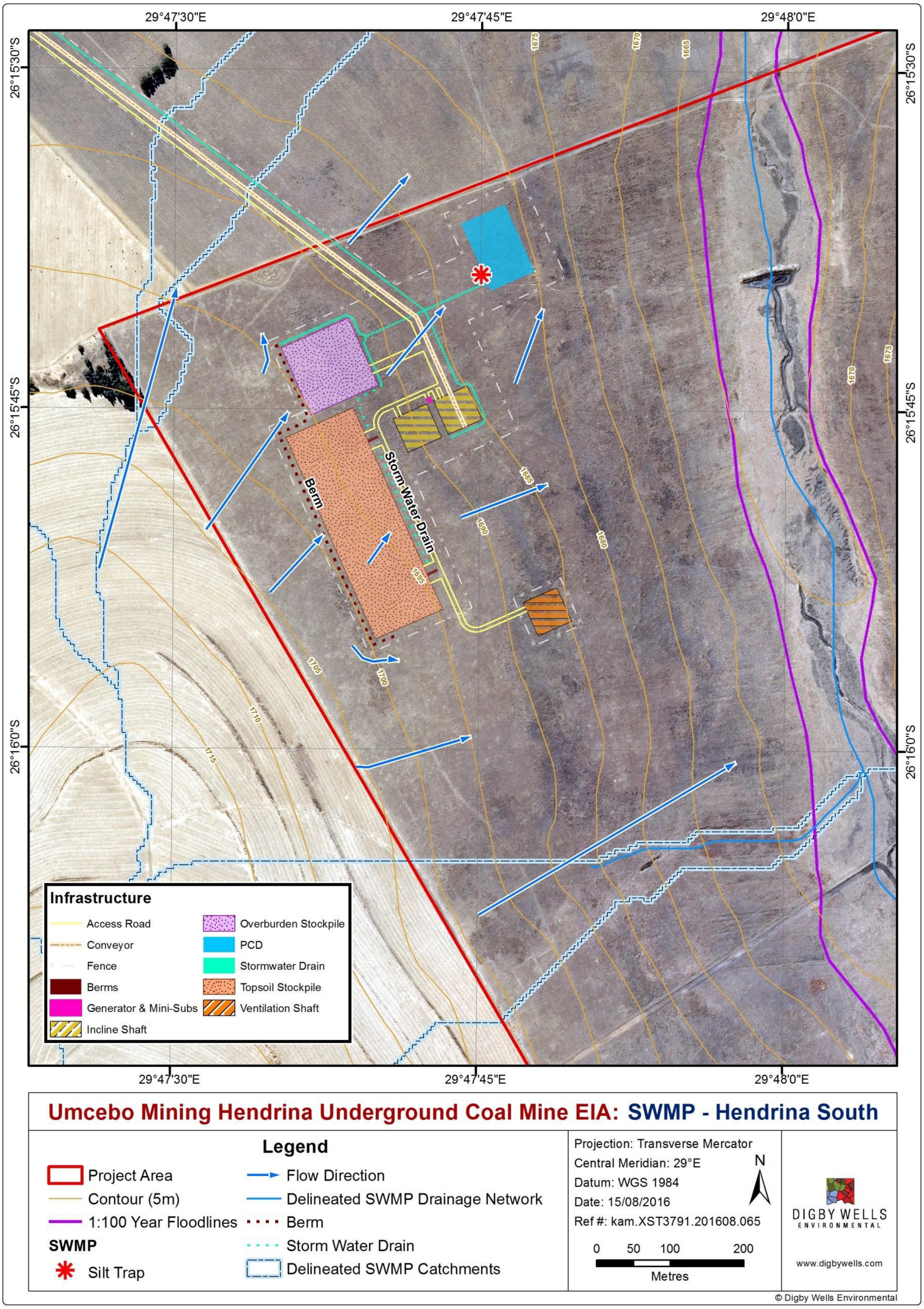

Figure 9-1: Conceptual Location of Clean and Dirty Water Separation Structures, Hendrina South

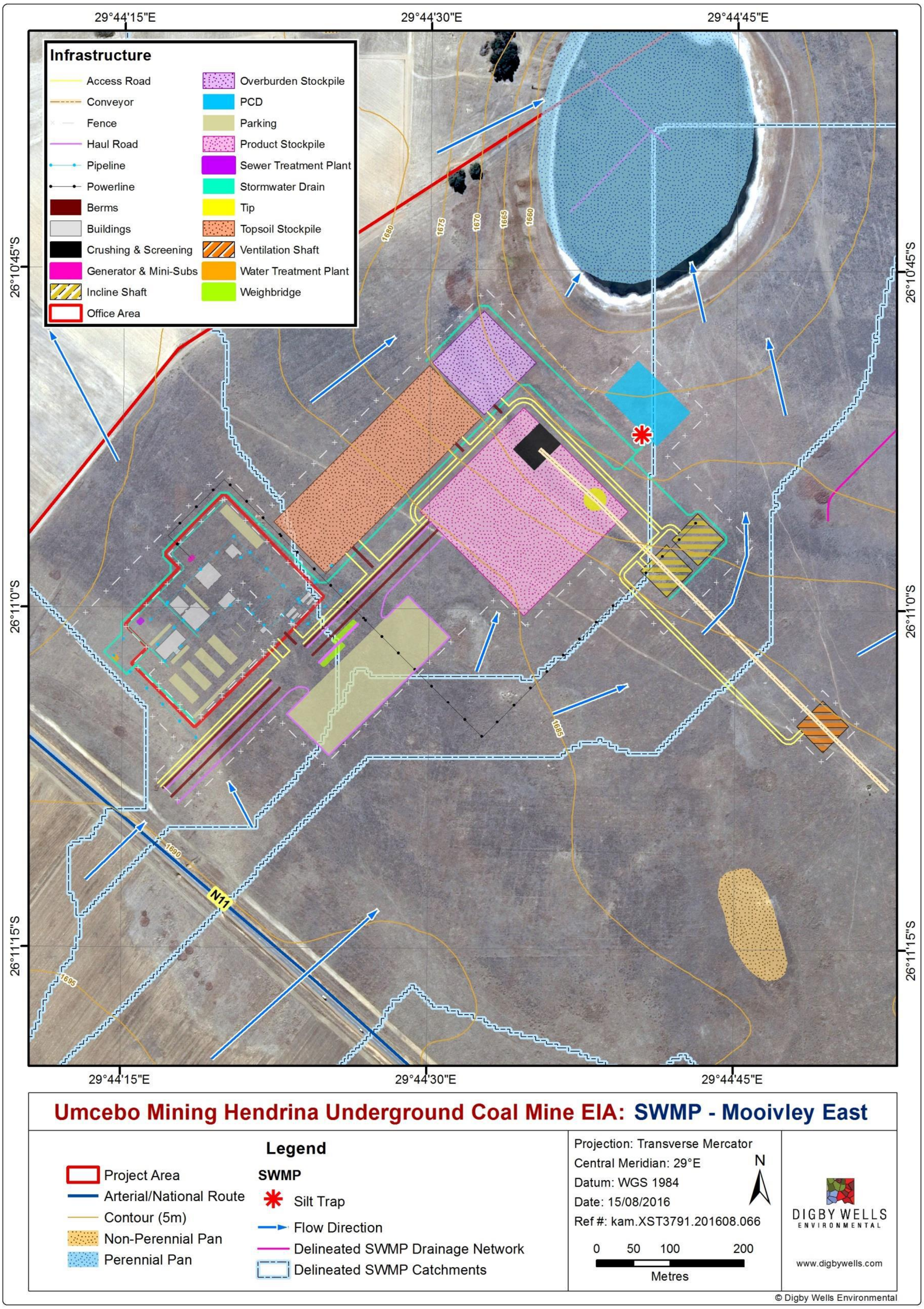

Figure 9-2: Conceptual Location of Clean and Dirty Water Separation Structures, Mooivley East

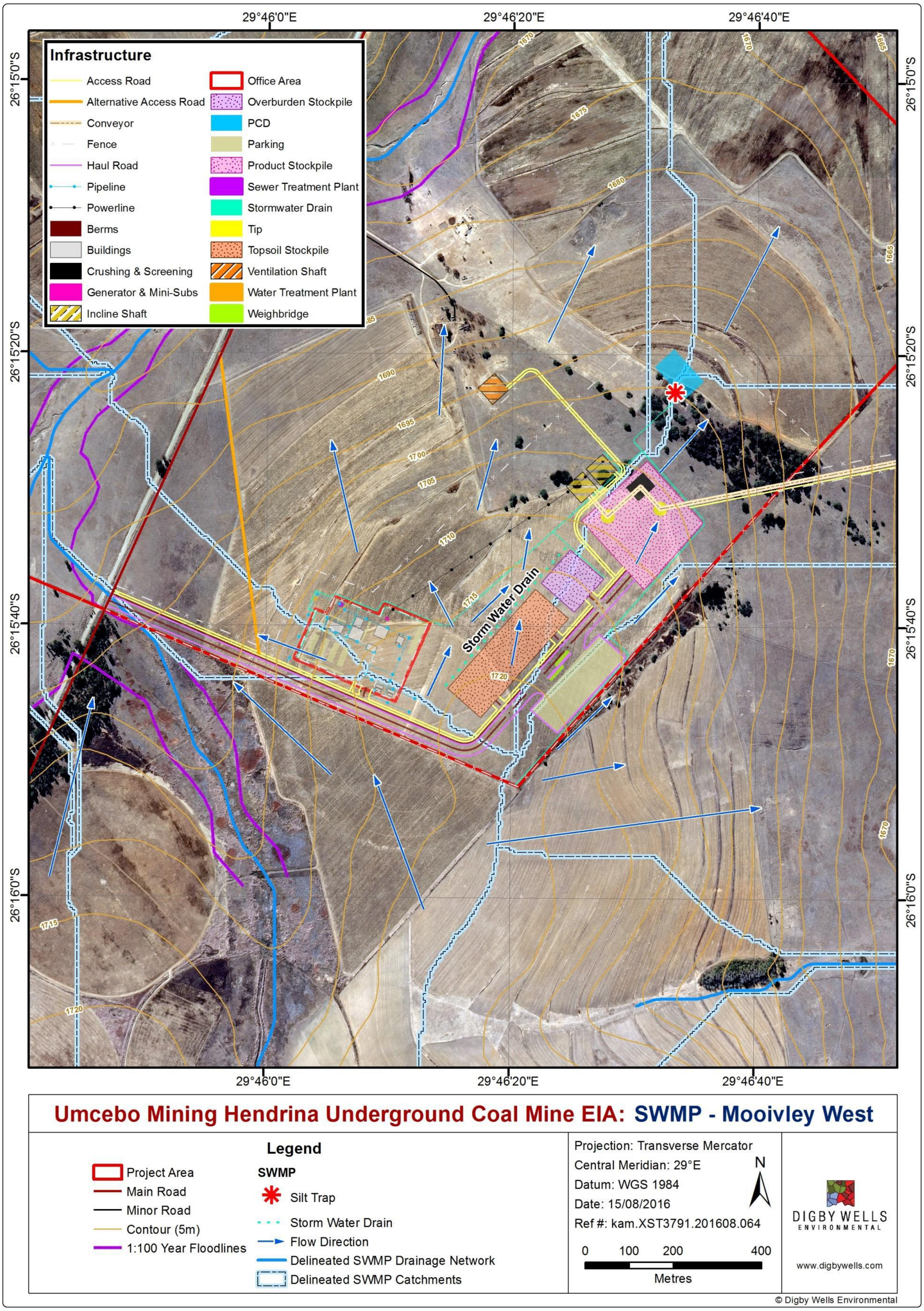

Figure 9-3: Conceptual Location of Clean and Dirty Water Separation Structures, Mooivley West

The site specific storm water management measures are detailed below.

9.3.1 Hendrina South

The SWMP layout for Mooivley West is depicted in Figure 9-1

- The existing mine infrastructure plan depicts storm water drains capturing runoff from the overburden stockpile, and the shafts area. The storm water drain needs to be extended to capture runoff generated at the topsoil stockpile. If possible the overburden stockpile can be vegetated to reduce erosion;
- Clean water diversion berms are proposed upstream of the topsoil stockpile to prevent erosion of the stockpile and overburden stockpile These will help prevent clean water from entering the dirty areas and ensure that it drains as clean water towards the tributary of the Klein Olifants River; and
- Silt traps are proposed on the downstream side before the storm water enters the PCD. This allows eroded material to settle before the water can be pumped to the PCDs or used.

9.3.2 Mooivley East

Refer to Figure 9-2 for a layout of the SWMP for Mooivley East.

- The existing mine infrastructure plan depicts storm water drains around the around the offices and parking areas, overburden which will direct contaminated runoff towards the PCD;
- The storm water drains also captures all runoff from the office area to the dirty water system. The runoff from the office area for this project has been deemed potentially contaminated due to the existence of other sites like the fuel station, sewage treatment and water treatment plant within the site;
- There are some berms located along the haul road and these are located on the upstream side of most of the infrastructure. These will prevent erosion on the haul road, but also serve at diverting clean storm water from the upstream sections in the subcatchments away from the site;
- The silt traps are proposed on the downstream side of the stockpiles at the downstream sites. This allows eroded material to settle before the water can be pumped to the PCDs and reused; and
- The upstream catchment of the proposed product stockpile area is very small (the stockpile is close to the subcatchment divide) such that it is not anticipated to generate much upstream runoff, as such there has been no need to propose an upstream berm. Clean water will divert naturally around the shafts to the downstream pan and some towards the Klein Olifants River.

9.3.3 Mooivley West

The SWMP layout for Mooivley West is depicted in Figure 9-3

- The existing mine infrastructure plan depicts storm water drains around the offices and parking areas, overburden stockpiles and product stockpiles which will direct contaminated runoff towards the PCD. The Storm water drain should be extended to capture runoff from the topsoil stockpile from the downstream point;
- The storm water drains also captures all runoff from the office area to the dirty water system. The runoff from the office area for this project has been deemed potentially contaminated due to the existence of other sites like fuel station and sewage treatment and the water treatment plant within the site. Parking areas constituting approximately 50% of the offices area, could be considered clean and the water that falls on surface should be encourages to sink into infiltrate into the soil;
- There are also some berms located along the haul road and these are located on the upstream side of most of the infrastructure. These will prevent erosion on the haul road and also divert clean storm water from the upstream sections in the sub-catchments away from the site; and
- It is proposed that a silt trap is constructed within the water circuit before the water enters the PCD. This allows eroded material to settle before the water can be pumped to the PCDs or used.

9.3.4 Summarised SWMP Measures

Table 9-2 presents a summary of the recommended storm water management measures.

Table 9-2: General Recommended SWMP Operational Management Measures per Infrastructure Type

SWMP Aspect Infrastructure	Storm Water Management measures
PCD	▪ The PCDs should have elevated downstream embankment /walls on flat ground so that water can be contained within and not overflow to the downstream clean water receiving environment and the nearby watercourse. ▪ PCDs should be designed and constructed to contain the daily operational volume, the runoff during a storm event and have a freeboard of 0.8m.The PCD should be operated as empty as possible to allow for it to hold runoff from the dirty areas in the event of a 1:50 year storm event. ▪ The PCDs should be design in such a way that all water entering the dam will go through a silt trap first. It is further proposed that two separate PCDs be constructed to ensure that one is always operational while the other one is cleaned out. The PCDs should be desilted when siltation occurs; however the presence of silt

SWMP Aspect Infrastructure	Storm Water Management measures
	traps at the dirty water runoff collection points (for example where water from the stockpiles is collected) should ensure limited siltation. ▪ The volumes of water flowing into and abstracted from the PCDs and water levels should be recorded on a daily basis. ▪ The water quality in the PCDs should be monitored monthly to help with the mine site water and salt balance.
Product and overburden stockpile areas	▪ Contaminated storm water runoff from this area will be routed through trenches to silt trap sumps at the bottom of the stockpiles. ▪ Contaminated storm water runoff from the sump will be routed through channels to the PCDs. ▪ Clean water from clean upstream catchments will be diverted around the sides of the stockpiles to stop it becoming contaminated. ▪ Storm water channels should be maintained and cleaned regularly to ensure that their capacities to convey contaminated runoff from the stockpiles are not compromised and it can still convey the 1:50 year peak flows. ▪ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles. ▪ All overburden stockpile areas should be vegetated as soon as possible to prevent erosion
Haul roads	▪ No formal diversions are recommended; rather normal roadside drainage, culverts with downstream dissipaters should be constructed. ▪ Where the proposed haul road crosses the water courses, culverts should be constructed to accommodate the 1:100 storm event. The necessary erosion protection measures will be implemented to prevent the erosion of the beds and banks once the culverts are constructed. ▪ The proposed haul roads designs indicate berms along the haul roads which will ensure erosion of haul roads does not occur. ▪ The haul roads will be double chip and spray which is a safe all-weather, dust-free riding surface for traffic with adequate skid resistance. This reduces dust and erodibility of the surfaces
Topsoil stockpile areas	▪ The sides of the top soil stockpiles will be vegetated to control erosion of sediment materials to surface water resources. ▪ Regular inspections will be undertaken to ensure that erosion is addressed as soon as it occurs to prevent the loss of topsoil.

SWMP Aspect Infrastructure	Storm Water Management measures
Dust suppression of areas	▪ Dust suppression should be applied in such a way that it does not runoff from the area and cause secondary pollution. ▪ Ponding of the water should be prevented.
Underground mining areas. incline shaft and ventilation shaft	▪ Surface water runoff ingress into shafts should be prevented by ensuring the shaft upstream side has a berm. ▪ In the case of incline shafts a downstream storm water drain has been proposed in the mine plan. ▪ In the case of ventilation shaft, the area around should be grassed and ingress should be prevented. ▪ Water pumped from underground mine dewatering to allow for mining will be collected in the surface PCDs or the underground sumps for immediate reuse for dust suppression

9.4 Hydraulic Design Standards

It should be noted that the sizing and design of the PCD and channels do not form part of this conceptual SWMP. These designs are available and were provided by Umcebo Mining for the compilation of this SWMP, these are attached in appendix B. These include the concrete trapezoidal storm water channels, earth berms, V –Drains, silt traps and PCDs. This section describes the standards in place for the design of PCD and channels in the SWMPs.

- GN704 requires that dirty water facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. GN704 also requires that as a minimum, the 1:50 year design volume and a 0.8 m freeboard allowance should always be available; and
- GN704 requires that the clean water systems are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. Therefore, proposed clean water channels should be sized to accommodate the 1:50 year peak flows.

9.5 Recommendations

A summary of the recommendations associated with the SWMP is listed below:

- Overburden and topsoil stockpiles should be vegetated to prevent erosion of occurring;
- The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows;
- Stockpiling of materials should be monitored so that the side slopes do not encourage erosion of the slopes, resulting in silt transported into the trenches from

the stockpiles, allowing silt to settle on the dirty water site rather than in the channels; and

- In addition to the control of storm water, water quality monitoring should form part of this system where water in the PCDs is monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to monitor should include but not limited to Total Suspended Solids (TSS, pH, SO_4, Salinity, EC and other metals).

10 Sensitivity Analysis and No-Go Areas

This study included floodline delineation as part of the hydrological assessment. Floodline delineation was done to understand the risk of flooding on the proposed mine infrastructure, and in accordance with GN 704 regulations, where it is states that infrastructure should not be placed within the 1:100 year floodline, or a horizontal distance of 100 m from a watercourse (whichever is greater).

The 1:100 year floodlines were delineated for the streams and drainage lines within close proximity to surface infrastructure areas, this is considered as a very sensitive area and no infrastructure with potential to impact water resources should be placed within the delineated floodline.

This is with the exception of the proposed fence and conveyors, in which the recommendation is to designed and construct in a manner that it will withstand a 1:100 year flood.

The perennial streams, dams and pans with the potential to be impacted by the proposed mining activities have been classified as high sensitive whilst the non-perennial and perennial streams, dams and pans that are not likely to be impacted are classified as moderately sensitive. Mining activities should not be undertaken within the water courses floodlines and the 100m buffer.

The sensitivity map is shown in Figure 10-1.

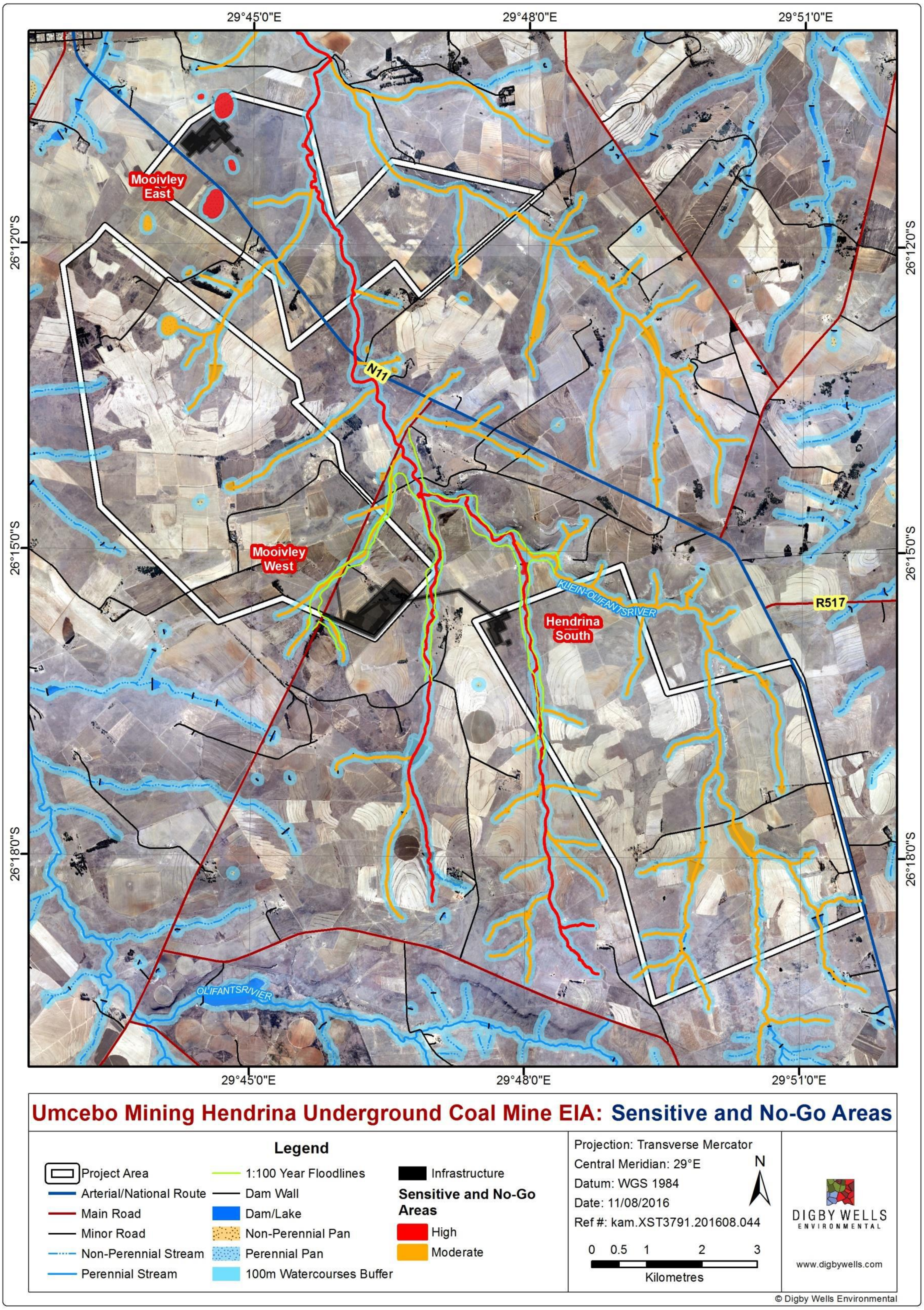

Figure 10-1: Sensitive and No-Go Areas

11 Impact Assessment

11.1 Methodology used in Determining and Ranking the Nature, Significance, Consequence, Extent, Duration and Probability of Potential Environmental Impacts and Risks

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts.

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 11-3. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this Hydrological Impact Assessment Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 11-2, which is extracted from Table 11-1. The description of the significance ratings is discussed in Table 11-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 11-1: Impact Assessment Parameter Ratings

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts **(Nature = -1)**	**Positive Impacts** **(Nature = +1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.

Rating	Intensity/Replacability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 11-2: Probability/Consequence Matrix

Significance

Probability																			
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3
Consequence	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3

Probability																			
7	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Consequence	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Table 11-3: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

11.2 Project Activities

A list of project activities to be assessed for the project is presented in Table 11-4.

Table 11-4: Description of Activities to be assessed

Project Phase	Project Activity	Project Structures
Construction	Site Clearance	Topsoil Stockpiles
	Blasting and Excavation	Two Shafts per mining right area
	Construction of Surface Infrastructure	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dam Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Water Abstraction and Use	Water Tanks and Pipes
	Waste Generation and Disposal	Waste Skips
	Power Generation	Diesel Generator
Operations	Underground Blasting and Mining	Heavy Machinery and Equipment
	Stockpiling	Waste Rock Berms Product Stockpile
	Hauling/Conveying of Coal	Overland Conveyor Belt Haul and Access Roads
	Plant and Equipment Operations	Crushing and Screening Plant Workshop and Diesel Storage Tanks
	Water Use and Storage	Pollution Control Dam and Jo Jo Tanks
	Waste Generation and Storage	Sewage Treatment Plant Waste Skips
	Power Generation	Diesel Generator

Project Phase	Project Activity	Project Structures
Mine Decommissioning and Closure	Removal of infrastructure and surface rehabilitation	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dam Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Waste Generation and Disposal	Waste Skips

11.3 Impact Assessment

11.3.1 Construction Phase

The assessed activities related to the construction phase include site clearance by removing vegetation to allow space for construction of surface infrastructure such as; crushing and screening plant, mine offices, pollution control dams, access roads, etc. These activities have the potential to impact on the surface water resources as discussed in the sections below.

Table 11-5: Interactions and Impacts of Activity

Interaction	Impact
Exposure of soils due to loss of vegetation (site clearance).	Siltation of surface water resources leading to deteriorated water quality. The tributaries of the Klein Olifants River will be impacted by Infrastructure at Hendrina South and Mooivley West. The pan at Moivley East will be impacted as well as the Klein Olifants River

11.3.1.1 Impact Description: Siltation of Surface Water Resources

Clearing and stripping of vegetation leaves the soils prone to erosion during rainfall events, and as a result runoff from these areas which will be high in suspended solids and will cause an increase in turbidity in the nearby surface water resource/ stream.

Dust generated during the construction activities and caused by increased vehicle movements and excavation can also be deposited into the local water course, thereby contributing to the accumulation of suspended solids in the water course, leading to the siltation of the water.

11.3.1.2 Impact Description: Water Contamination leading to deterioration of water quality

Dirty or contaminated runoff emanating from fuels storage areas, other liquid waste and general waste areas have the potential to contaminate the nearby streams.

The construction activity will generate waste which includes general wastes (paper, glass, plastic and cans), biological sewage waste and other hazardous waste that may be generated during construction. The handling and disposal of these waste poses a risk to the tributaries of the Klein Olifants River, the pan at Moivley East and the Klein Olifants River if not managed appropriately.

During construction, the soil cover is removed. When the soil is exposed to erosion elements, the washed off loose soil results in production of silt which can be transported in runoff towards the Kelin Olifants tributaries and the pan at Mooivley East.These impacts will lead to the deterioration of water quality and impacting on the aquatic life and the downstream water users. However, these impacts can greatly be prevented and/or reduced if the recommended measures in the following section are implemented.

11.3.1.2.1 Management Objectives

To minimise or avoid the potential impact (impact on water quality and/or quantity) during construction on the rivers.

11.3.1.3 Management/ Mitigation Measures

The following mitigation measures are recommended:

- Clearing of vegetation must be limited to the development footprint area, and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas;
- If possible, construction activities must be prioritised to the dry months of the year (May-October) to limit mobilisation of sediments, dust generation and hazardous substances from construction vehicles used during site clearing;
- Dust suppression with water on the haul roads and cleared areas must be regularly undertaken;
- The proposed topsoil and overburden stockpile must be covered or vegetated as soon as possible to prevent sediment erosion;
- Contaminated storm water runoff from this area will be routed through trenches to silt trap sumps at the bottom of the stockpiles.

- Contaminated storm water runoff from the sump will be routed through channels to the PCDs;
- Water quality monitoring should be implemented as an management option
- Haul roads must be well compacted to avoid erosion of the soil into the streams;
- All fuel storage areas should be appropriately bunded to ensure that 110 % of the volumes can be contained and spill kits should be in place, and construction workers trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills;
- Mobile chemical ablutions for construction workers and general waste bins should be provided and regularly maintained; and
- Environmental Control Officer (ECO) should be appointed to ensure implementation of the recommended mitigation/management measures during construction, operational, mine decommissioning and closure.

11.3.1.4 Impact Ratings

Table 11-6: Impact Rating for the Construction Phase

Dimension	Rating	Motivation	Significance
Impact: Siltation of surface water resources leading to deteriorated water quality			
Pre-Mitigation			
Duration	Medium term (3)	With no measures in place, siltation may occur for as long as the construction takes place The tributaries of the Klein Olifants River will be impacted by Infrastructure at Hendrina South and Mooivley West. The pan at Moivley East will be impacted as well as the Klein Olifants River	Minor - negative (70)
Extent	Local (3)	The impacts will be localized to the nearby water resources from where the silt is being generated and the immediate downstream	
Intensity x type of impact	Serious - negative (-4)	This will have moderate impacts resulting in a poor water quality for downstream users relying on Klein Olifants River water	
Probability	Certain (7)	Without appropriate mitigation there will definitely be significant erosion	
Mitigation/ Management Actions			

Dimension	Rating	Motivation	Significance
▪ Clearing of vegetation must be limited to the development footprint area, and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas; ▪ If possible, construction activities must be prioritised to the dry months of the year (May-October) to limit mobilisation of sediments or hazardous substances from construction vehicles used during site clearing; ▪ The proposed topsoil and overburden stockpiles must be covered or vegetated as soon as possible to prevent sediment erosion;' ▪ Contaminated storm water runoff from this area will be routed through trenches to silt trap sumps at the bottom of the stockpiles. ▪ Contaminated storm water runoff from the sump will be routed through channels to the PCDs; ▪ Water quality monitoring should be implemented as an management option ▪ Haul roads must be well compacted to avoid erosion of the soil into the streams; and ▪ Dust suppression on the haul roads and cleared areas must be regularly undertaken.			
Post-Mitigation			
Duration	Medium term (3)	The tributaries of the Klein Olifants River will be impacted by Infrastructure at Hendrina South and Mooivley West. The pan at Moivley East will be impacted as well as the Klein Olifants River	Minor - negative (36)
Extent	Local (3)	Only immediate subcatchment, and the impacts can be collected in management measures	
Intensity x type of impact	Moderate - negative (-3)	Mitigation will reduce the impacts	
Probability	Probable (4)	Necessary mitigations will reduce the erosion probability significantly	
Impact: Deterioration of water quality due to dirty water reporting into natural water resources			
Pre-Mitigation			
Duration	Medium term (3)	With no measures in place, this impact may occur for as long as the construction takes place.	Minor - negative (55)
Extent	Local (3)	The impacts will be localized to the nearby Klein Olifants tributaries and the pan at Mooivley East from where the contaminated runoff enters the stream and the immediate downstream	

<table>
<tr><th>Dimension</th><th>Rating</th><th>Motivation</th><th>Significance</th></tr>
<tr><td>Intensity x type of impact</td><td>Moderately high - negative (-5)</td><td>This may have serious impacts on the downstream water users due to elevated hydrocarbon levels, ammonium and chloride in the nearby tributaries of the Klein Olifants and the pan at Mooivley East.</td><td rowspan="2"></td></tr>
<tr><td>Probability</td><td>Certain (5)</td><td>Without appropriate mitigation, there probability of the impact occurring is <65%</td></tr>
<tr><td colspan="4">Mitigation/ Management Actions</td></tr>
<tr><td colspan="4">All fuel storage areas should be appropriately bunded and spill kits should be in place, and construction workers trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills;
Vehicles should regularly be maintained as per the developed maintenance program. This should also be inspected on a daily basis before use to ensure there are no leakages underneath
Ablutions facility for construction workers and general waste bins should be provided. An accredited contractor should be appointed to properly dispose the waste; and
ECO should be appointed to ensure implementation of the recommended mitigation/management measures during construction</td></tr>
<tr><td colspan="4">Post-Mitigation</td></tr>
<tr><td>Duration</td><td>Medium term (3)</td><td>The impact can occur at any time of the construction Phase</td><td rowspan="4">Negligible - negative (33)</td></tr>
<tr><td>Extent</td><td>Local (3)</td><td>The impacts will be localized to the nearby the Klein Olifants tributaries and the pan at Mooivley East from where the contaminated runoff enters the stream and the immediate downstream</td></tr>
<tr><td>Intensity x type of impact</td><td>Moderate - negative (-5)</td><td>This may have serious impacts on the downstream water users due to elevated hydrocarbon, ammonium and chloride levels from waste in the nearby tributaries of the Klein Olifants and the pan at Mooivley East.</td></tr>
<tr><td>Probability</td><td>Probable (3)</td><td>Necessary mitigations will reduce the probability of impact occurrence significantly (<25%)</td></tr>
</table>

11.3.2 Operational Phase

Activities that may have surface water impacts during the operational phase include stockpiling, hauling/conveying of coal, plant and equipment operations, water use and storage, and waste generation and storage.

As stated in the aquatics assessment report, it should be noted that at the time of the impact ratings, no geotechnical data or any safety factors of the underground workings were available. The assumption was made that detailed geotechnical investigations would be conducted and that the required safety factor will be sufficient to prevent any subsidence and associated surface cracks of the undermined areas to prevent any serious negative impacts with regards to subsidence within the undermined surface water resources.

Table 11-7: Interactions and Impacts of Activity

Interaction	Impact
Runoff from the dirty water areas (waste rock, crushing plant, conveyors and product stockpile)	Runoff reporting into the Klein Olifants River and other unnamed streams resulting in water contamination or the deterioration of the water quality
Development and operation of surface infrastructure (pollution control dams, stockpiles, workshops & offices, crushing and screening plant)	Reduction of Catchment Yield as dirty water runoff within the mine will be contained in the PCD.

11.3.2.1 Impact Description: Water Contamination leading to deterioration of water quality

Dirty water runoff laden with carbonaceous material from the contaminated surfaces and the infrastructure within the mine (ROM stockpiles, crushing plant, conveyors and product stockpile) has the potential to contaminate and silt up the natural water resources or streams, should it not be contained within the mine. This impact will therefore deteriorate the water quality and hence impact the downstream water users and the aquatic life.

11.3.2.2 Impact Description: Reduction of Catchment Yield

Containment of dirty water runoff from the within the mining area will reduce the amount of runoff reporting to the Klein Olifants River and other unnamed streams. A decrease in the catchment yield may have an impact on the downstream water users as they may not have sufficient water for their needs, while also decreasing the flow required for the ecological reserve.

However, the total provided infrastructure footprint area amounts to approximately 1.5 km^2 and makes up less than 1% of total quaternary catchment area of 405 km^2. The percentage decrease in MAR as a result of the proposed development of an underground coal mine and associated infrastructure will amount to 0.04% for B12A quaternary catchment. This percentage loss in MAR is negligible and therefore considered to be insignificant; this will not be rated further as an impact.

11.3.2.2.1 Management Objectives

To minimise or avoid the potential impact (impact on water quality and/or quantity) during operation on the rivers.

11.3.2.3 Management/ Mitigation Measures

This section provides the necessary management measures to prevent and/or reduced the identified impacts:

- As proposed in the project activities, ensure that all the dirty water emanating from the dirty water areas be collected via silt traps before entering the PCD for re-use within the mine, to prevent unnecessary discharge into the environment;
- The dirty water collection trenches (as detailed in section 9) should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows. The sludge should be disposed to an appropriate licenced facility
- Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels;
- In addition to the control of storm water, water quality monitoring should form part of the system where water in the PCD's are monitored for quality. This ensures that pollution sources are monitored during the mining operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to check would be the TSS, EC, Salts and some chemical parameters that such as (pH, SO_4 and other metals);
- Should a subsidence occur during operation, it should be rehabilitated as soon as possible to avoid impoundment of surface water; and
- Water quality monitoring on the upstream and downstream points of the proposed coal mine must continue as set out in Table 6-7.

11.3.2.4 Impact Ratings

Table 11-8: Impact Rating for the Operation Phase

Dimension	Rating	Motivation	Significance
Impact: Water Contamination leading to deterioration of water quality			
Pre-Mitigation			
Duration	Project Life (5)	Due to the nature of the mining activities the contamination of water resources may occur over the project life if mitigation measures are not in place.	Moderate - negative (90)
Extent	Region (5)	The impacts may affect the Klein Olifants	
Intensity	Serious - negative (-5)	This may have serious impacts on the water quality that will be made available to the downstream water users (agricultural- livestock watering and crop irrigation)	
Probability	Almost Certain (6)	Without appropriate mitigation, there probability of the impact occurring is almost certain <80 %	
Mitigation Measures			
▪ All the dirty water emanating from the dirty water areas should be collected via silt traps before entering the PCD for re-use within the mine, to prevent unnecessary discharge into the environment; ▪ The dirty water collection trenches should be cleaned regularly to reduce silt build up and ensure they are able to accommodate and convey the 1:50 year peak flows; ▪ Stockpiling should be monitored so that the side slopes do not encourage erosion of the slopes resulting in silt transported into the trenches from the stockpiles, allowing some silt to settle on the dirty water site rather than in the channels; ▪ In addition to the control of storm water, water quality monitoring should form part of the system where water in the PCD's are monitored for quality. This ensures that pollution sources are monitored during the mines operational process and in the unlikely event of any spillages the downstream impacts can be estimated. The main constituents to check would be the TSS, EC, Salts and chemical parameters such as (pH, SO_4 and other metals); ▪ Should subsidence occur during operation, it should be rehabilitated as soon as possible to avoid impoundment of surface water; and ▪ Water quality monitoring on the upstream and downstream points of the proposed coal mine must continue			
Post-Mitigation			
Duration	Medium term (5)	Impact may occur over the project life if mitigation measures are not in place	Negligible - negative (45)

Dimension	Rating	Motivation	Significance
Extent	Region (5)	The impacts may affect the flow in the Klein Olifants and possibly contributes to the Olifants River	
Intensity	Moderate - negative (-5)	This may have serious impacts on the downstream agricultural water users	
Probability	Probable (3)	Necessary mitigations will reduce the probability of impact occurrence significantly (<25 %)	

11.3.3 Closure and Rehabilitation Phase

Activities during this phase include dismantling and removal of infrastructure (infrastructures listed in table Table 11-4) and surface rehabilitation. The major impacts to consider in the decommissioning and rehabilitation of the site will be siltation of surface water resources as a result of soil erosion influenced by removal of infrastructures.

Groundwater model simulated that the mine is likely to decant through the proposed shaft in Mooivley East. The decanting is likely to start 30 years after mine closure, at a rate of 7 m^3/d (Groundwater Report, 2016 (Digby Wells)). This will report into the nearby streams will likely result into acidification of surface water.

Table 11-9: Interactions and Impacts of Activity

Interaction	Impact
Exposure of soils after the removal of infrastructure	Siltation of surface water resources leading to deteriorated water quality on the Klein Olifants River , the pan at Moivley East will be impacted as well as the Klein Olifants River
Mine decant	Deterioration of surface water quality on the pan at Mooivley East and under extreme conditions to the Klein Olifants River.The levels of Sulfate, Sodium and TDS could affect the agricultural and domestics uses downstream.

11.3.3.1 Impact Description: Siltation of Surface Water Resources

Removal of infrastructure will expose the soil surfaces and leave it prone to erosion, resulting in siltation of the natural water resources (Klein Olifants and unnamed streams) when runoff reports to these rivers. This will deteriorate the water quality and hence impact the downstream agricultural water users.

Groundwater model simulated that the mine is likely to decant through the proposed shaft in Mooivley East. The decanting is likely to start 30 years after mine closure, at a rate of 7 m^3/d (Digby Wells, Groundwater Report 2016). This will report into the nearby streams will likely result into acidification of surface water.

11.3.3.2 Management/ Mitigation Measures

These impacts can be prevented and/or reduced by implementing the following measures:

- Use of accredited contractors for removal or demolition of infrastructures; this will reduce the risk of waste generation and accidental spillages;
- Rehabilitated and backfilled areas must be seeded as soon as possible; pending the vegetation establishment after seeding, sedimentation should be mitigated by installing silt traps at areas where the surface runoff enters the surface water resources;
- The constructed dirty water trenches and berms will have to remain until post closure. This will ensure dirty water is captured and contained during removal of infrastructures;
- Surface inspection on the fully rehabilitated areas must be undertaken to ensure a surface profile that allows good drainage. This will ensure improvement or increased catchment yield on to the surrounding streams;
- Capture decanting water before it flows into the stream, treat it and re-introduce it into the streams. Please refer to the ground water report for detailed decant simulation results and management measures;
- The decant should be treated to the acceptable water quality levels (Olifants RWQO; and
- Water quality monitoring on the upstream and downstream points of the coal mine must continue as set out in Section 15.

11.3.3.3 Impact Ratings

Table 11-10: Impact Rating for the Closure and Rehabilitation Phase

Dimension	Rating	Motivation	Significance
Impact: Siltation Of Surface Water Resources Leading To Deteriorated Water Quality			
Pre-Mitigation			
Duration	Medium term (3)	Equal to the duration of 1-5 years during which decommission will occur	Minor - negative (70)
Extent	Local (3)	Siltation may only affect the tributaries of the Klein Olifants and the pan at Mooivley East within the immediate subcatchments	

Dimension	Rating	Motivation	Significance
Intensity	serious - negative (-4)	This may have serious impacts on the downstream agricultural water users in the Klein Olifants Catchment	
Probability	Certain (7)	Without appropriate mitigation there will definitely be significant erosion	
Mitigation Measures			
▪ Use of accredited contractors for removal or demolition of infrastructures; this will reduce the risk of waste generation and accidental spillages; ▪ The PCDs, constructed dirty water trenches and berms will have to remain until post closure should be removed last form the site so that the silt trap and the sto dirty water can contained for treatment before discharge until rehabilitation is completed. ▪ Surface inspection on the fully rehabilitated areas must be undertaken to ensure a surface profile that allows good drainage. This will ensure improvement or increased catchment yield on to the surrounding streams; ▪ Water quality monitoring on the upstream and downstream points of the coal mine must be undertaken and suspended solids and turbidity levels accessed			
Post-Mitigation			
Duration	Medium term (3)	With mitigation, the impact may occur at any time during the decommissioning phase although at a reduced frequency.	Minor - negative (36)
Extent	Local (3)	Siltation may only affect the tributaries of the Klein Olifants and the pan at Mooivley East within the immediate subcatchment only in extreme rainfall more that the 1:50 year storm lasting more than 24 hours (more than the acceptable GN704 design specifications).	
Intensity	Moderate - negative (-3)	Mitigation will reduce the impacts	
Probability	Probable (4)	Necessary mitigations will reduce the erosion probability significantly	
Impact: Mine decanting resulting in contamination of surface water bodies			
Pre-Management/Enhancement Measures			
Duration	Permanent (7)	Once the mine starts to decant from the shaft in Mooivley East to the Pan it is not expected to stop naturally	Moderate (negative) – 105
Extent	Local (3)	The decant is likely to flow to the pan at Mooivley East and under extreme conditions to the Klein Olifants River.	

Dimension	Rating	Motivation	Significance
Intensity x type of impact	Serous-negative (-5)	Deterioration of surface water quality on the pan at Mooivley East and under extreme conditions to the Klein Olifants River. The levels of Sulfate, Sodium and TDS could seriously affect the agricultural and domestics uses downstream.	
Probability	Certain (7)	Based on analytical and numerical modelling, it is certain that there will be a decant after mine closure	
Post- Management/Enhancement Measures			
Duration	Permanent (7)	The decant is expected to continue for the foreseeable future	Negligible (negative) – 27
Extent	Very Limited (1)	With the re-introduction of the treated water into the Kklein Olifants or the Pan, , the extent of impact will be limited	
Intensity x type of impact	Minimal - negative (-1)	Once the decanted water is treated and re-introduced to the streams, the environmental significance is rated as minimal to no loss	
Probability	Unlikely (3)	If the decant is treated to the acceptable water quality levels (Olifants RWQO), its impact is unlikely	

12 Cumulative Impacts

Negative water quality impacts can result in the deterioration of surface water resources. All runoff draining from the project area via the Klein Olifants River will eventually report into the Olifants River.

The baseline water quality showed poor qualities of water as TDS, ammonia and chloride were exceeding the water quality guidelines for irrigation. The Klein Olifants River has several tributaries downstream of the project area before its confluence with the Olifants River; these streams are likely contributing on impacting the Klein Olifants River as there are different activities (irrigation, mining, domestic uses and livestock watering) taking place along these tributaries.

The Olifants River is already under stress regarding the quality status due to coal mines within the catchment. The Groundwater Report (Digby Wells, 2016) states that the project is likely to alter the natural geochemistry of the area by exposing the sulphides to oxygenation which could result in sulphate contamination. It is assumed that concentration could reach up to 2 500 mg/L and this has a potential to acidify the surface water resources.

The proposed development of an underground coal mine could potentially increase the impacts on the Klein Olifants River if management measures are not in place. However, this could greatly be prevented by implementing the recommended mitigation measures presented in this report. This will prevent further deterioration of water quality in the Klein Olifants River.

13 Unplanned Events and Low Risks

The potential risks or unplanned events involve accidental spillages of hazardous substances (e.g. hydrocarbons) from vehicles or other machineries and from waste storage facilities during construction, operation and closure phases. This may lead to impacts on water quality in the surrounding streams, should runoff from these contaminated areas enter the system.

There is a risk of flooding and subsequent damage to some mine infrastructure that are placed within the 1:100 year floodline or 100 m buffer. The following surface infrastructure falls within the floodlines and/or the 100 m buffer of watercourses:

- Fence around Mooivley East infrastructure;
- Conveyor, access road and fence connecting Hendrina South and Mooivley West sites; and
- Fence, haul road and access road at Mooivley West.

This may lead to mobilisation of hazardous substances from the mine area and impact on the river water quality, as well as damage to the mine infrastructure within the determined floodline. A summary of the risks or unplanned events, together with the management measures are presented in Table 13-1.

Table 13-1: Unplanned Events, Low Risks and their Management Measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Hydrocarbons and any hazardous material spillage	Surface water contamination	Vehicles must only be serviced within designated service bays. The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites. The fuel, lubricant and explosives storage facilities must be located on a hard standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilization of leaked hazardous substances. An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team. The Material Safety Data Sheets (MSDS) should be kept on site for the Life of Mine for reference to anytime in terms of handling, storage and disposal of materials.

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Flooding of Mine Infrastructure	Surface water contamination	The conveyor and access road connecting Hendrina South and Mooivley West, should be elevated above the floodline at a height of approximately 1 662 mamsl (height subject to more detailed and accurate elevation survey data). A culvert / bridge for the road crossing should be constructed and sized appropriately. The fence should be designed and constructed to withstand a 1:100 year flood. The proposed berm running along the haul road at Mooivley West, must be constructed above the floodline at a height of approximately 1 696 mamsl (height subject to more detailed and accurate elevation survey data), to ensure that flooding of infrastructure does not occur.
Subsidence of undermined areas	This may result in impoundment of surface water and reduces quantity of water reporting into the streams	A geotechnical study should be undertaken to determine possibilities of subsidence. Mitigation measures should the recommended, should there be chance of subsidence.
PCD overflow	The degradation of downstream water quality.	Paddocks should be placed adjacent to the PCD spillway to contain any spill and prevent erosion and water reporting in to the nearby stream

14 Environmental Management Plan

14.1 Project Activities with Potentially Significant Impacts

This study has identified the surface water impacts that may occur as a result of the proposed mine and its associated activities. These activities could negatively impact on surface water resources by deterioration of water quality and/or the decrease in water quantity. Table 14-1 presents the potential significant impacts; a detailed description on these can be found in Section 11.3.

Table 14-1: Potentially Significant Impacts

Activity	Aspects	Potential Significant Impacts
Removal of vegetation, Construction of roads, workshops, offices and all mine infrastructure.	Project area	Siltation of the Klein Olifants River and other unnamed streams when the runoff from the eroded area reports into these streams
		Reduction in catchment yield when all the runoff within the dirty water areas is captured within the PCD’s

Activity	Aspects	Potential Significant Impacts
Product stockpiling, crushing of coal, hauling of coal by trucks and conveying coal.	Mine dirty areas	Contamination of the surrounding streams when the dirty water areas reports into these streams

14.2 Summary of Mitigation and Management Measures

Section 11.3 provides a description of the mitigation and management options for the environmental impacts anticipated during the construction, operational, decommissioning and closure phases.

Table 14-2 and Table 14-3 provide a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMP.

Table 14-2: Impacts, Objectives and Outcomes of the EMP

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Site clearing and grubbing/excavating	Construction	<0.5 km^2	Clearing of vegetation must be limited to the development footprint area, and the use of existing access roads must be prioritized so as to minimise construction of new access roads in these areas; If possible, construction activities must be prioritised to the dry months of the year (May-October) to limit mobilisation of sediments or hazardous substances from construction vehicles used during site clearing; The proposed topsoil stockpile must either be covered or vegetated as soon as possible to prevent sediment erosion; Haul roads must be well compacted to avoid erosion of the soil into the streams; Dust suppression on the haul roads and cleared areas must be regularly undertaken; All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The proposed channels should be lined and sized to cater for the 1:50 year storm event.	Based on the GN 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. The clean water diversion will be sized to accommodate the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event.	Water storage and conveyance structures should be sized accurately for the life of project.
Construction and operation of infrastructures (roads, workshops, offices, pollution control dams).	Construction	All surface infrastructure amounts to 1.5 km^2	As proposed, ensure all the dirty water emanating from the dirty water areas will be collected via silt traps before entering the PCD. This water should be stored for re-use within the mine so as to prevent unnecessary discharge into the environment. Should the contained water be more than the water use requirement, the Best Practice Guidelines (BPGs) advise that the water be recycled or as the last resort be treated to acceptable levels and discharged either to the natural environment or be supplied to other industries as a lower grade of water.	DWS Best Practice Guideline G4: Impact prediction Based on GN 704, the mine infrastructure in question should fall outside of the 1:100 year floodline or 100 m, whichever is greater.	During the construction and operation of the entire infrastructure.
Construction over watercourses	Construction	Limited	Construction over sensitive riparian habitats resulting in the loss or degradation of aquatic habitat. There is also a Risk of contamination of water on the stream	Based on Reg 704, the mine infrastructure in question should fall outside of the 1:100 year floodline or 100 m, whichever is greater.	During the construction and operation of the entire infrastructure.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Potential spillages on Storage of fuel areas, workshops and heavy machinery on site	Operational	<0.5 km^2	Vehicles must only be serviced within designated service bays. The management of general and other forms of waste must ensure collection and disposal into clearly marked skip bins that can be collected by approved contractors for disposal to the appropriate disposal sites. The fuel, lubricant and explosives storage facilities must be located on a hard standing area (paved or concrete surface that is impermeable), roofed and bunded in accordance with SANS1200 specifications. This will prevent mobilization of leaked hazardous substances. An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team. The Material Safety Data Sheets (MSDS) should be kept on site for the Life of Mine for reference to anytime in terms of handling, storage and disposal of materials.	SANS1200 specifications.	During the entire project life.
Removal of infrastructure and surface rehabilitation	Mine Decommissioning and Closure	Removal of infrastructure (listed in Table 11-4)and surface rehabilitation	Use of accredited contractors for removal or demolition of infrastructures must be ensured. Seeding of the backfilled area must be implemented, where seeding is not effective, this must be repeated until it becomes sustainable, The constructed dirty water trenches will have to remain until post closure. This will ensure dirty water is captured and contained during removal of infrastructures.	GN 704 *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations.	During cessation of operations
Underground mine closure and rehabilitation	Post closure rehabilitation	All cleared areas should be rehabilitated	Surface inspection on the fully rehabilitated areas must be undertaken to ensure a surface profile that allows good drainage. This will ensure improvement or increased catchment yield on to the surrounding streams.	GN 704 *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations.	Post closure or after cessation of operations

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Underground mine closure and rehabilitation	Post-mining decant of groundwater will have negative impacts on the downstream water quality	Municipality	Decant capture and treatment prior to discharge into the stream	Section 19 of the National Water Act (NWA), 1998 (Act No. 36 of 1998);	Rehabilitation and closure phase

Table 14-3: Prescribed environmental management standards, practice, guideline, policy or law

Specialist field	Applicable standard, practice, guideline, policy or law	
Hydrology/Surface water	National Water Act, 1998 (Act No. 36 of 1998) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended (NEMA), GNR 544 and GNR 545 (Section 24 (1)).	Department of Water Affairs and Forestry, 2006, "*Best Practice Guideline No. G1: Storm Water Management*" Government Notice 704 (GN704). Regulations on the Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources. Published in Government Gazette 20119.

15 Surface Water Monitoring Programme

A monitoring programme is essential as a management tool to detect negative impacts as they arise and to ensure that the necessary mitigation measures are implemented. It also ensures that storm water management structures are in working order. Monitoring should be implemented throughout the life of the mine. Continuous water quality monitoring should be undertaken, the monitoring data should be benchmarked with the Olifants RWQO and the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996), to determine deviations from the baseline water quality so as to establish if the mine is impacting on the surface water resources.

Water quality monitoring is recommended at the locations where sampling was undertaken during this study and also at the proposed additional locations. Table 15-1 provides the coordinates of these monitoring locations and are also shown in Figure 6-3.

Table 15-1 : Surface Water Monitoring Locations

Point Name	Latitude*	Longitude*
SW01	26°13'58.88"S	29°46'35.67"E
SW02	26°14'40.47"S	29°46'56.78"E
SW03	26°13'6.39"S	29°46'7.33"E
SW04*	26°11'41.19"S	29°47'52.50"E
SW05	26°17'30.89"S	29°50'14.73"E
SW06	26°8'49.83"S	29°45'8.31"E
SW07*	26°10'38.67"S	29°44'8.39"E
SW08*	26°10'35.23"S	29°45'40.46"E
SW09*	26°14'33.40"S	29°47'21.35"E
SW10*	26°15'8.81"S	29°47'58.76"E
SW11*	26°16'17.29"S	29°46'57.20"E
SW12*	26°17'6.28"S	29°48'8.84"E

*Proposed monitoring points
Geographic Coordinate System WGS84 Datum

The constituents in Table 15-2 should be analysed to determine the water quality.

Table 15-2: Considered In Water Quality Analysis

pH Value @ 20°C	Bicarbonate, HCO_3
Sodium, Na	Sodium Absorption Ratio (SAR)
Conductivity mS/m @ 25°C	Chloride, Cl
Potassium, K	Aluminium, Al
Total Dissolved Solids	Sulphate, SO_4
Free and Saline Ammonia as NH_4	Manganese, Mn
Calcium, Ca	Nitrate, NO_3
Magnesium Hardness as $CaCO_3$	Iron, Fe
Calcium Hardness as $CaCO_3$	Fluoride, F
Total Hardness as $CaCO_3$	Chromium, Cr
Langelier Saturation Index (pH-pHs)	Total Suspended Solids
Total Alkalinity as $CaCO_3$	Phosphorus, P

Table 15-3 details the surface water monitoring plan.

Table 15-3 : Surface Water Monitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure that monitoring is implemented to cover all mining activity areas. Recommended monitoring sites are shown in Figure 6-3. It is also recommended to monitor water quality within the mine water system (PCD's) to determine the concentration levels in case of an overflow or need for discharge. Water quality parameters that need to be analysed include but not limited to the parameters shown in Table 6-8.	-Monthly during construction and operational phase. - Reduce to quarterly on rehabilitated areas. - This can further be reduced to biannually (wet and dry season) when most of the project area is rehabilitated. -Monitoring needs to carry on after the project has ceased until such time that the DWS approves closure.	Environmental Officer

Monitoring Element	Comment	Frequency	Responsibility
Water quantity	Flow monitoring should be carried out in channels and pipelines on site just before the water enters the storage facilities such as PCDs. Monitoring water levels in dams and channels by visual assessments along the channels. Records of pit dewatering volumes must be kept.	-Instantaneous where automatic flow meters are in place for real time measurements. -Where there are no automatic flowmeters weekly monitoring needs to be done. -In operational areas, daily records need to be kept.	Environmental Officer
Physical structures and SWMP performance	Personnel should have a walk around the facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions.	As often as is possible, most preferable daily.	Environmental Officer
	SWMP structures and dams should be inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.	Quarterly or monthly with the general maintenance schedule at the mine.	
Meteorological data	Measure rainfall.	Real time automatic weather system if in place, otherwise collect rainfall readings after every rainfall event or monthly.	Environmental Officer/Technician

16 Consultation Undertaken

During the surface water site visit for sample collection, Digby Wells communicated with the some residents in the informal settlement regarding directions to identified sampling locations.

16.1 Comments and Responses

The scoping report was published for the stakeholders and the interested & affected parties to comment. The comments received from stakeholders and responses provided are listed in in Table 16-1.

Table 16-1 : Comments and responses

Name of Individual	Consulted	Date of comments received	Issues Raised	EAPs response to issues as mandated by the applicant
Alpheus Pretorius Landowner	Landowners Focus Group Meeting	05-May-16	If it rains, the groundwater volume will increase and also impact the flow of the river. With the flow of this water into the underground cavities, the land capability will be negatively impacted.	Only areas that are cleared for infrastructure purposes will result in the loss of land capability. As part of these infrastructure areas, storm water management structures will be established to allow water to flow freely across the project site. A Groundwater, Surface Water and Soils Study will be undertaken and the impacts of water quantity will be assessed.
Gert Davel Landowner	Landowners Focus Group Meeting	05-May-16	Will the Klein Olifants River be dammed?	The Klein Olifants River will not be dammed.

17 Conclusions and Recommendations

Samples were collected during the dry and wet seasons within the project area and the surrounding streams to determine a baseline water quality status prior to commencement of the proposed project. Although the river was not flowing at the time of sampling, samples were taken at stagnant pools of water along the river channel to determine an indicative baseline water quality. Parameters such TDS, Chloride and Sodium were exceeding the target water quality range for irrigational use as set in the South African Water Quality Guidelines (DWAF, 1996).

The proposed development and operation of a new underground coal mine and associated activities have the potential to impact on the water resources within and around the project area. The identified potential surface water impacts include, but are not limited to:

- Siltation of surface water resources leading to deteriorated water quality as a result of eroded material reporting into the streams;
- Contamination of surface water resources when contaminated water runoff form the mine reports into the nearby streams;
- Reduction in runoff catchment yield in to the natural streams when all the dirty water runoff is captured and contained within the mine;

- Potential subsidence on the undermined areas that may lead to impoundment of water there by reducing surface runoff reporting into the Klein Olifants; and
- Potential decant of Acid Mine Drainage within the post-closure phase resulting in significant water quality modification in the Klein Olifants drainage.

A site-wide water balance model has been prepared to understand flows within the Hendrina underground coal mine operational water circuit, during average dry season and average wet season scenarios and to understand if the water requirements will be met. The water balance results are summarised as follows:

- The water requirements for the three sites were calculated based on the maximum water use of 2 000 m^3/day and these resulted in water demand of 20 333 m^3/month;
- The water balance calculations indicate that the water requirements (2000 m^3/day) at the mine will not be met by the water make as underground water make is on average between 0 and 1 000 m^3/day with runoff within the ranges 0 and 84 m^3/day; and
- The deficits in the dry season vary between 8 000 and 18 000 m^3/month per site; and in the wet season between 7 000 and 14 000 m^3/month per site.

A storm water management plan was undertaken for the project area, which covered the clean and dirty water control requirements based on the placement of the proposed infrastructure as per GN 704 requirements of the National Water Act, 1998 (Act No. 36 of 1998). The summary of findings from the stormwater management plan includes, but is not limited to:

- The PCDs should have elevated downstream embankments /walls on flat ground so that water can be contained within and not overflow to the downstream clean water receiving environment and the nearby watercourse;
- The PCD should be run close to empty to allow for it to hold runoff from the dirty areas in the event of a 1:50 year storm event;
- The PCDs should be desilted when siltation occurs; however the presence of silt traps at the dirty water runoff collection points (for example where water from the stockpiles is collected) should ensure limited siltation;
- The volumes of water abstracted from the PCDs and water levels should be recorded; and
- The water quality in the PCDs should be monitored at least monthly to help with the mine site water and salt balance.

A floodline delineation study was also conducted to understand the risks of flooding on the proposed mine infrastructure, and in accordance with GN704 regulations, where it is states that infrastructure should not be placed within the 1:100 year floodline, or a horizontal distance of 100 m from a watercourse (whichever is greater). The 1:100 year floodlines were delineated for the streams and drainage lines within close proximity to surface infrastructure areas. The following surface infrastructure was found to be within the 1:100 year floodline and/or the 100 m buffer of watercourses:

- Fence around Mooivley East infrastructure;
- Conveyor, access road and fence connecting Hendrina South and Mooivley West sites; and
- Fence, haul road and access road at Mooivley West.

However, appropriate management measures were provided to prevent and/or reduce the risk of flooding of these infrastructures, as well as risk of contamination of surface water resources due to mobilisation of chemicals during flooding. Appropriate mitigation/management measures to prevent, and/or minimise all other identified potential surface water impacts are detailed in this report.

With all the mitigation and management measures in place, this project will not pose any threat into the natural surface water resources and can therefore go ahead.

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WR2005, 2009, “Water Resources of South Africa, 2005 Study (WR2005)”, Water Research Commission, Pretoria.

WR2012, “Water Resources of South Africa, 2012 Study (WR2012)”, Water Research Commission, Pretoria.

Appendix A: Specialist Curriculum Vitae

Mrs. Chenai E Makamure (Pr. Sci. Nat.)

Hydrologist

Surface Water

Digby Wells Environmental

1 Education

Qualification:	MSc. Geo-Information Science and Earth Observation for Water Resources and Environmental Management – Integrated Watershed Modelling and Management - Environmental Hydrology
Institution:	University of Twente ITC Faculty, Enschede, The Netherlands
Date Completed:	2010

Qualification:	BSC Honours Degree in Applied Environmental Science
Institution:	University of Zimbabwe, Harare, Zimbabwe
Date Completed:	2005

2 Language Skills

English:	Excellent (Speak, Read, Write)
Shona:	Excellent (Speak, Read, Write)
French:	Very basic (Learning)

3 Employment

Period:	April 2012 to Date
Company:	Digby Wells Environmental, Republic of South Africa
Designation:	Surface Water Consultant

Period:	February 2011 to March 2012
Company:	EnviroFact Consulting Co, Republic of South Africa
Designation:	Assistant Consultant and Scientific Researcher

Period: August 2007 to August 2010-

Company: Environmental Management Agency, Zimbabwe

Designation: Environmental Officer - Water & Effluent Management

Period: April 2007 to August 2007-

Company: Environmental Management Agency, Zimbabwe

Designation: Environmental Quality Scientist – Air Quality Management

Period: August 2005 -March 2007

Company: Shabanie Mine - AA Mines, Zimbabwe

Designation: Safety Health and Environment - Officer

Period: April 2004 -March 2005

Company: Zimbabwe National Water Authority, Zimbabwe

Designation: Intern Pollution Control Unit- Water and Effluent Management

4 Experience

My hydrology consulting experience is listed below;

- Surface Water Quality monitoring and assessments
- Integrated Water and Waste Management Plans (IWWMP/ BPG: H1)
- Integrated Water Use Licence (IWUL) Audit
- Storm water Management Plan for mining developments
- Development of Water and Salt balances for mines Floodlines Modelling
- Water Conservation and Water Demand Management
- Floodline delineations using the HEC-RAS hydraulic model.
- Baseline surface water specialist studies,
- Surface water impact assessment's regarding the development of
- Surface Water Modelling using: DUFLOW, HEC –HMS and HEC-Ras, Surface Energy Balance, ET, baseflow calculations, Utilities Programmes for Drainage (UPD),

- Digital Terrain Model (DTM) Hydro processing in ILWIS and ArcHydro
- Water Quality Modelling and Management using DUFLOW, WASI, AQUACHEM, Remote sensing and GIS and Retrieval Algorithms

My Environmental Management System (EMS) experience is listed below;

- Environmental management systems implementation and review (ISO 14001),
- Environmental auditing, small projects EMP and EIA
- Water and effluent quality monitoring and management (National Legislation)
- Mine Safety audits (mines management and safety regulations),
- Emergency preparedness testing (drills) and accident \ incident investigation
- Development of OHSAS 18001 management system
- ISO 17020 System Developments
- Financial management of mine's Personal Protective Equipment (PPE)

5 Project Experience

A sample list of most recent projects undertaken is listed below:

- Hydrologist: ABOSSO GOLDFIELDS LIMITED. Damang Gold Mining operations, Ghana. Assessment of the existing mine water management infrastructure, draft a report and compile a current water balance model for the mine, reporting of conclusions, whilst providing the necessary recommendations.
- Hydrologist: EXXARO COAL CENTRAL (Pty) Ltd, Dorstfontein East Mine - Storm Water Management Plan, South Africa. Assessment of the existing mine water management infrastructure, draft a report and compile a current water balance model for the mine, reporting of conclusions, whilst providing the necessary recommendations.
- Hydrologist: MOTA ENGIL AFRICA, Liwonde Dry port, Malawi. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points, updating the baseline hydrology and water quality, undertaking a risk assessment and reporting of conclusions, whilst providing the necessary recommendations.
- Hydrologist: FOSKOR PTY LTD, FOSKOR PALABORWA Mine, South Africa. Mine water management assessments and Storm water management plan to Department of Water and Sanitation Best Practise guidelines (BPG: G1) SOUTH AFRICA. Assessment of the existing storm water infrastructure within the Palaborwa Foskor operations and providing conceptual design recommendations to meet regulation 704 of the National Water Act no 36 of 1998. The study included the following: climate

analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Calculating the water levels for the existing storm water network based on the peaks obtained, verifying the required capacity of the mine storage facilities whilst ensuring they meet regulation 704 requirements, flood risk assessment, providing final design layout showing changes to storm water infrastructure network if required, reporting of conclusions, whilst providing the necessary recommendations.

- Hydrologist: ESKOM LIMITED SOC (ESKOM), ESKOM Lambda Substation and Transmission Lines Floodlines, South Africa. The 1:100 and 1:50 floodlines for the powerline river crossings. The study required the following: climate data analysis, characterisation of the catchment hydrology, obtaining the peak 1 in 100 and 1 in 50 year flows, Terrain modelling and catchment delineation using ArcGIS software, hydraulic structures surveys on site, river flow monitoring and the interpretation of flow monitoring measurements, setting up 10 HecRAs Models and running them, determine the flood elevations and reporting of conclusions, whilst providing the necessary recommendations.
- Hydrologist: GLENCORE MINE, Impunzi and Tweefontein Water Balance Models, South Africa. Construction of a water and salt balance based for the Polokwane Smelter. The study includes the following: collection of climate data most specifically rainfall and evaporation, collection of flow data, collection of water quality data at various locations within the mine circuit, construction of the water and salt balance diagram using the process flow diagrams (pfd's) from the mine and existing model data, development of a monthly time step water and salt balance that can be updated as the monthly climate, flow and water quality data is updated, Reporting of conclusions, whilst providing the necessary recommendations for each site.
- Hydrologist: MSOBO COAL, Sara Buffels Water Balance, South Africa. Construction of a water and salt balance based for the Polokwane Smelter. The study includes the following: collection of climate data most specifically rainfall and evaporation, collection of flow data at various monitoring locations within the mine, collection of water quality data at various locations within the mine circuit, construction of the water and salt balance diagram using the process flow diagrams (pfd's) from the mine, development of a monthly time step water and salt balance that can be updated as the monthly climate, flow and water quality data is updated, Reporting of conclusions, whilst providing the necessary recommendations.
- Hydrologist: MSOBO COAL, Duiker 15 Water Balance, South Africa. Construction of a water and salt balance based for the Polokwane Smelter. The study includes the following: collection of climate data most specifically rainfall and evaporation, collection of flow data at various monitoring locations within the mine, collection of water quality data at various locations within the mine circuit, construction of the water and salt balance diagram using the process flow diagrams (pfd's) from the mine, development of a monthly time step water and salt balance that can be

updated as the monthly climate, flow and water quality data is updated, Reporting of conclusions, whilst providing the necessary recommendations.

Other projects have included

- Water balance and water quality prediction modelling GOLDSIM (Xstrata- RSA)
- Hydrology assessments for ESIA IFC/ WB standard projects (Sierra Leone- Koidu, Tonguma, Liberia – Putu)
- Surface water investigation for EIA/ EMPR study and IWULA applications; (Coal, Iron, Platinum, Gold and Uranium Projects - RSA)
- Hydrology Fatal Flaw Analysis (Aecom - AMD Witwatersrand Eastern Basin - RSA)
- Water Management Compliance and IWUL Audit (SASOL - RSA)
- Several IWWMP compilations (HCI Coal, Msobo Coal, Sasol - RSA)
- Water Management Strategy for Union Colliery- Water quality data Analysis (BHP Billiton - RSA)

6 Professional Affiliations

Associate Member - Water Institute for South Africa (WISA)

7 Professional Registration

South African Council for Natural Scientific Professions (Professional Natural Scientist - Water Resources Scientist) (no 400150/16))

8 Professional Development

1. 2D Surface Flow Modeling [HecRas Suite] (University Of Pretoria, Feb 2015)

2. Advanced Mine Water Management (EduMine, Mining Studies Institute at University of British Columbia Oct 2014)

3. Advanced Short Course in Environmental Management Enforcement and Prosecution (UNISA Nov 2013)

4. Advanced Short Course in the Legal Context for Environmental Management Compliance (UNISA Nov 2013)

5. Advanced Short Course in Environmental Management Compliance Inspection and Investigation (UNISA Nov 2013)

6. Hydrology Course North West University, South Africa May 2013)

7. ISO 14001 Internal Auditing and ISO 14001 Systems Development (May 2007)

8. ISO 17020 System Developments, (June 2007)

9. SAZS OHSAS 18001 System Development (Nov 2007)

10. Certificate in Project Management (Trust Academy, Zimbabwe Dec 2006)

9 Publications

D.T. Rwasoka, C.E. Madamombe, W. Gumindoga, A.T. Kabobah, Calibration, validation, parameter indentifiability and uncertainty analysis of a 2 – parameter parsimonious monthly rainfall-runoff model in two catchments in Zimbabwe, Physics and Chemistry of the Earth, Parts A/B/C, Available online 10 October 2013, ISSN 1474-7065, http://dx.doi.org/10.1016/j.pce.2013.09.015

Kabo-bah, A., Gumindoga, W., Rwasoka, D., Madamombe, C., (2012), Spatial and Temporal Analysis of TAMSAT Rainfall for Hydrologic Modelling – A Case of Zambezi Basin. Poster to be presented at 13th WARFSA/WATERNET/GWP-SA symposium 31 October - 2 November 2012, Johannesburg, South Africa POSTER PRESENTATION

Kabo-bah A., Xie Yuebo, Gumindoga, W., Rwasoka, D., Madamombe, C.,(2012), Validity of TAMSAT rainfall products for hydrological modelling in large river basins of Africa, 5th International workshop on Catchment Hydrology Modelling and Data Assimilation (CAHMDA-V) “Catchments in a Changing Climate” 9-13 July 2012, University of Twente, Faculty of Geoinformation Sciences

Kabo-bah, A., Madamombe, C.E., and Rwasoka, D.T. (2011), Estimation of Hyper-Temporal Evapotranspiration over the Middle-Zambezi Using the GEONETCast Toolbox and SEBS. Paper presented at the 12th WARFSA/WATERNET/GWP-SA symposium 27 – 30 October 2011, Maputo, Mozambique. Poster PRESENTATION

Gumindoga, W., Kabo-bah, A., Madamombe, C. E. , Hoko, Z. and Shekede, M.D (2011), Rainwater Harvesting For Improved Agriculture In Gutu District, Zimbabwe. Paper presented at the 12th WARFSA/WATERNET/GWP-SA symposium 27 – 30 October 2011, Maputo, Mozambique. POSTER PRESENTATION

Madamombe, C.E and Rwasoka, D.T. (2010), Application of Remote Sensing for Water Quality Monitoring: A Case Study of Lake-Chivero, Zimbabwe. Paper presented at the 11th WARFSA/WATERNET/GWP-SA symposium 27 – 30 October 2010, Victoria Falls, Zimbabwe. ORAL PRESENTATION

Mr Andy Pirie

Hydrologist

Hydrology Unit

Digby Wells Environmental

1 Education

1.1 Formal

- 2013: MSc: Water Resource Management, with distinction (University of Pretoria).

1.2 Courses

- 2015: 2D – Free Surface Water Flow Modelling (New HEC-RAS version 5.0) (University of Pretoria)
- 2013: Hydrology Course (North-West University).
- 2011: Introduction to Quantum GIS (University of Pretoria).
- 2011: Learning ArcGIS Desktop (for ArcGIS 10) (ESRI online course).
- 2010: ISO 14001: 2004 (University of Pretoria).
- 2009: Environmental Management Inspectorate (EMI) course (University of Pretoria).

2 Language Skills

- English: Excellent
- Afrikaans: Fair

3 Employment

- June 2012 - Present: Hydrologist and GIS Specialist at Digby Wells Environmental.

4 Software Experience

- ArcHydro
- Utilities Programme for Drainage (UPD)
- Visual SCS-SA
- HEC-RAS 1D and 2D
- HEC-GeoRAS
- WRSM2000

- Soil and Water Assessment Tool (SWAT)
- Microsoft Excel
- Microsoft Access
- ArcGIS
- Global Mapper
- Quantum GIS

5 General Experience

- Proposal writing.
- Baseline hydrological studies - reviewing literature and analyzing data such as rainfall, temperature, humidity, wind speed, runoff, soils, land use, topography, water quality, etc. of a study area to obtain the existing hydrological conditions. This includes report writing and summarizing the above data into graphs, tables and figures.
- Conducting hydrological studies into the impacts that developments (mostly mining) have on the surface water environment. This includes using an approved impact assessment methodology to determine the significance of the impacts. Reports include the description of the methods used and the results obtained as well as to provide mitigation measures for identified impacts.
- Water quality sampling and the interpretation of water quality results by summarizing results into tables, graphs and figures. This includes the generation of a report describing the sampling methods used and results obtained, and identification of possible sources of pollution, as well as suggesting mitigation measures to reduce pollution.
- Setup of water quality and streamflow monitoring networks.
- Streamflow monitoring and the interpretation of flow monitoring measurements.
- Floodline modelling to determine flood water elevations. This includes delineating catchments using GIS software, determining the flood peaks for the delineated catchments by analyzing rainfall, land use, slope, soils, etc., and using an appropriate flood method (Rational, SCS, SDF, etc.) to determine the peak flows.
- Development of storm water management plans according to the Department of Water and Sanitations (DWS) Best Practice Guideline G1: Storm Water Management and GN704 regulations to separate clean and dirty water at development sites.
- Audit of mine sites to GN704 regulations.
- Development of water and salt balances according to DWS Best Practice Guideline G2: Water and Salt Balances.

6 Worked In

- South Africa
- Botswana
- Zambia
- Namibia
- Mali
- Senegal

7 Project Experience (Selected)

Company	Position	Project Location	Project	Responsibilities
Digby Wells Environmental	Hydrologist	Gauteng, South Africa	Sibanye Gold Kloof Floodline Determination	• Catchment assessment of soils, vegetation, slope and land use to obtain suitable runoff coefficients. • Calculation of peak flows using Rational, SCS and SDF methods. • Hydraulic modelling in HEC-RAS for approximately 25 river reaches.
Digby Wells Environmental	Hydrologist	Senegal	Randgold Massawa ESIA	• Baseline hydrological study. • Floodline determination. • Water balance. • Calculation of environmental water requirements. • Modelling of catchment hydrology. • Stormwater management plan. • Surface water impact assessment.
Digby Wells Environmental	Hydrologist	Free State, South Africa	Sasol Defunct Mines Surface Flow Analysis	• Project manager. • Creation of detailed DEMs from Lidar data for 4 of Sasol's defunct subsided collieries. • Modelling of surface water flows to determine areas that are not free draining.

Company	Position	Project Location	Project	Responsibilities
Digby Wells Environmental	Hydrologist & GN704 Auditor	Northern Cape, South Africa	Assmang Khumani Iron Ore Mine GN704 Audit	• Project manager. • Preparation of an audit checklist. • Audit of the mine to GN704 regulations. • Reporting on findings and recommendations for improvement to comply with GN704 regulations.
Digby Wells Environmental	Hydrologist	Gauteng, South Africa	DRD Gold Stormwater Management Plans for the Ergo Elsburg & Van Dyk Tailings Dams	• Project manager. • Site visit audit of stormwater management structures. • Flood peak calculations. • Stormwater structure sizing. • Management measures to ensure that stormwater structures are maintained. • Reporting.
Digby Wells Environmental	Hydrologist	Mpumalanga, South Africa	Exxaro Surface Water Study for the Environmental Authorisation for the Proposed Schoonoord Underground Mine, Arnot Coal, Mpumalanga	• Baseline hydrological study. • Surface water impact assessment. • Water quality sampling and analysis of results. • Setup of a water monitoring network and programme. • Stormwater structure placement and sizings of structures. • Terrain modelling and catchment delineation using ArcGIS software. • Land use and soil assessment. • Determination of Peak flows for the 1:50 and 1:100 year storm event. • Hydraulic modelling using the HEC-RAS model to determine the 1:50 and 1:100 year floodlines. • Reporting.
Digby Wells Environmental	Hydrologist	Botswana, Zambia and Namibia	Kazungula Bridge Project Surface Water Quality Monitoring	• Setup of a water quality monitoring network and programme. • Monthly water sampling from the Zambezi and

Company	Position	Project Location	Project	Responsibilities
				Chobe Rivers over a 6 year period to determine whether the construction and operation of the Kazungula Bridge is impacting on the water quality. • Analysis of water quality results. • Monthly monitoring reports describing the water quality results for the month and identifying possible sources of pollution as well as providing mitigation measures.
Digby Wells Environmental	Hydrologist	Mpumalanga, South Africa	Sasol Surface Water Study for the Environmental Authorisation for the Imvula Coal Mining Project	• Baseline hydrological study. • Surface water impact assessment. • Terrain modelling and catchment delineation using ArcGIS software. • Land cover and soil hydrological assessment. • Surface water report writing and compilation.
Digby Wells Environmental	Hydrologist	Limpopo, South Africa	Exxaro Floodline Determination for the Closure Environmental Management Plan for the Tshikondeni Coal Mine	• Catchment assessment of rainfall, topography, soils and land cover. • Determination of the 1:50 and 1:100 year peak flows. • Hydraulic modelling using HEC-RAS to determine the 1:50 and 1:100 year floodlines. • Reporting on catchment characteristics, methods and results obtained.
Digby Wells Environmental	Hydrologist	North-west, South Africa	Sun City Drinking Water Quality Analysis	• Sampling of drinking water at Sun City. • Interpretation of water quality results. • Reporting.
Digby Wells Environmental	Hydrologist	Limpopo, South Africa	Surface Water Study for the Mining Permit Application for the De Groote	• Baseline hydrological study. • Surface water impact assessment. • Water quality sampling and assessment of water

Company	Position	Project Location	Project	Responsibilities
			Boom Project	quality results. • Setup of a water quality monitoring programme. • Reporting.
Digby Wells Environmental	Hydrologist	South Africa	Floodline Determination for Proposed Development of an Open Pit Coal Mine and Associated Infrastructure near Bronkhorstspruit, Gauteng	• Catchment assessment of rainfall, topography, soils and land cover. • Determination of the 1:50 and 1:100 year peak flows. • Hydraulic modelling using HEC-RAS to determine the 1:50 and 1:100 year floodlines. • Reporting on catchment characteristics, methods and results obtained.
Digby Wells Environmental	Hydrologist	Limpopo, South Africa	Floodline Determination for the Proposed Open Pit Magnetite Mine and Concentrator Plant, Mokopane, Limpopo Province	• Catchment assessment of rainfall, topography, soils and land cover. • Determination of the 1:50 and 1:100 year peak flows. • Hydraulic modelling using HEC-RAS to determine the 1:50 and 1:100 year floodlines. • Reporting on catchment characteristics, methods and results obtained.
Digby Wells Environmental	Hydrologist	Mpumalanga, South Africa	Eskom Surface Water Study for the Mashala Resourses 22kV Power Line	• Baseline hydrological study • Surface water impact assessment. • Hydraulic modelling using HEC-RAS to determine the 1:50 and 1:100 year floodlines. • Reporting.
Digby Wells Environmental	Hydrologist	Mpumalanga, South Africa	Msobo Coal Surface Water Study for the Sara Buffels A and B: IWULA and IWWMP for Opencast and Underground Mining Activities	• Surface water impact assessment. • Terrain modelling and catchment delineation using ArcGIS software. • Land use and soil assessment. • Determination of Peak flows for the 1:50 and 1:100 year storm event. • Hydraulic modelling using the HEC-RAS model to

Company	Position	Project Location	Project	Responsibilities
				determine the 1:50 and 1:100 year floodlines. • Reporting.
Digby Wells Environmental	Hydrologist	Mali	Randgold Surface Water Study for the Morila Gold Mine Agri-Assessment Project	• Review of reports, mine layout plan and water quality data. • Classification of clean and dirty water areas based on the above. • Recommendations on water sources and areas for agri-business purposes post mine closure.

Mr Mashudu Rafundisani

Hydrologist

Water Geo-Sciences Department

Digby Wells Environmental

1 Education

1.1 Formal

- Bsc (Hons) Environmental Management (University of Venda).

1.2 Courses

- 2015: 2D – Free Surface Water Flow Modelling (New HEC-RAS version 5.0) (University of Pretoria)
- 2016: Project Management (Primeserv Group Limited)

2 Language Skills

Tshivenda: Excellent

English: Excellent

Zulu: Fair

Tsonga: Fair

Sepedi: Fair

3 Employment

- 2013 - Present: Hydrologist at Digby Wells Environmental.

4 General Experience

- Baseline hydrological studies by reviewing literature and analyzing data such as rainfall, temperature, humidity, wind speed, Stream flows, soils, etc. of a study area to obtain the existing hydrological conditions. This includes report writing and summarizing the above data into graphs, tables and figures.
- Conducting hydrological studies into the impacts that developments (mostly mining) may have on the surface water environment. This includes using an adopted impact assessment methodology to determine the significance of the impacts. Reports

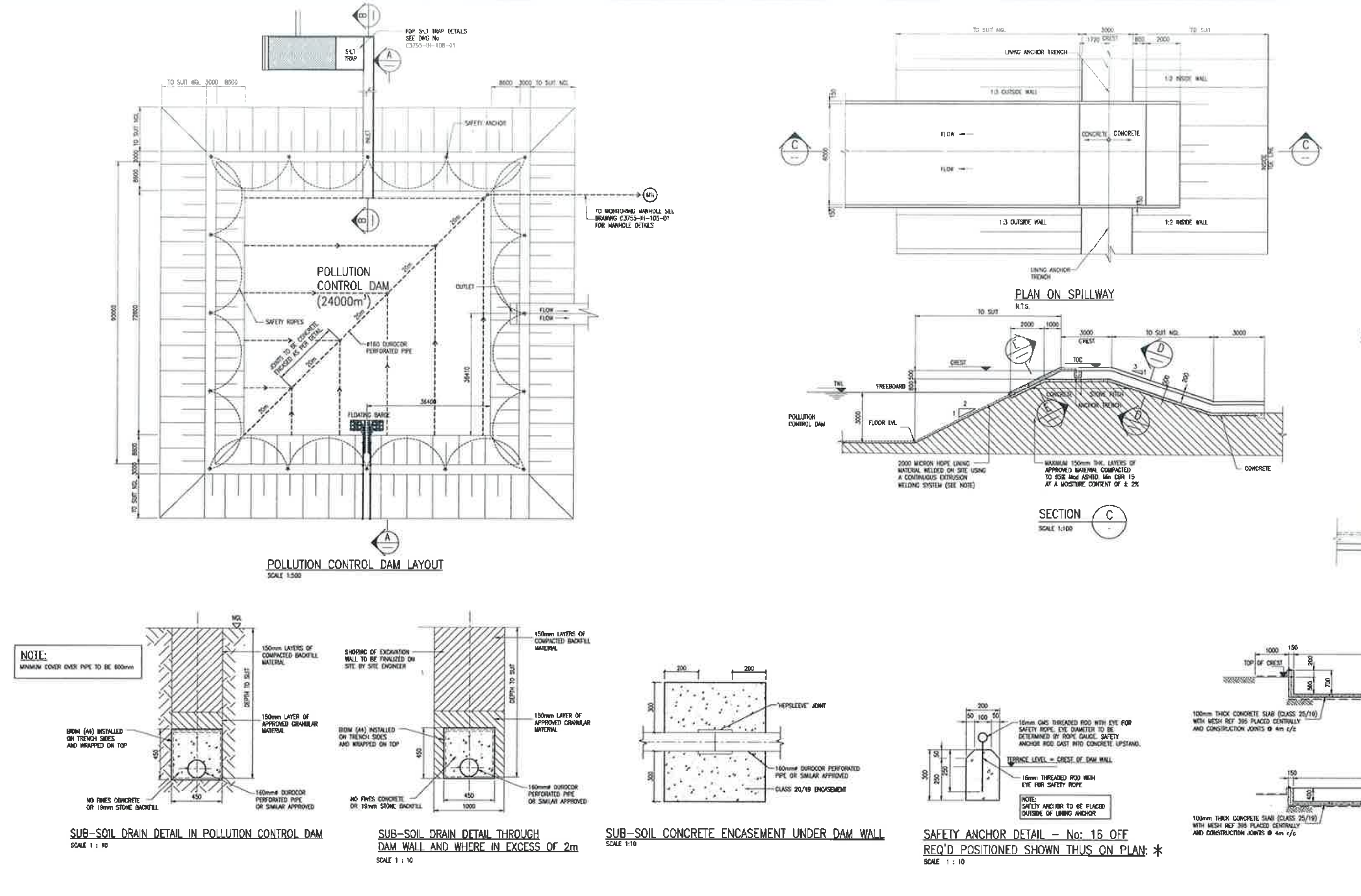
include the description of the methods used and the results obtained as well as to provide mitigation measures for identified impacts.

- Water quality sampling and the interpretation of water quality results by summarizing results into tables, graphs and figures. This includes the generation of a report describing the sampling methods used and results obtained, and identification of possible sources of pollution, as well as suggesting mitigation measures to reduce the pollution.
- Setup of water quality monitoring networks.
- Streamflow monitoring and the interpretation of flow monitoring measurements.
- Floodline modelling using HEC-RAS software to determine flood water elevations. This includes delineating catchments using GIS software, determining the flood peaks for the delineated catchments by analyzing rainfall, land use, slope, soils, etc., and using an appropriate method to determine the flood peaks.
- Development of storm water management plans according to GN704 to separate clean and dirty water at development sites.
- Development of water and salt balances in order to manage mine water.

5 Software Experience

- Utility Program for Drainage (UPD)
- ArcGIS
- HEC-RAS
- WRSM2000

Appendix B: SWMP Designs

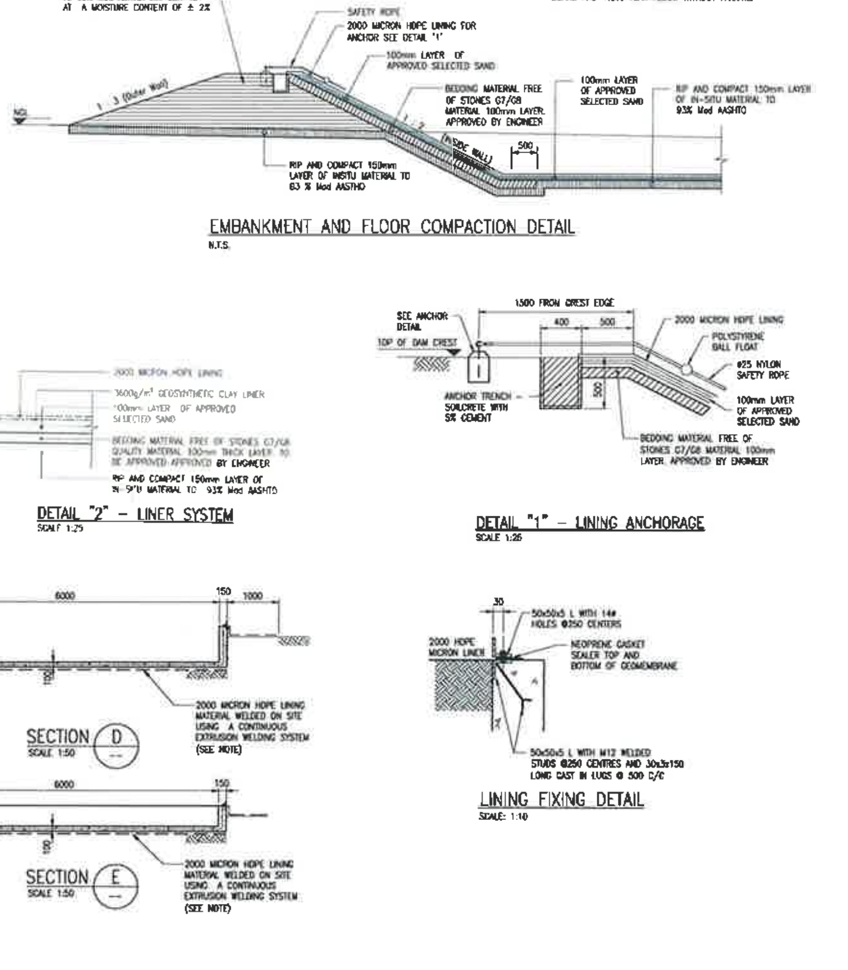


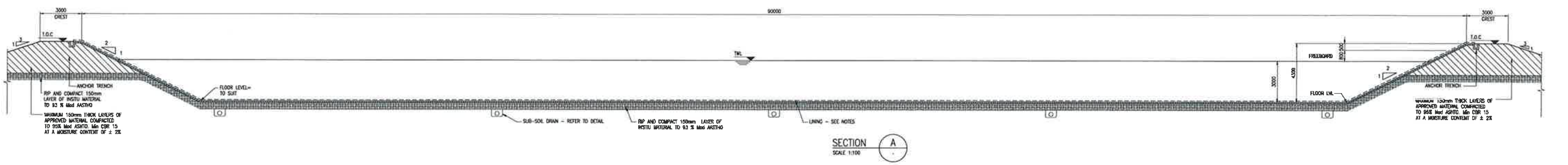
GEOTECHNICAL NOTES :

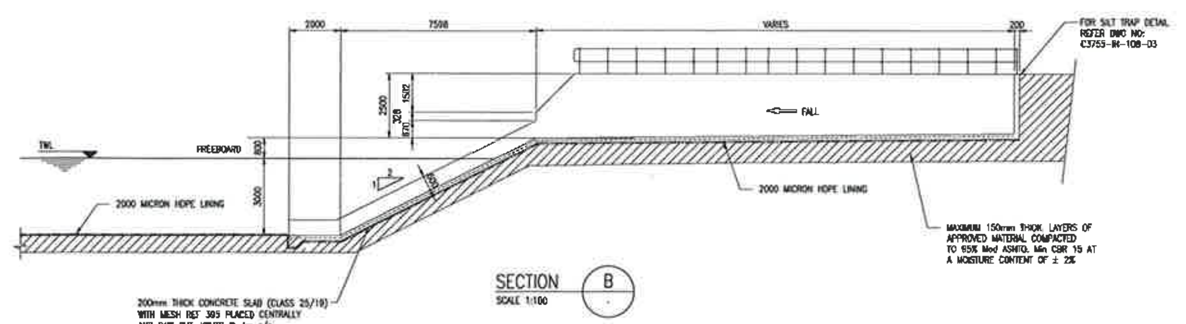
1. TRIM WALL TO 100mm FROM FINAL LEVEL.
2. BEDDING MATERIAL FREE OF STONES G7/G8 MATERIAL 100mm LAYER APPROVED BY ENGINEER
3. COMPACT WITH HAND OPERATED ROLLER (6 PASSES)
4. FULL METHOD STATEMENT TO BE SUBMITTED TO ENGINEER BEFORE COMMENCING ON SITE.

NOTES :

1. MATERIAL DESCRIPTION LINING TO COMPLY WITH SANS 1526-1991 AND TO BE AQUATAN H-DRILINE OR SIMILAR APPROVED AND SHALL CONSIST OF SUITABLY COMPOUNDED HIGH DENSITY POLYETHYLENE THICKNESS : FLOOR AND WALLS - 2000 MICRONS DESIGN LIFE OF 20 YEARS
2. JOINT INFORMATION ALL JOINTS TO BE WATERTIGHT AND THE MATERIAL JOINED TOGETHER USING A CONTINUOUS EXTRUSION FUSION OR ELECTRIC WEDGE WELDING SYSTEM TO ENSURE A TOTALLY INTEGRATED HOMOGENEOUS JOINT. JOINTING TO BE IN STRICT ACCORDANCE WITH THE MANUFACTURERS INSTRUCTIONS & SANS 1526-1991.
3. POLLUTION CONTROL DAMS HAVE BEEN DESIGNED IN ACCORDANCE WITH DWAF,2007: BEST PRACTICE GUIDELINES A4: POLLUTION CONTROL DAMS AND GOVERNMENT GAZETTE No.704, 4 JUNE 1999 (VOL. 408, No.20119) WHERE PCD'S:
   - ARE NOT WITHIN A 1:100 YEAR FLOOD-LINE OR WITHIN 100m OF ANY WATERCOURSE OR ESTUARY.
   - ARE NOT LIKELY TO SPILL INTO ANY CLEAN WATER SYSTEM MORE THAN ONCE IN 50 YEARS AND WILL NOT FAIL DURING A 1:200 YEAR FLOOD EVENT.
   - HAVE A MINIMUM FREEBOARD OF 0.8m AND A FLOOD BUFFER ZONE OF 0.5m ABOVE FULL SUPPLY LEVEL.
   - RETAIN DIRTY WATER RUN-OFF
   - OPERATE AT OR NEAR EMPTY.
   - DIRTY WATER WITHIN THE PCD'S ARE RE-USED WITHIN THE PROCESS PLANT BY MEANS OF RETURN WATER PIPELINES.
   - ARE FENCED OF WITH PALISADE FENCING SO AS TO RESTRICT ACCESS.
4. SPILLWAYS HAVE BEEN DESIGNED IN ACCORDANCE WITH DWAF, 2007: BEST PRACTICE GUIDELINES A4: POLLUTION CONTROL DAMS TO PASS A 1:50 YEAR FLOOD WITH REQUIRED FREE BOARD AND 1:200 YEAR FLOOD WITHOUT FAILURE.







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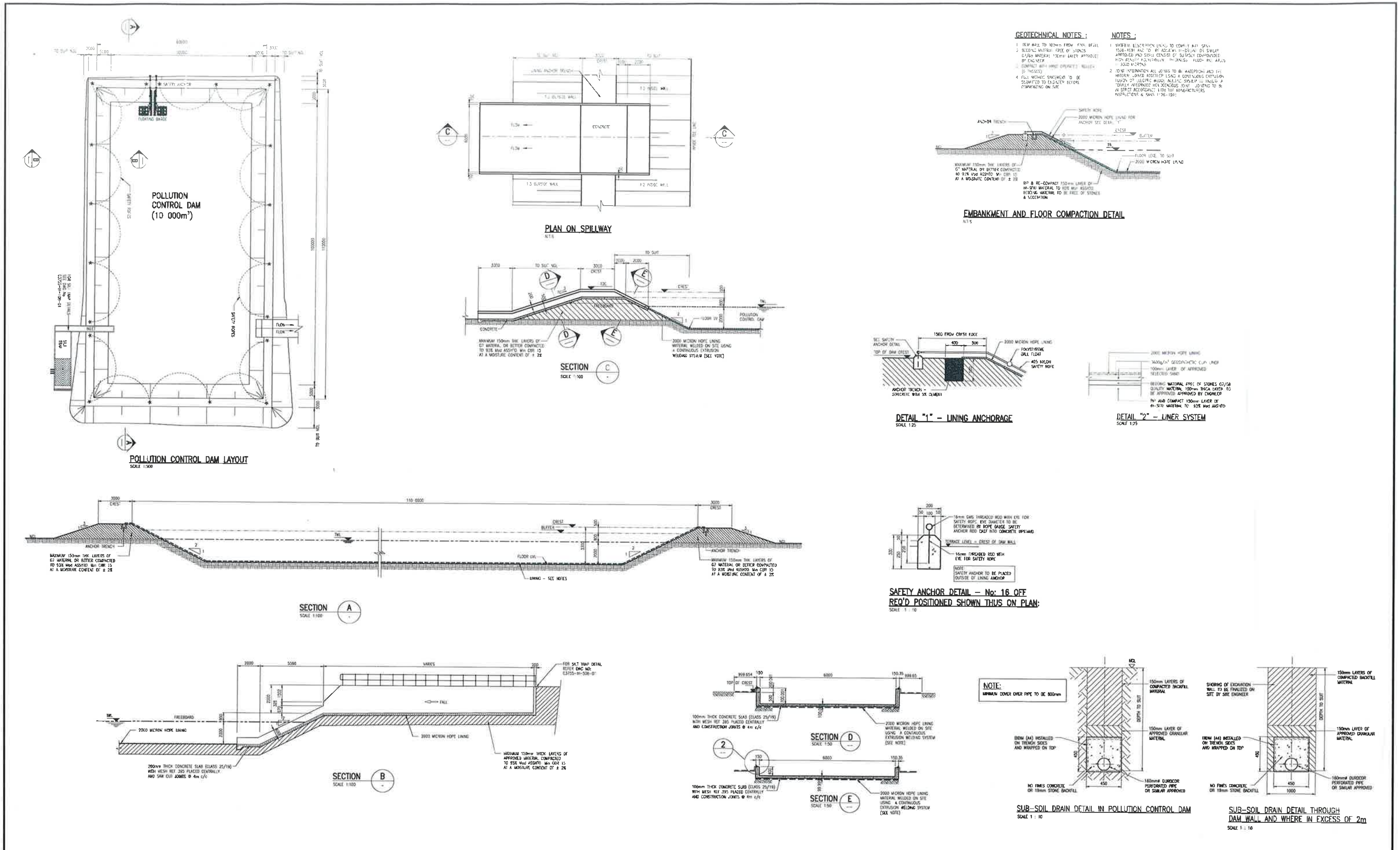
DRAWING DATE: 20 / 05 / 2016		DWG NO: GC-HEN-005-01	Rev 00
DRAWING REVIEW		TITLE:	HENDRINA UNDERGROUND PROJECT SURFACE INFRASTRUCTURE POLLUTION CONTROL DAM - MOOIVLEY EAST
Drawn By:	Project Engineer:		
Project Manager:	General Manager:		



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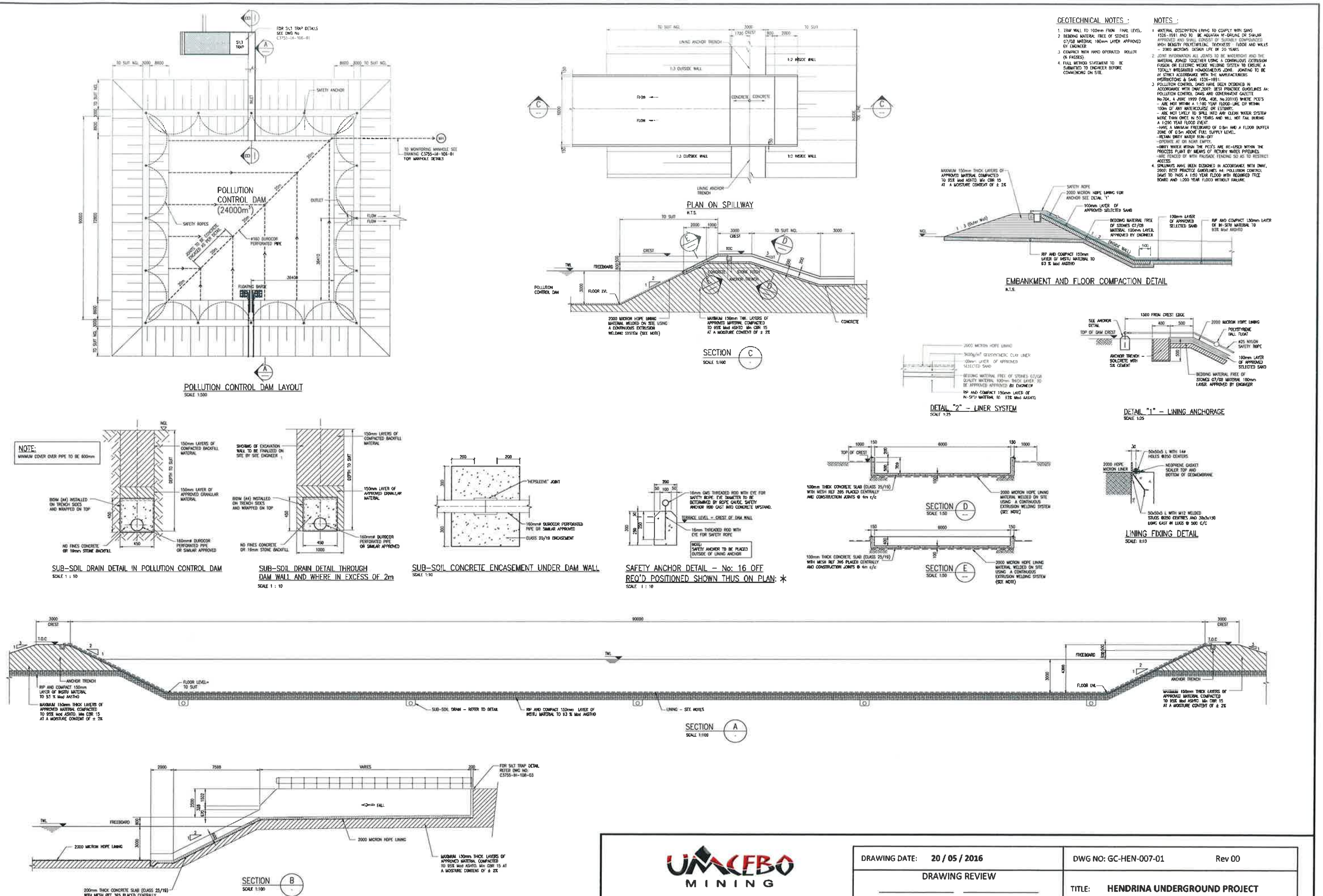
DRAWING DATE: 20 / 05 / 2016	DWG NO: GC-HEN-006-01 Rev 00
DRAWING REVIEW Drawn By: Project Engineer: Project Manager: General Manager:	TITLE: **HENDRINA UNDERGROUND PROJECT** SURFACE INFRASTRUCTURE POLLUTION CONTROL DAM - MOOIVLEY WEST



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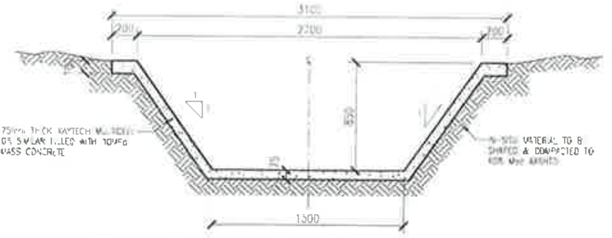
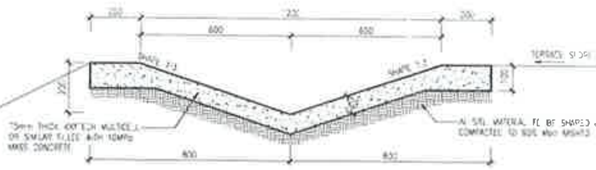
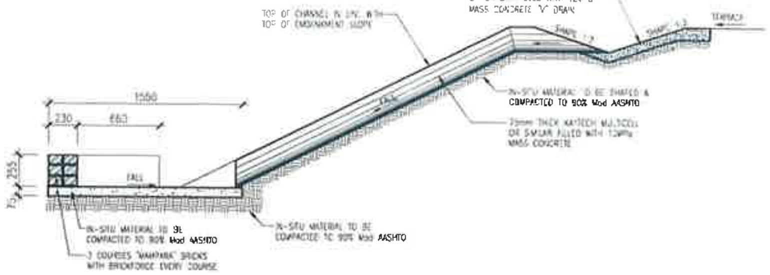
DRAWING DATE:	20 / 05 / 2016	DWG NO: GC-HEN-007-01	Rev 00
DRAWING REVIEW		TITLE:	HENDRINA UNDERGROUND PROJECT SURFACE INFRASTRUCTURE POLLUTION CONTROL DAM - HENDRINA SOUTH
Drawn By:	Project Engineer:		
Project Manager:	General Manager:		



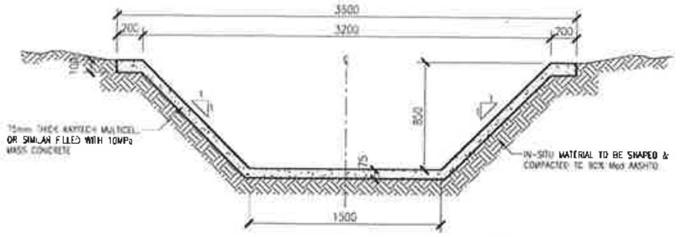
CONCRETE TRAPEZOIDAL STORMWATER CHANNEL TYPE 1 (HARD & SOFT STOCKPILES)
1 : 20



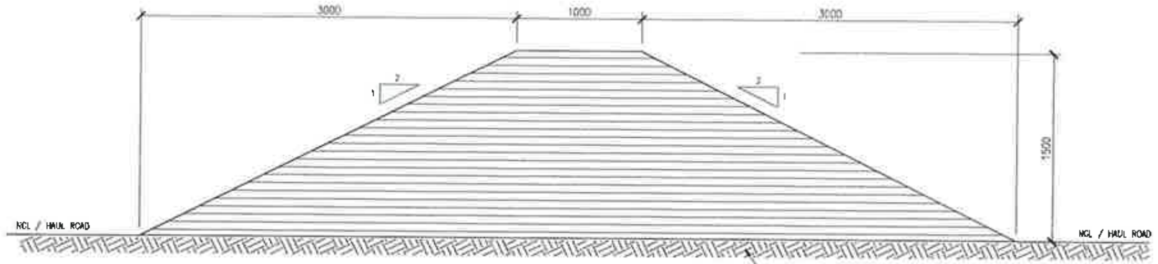
TYPICAL "V"-DRAIN (OFFICES)
SCALE 1:10



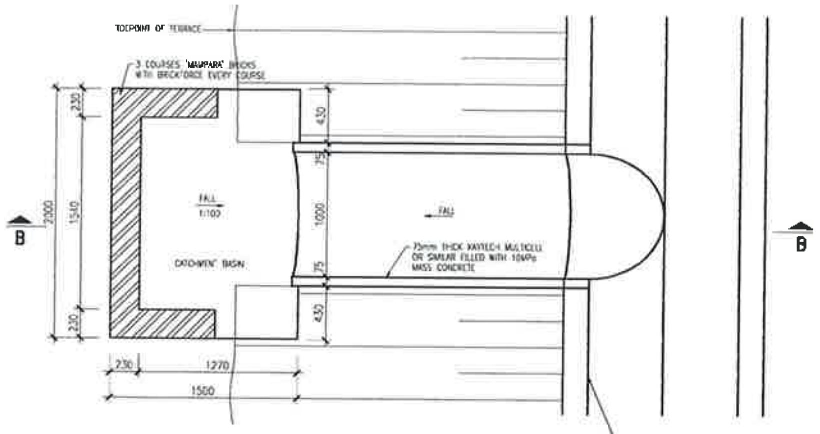
SECTION B–B
1:20



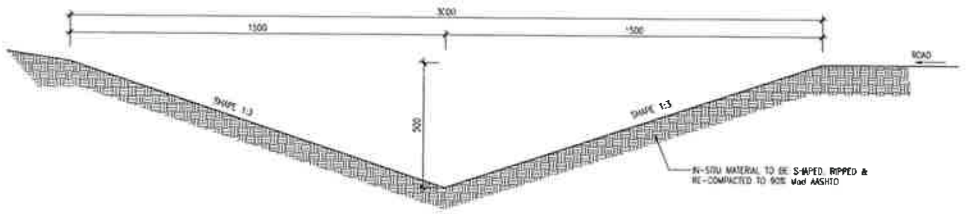
CONCRETE TRAPEZOIDAL STORMWATER CHANNEL TYPE 2 (RAILWAY SIDING)
1 : 20



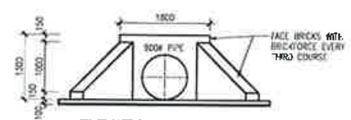
TYPICAL SECTION THROUGH EARTH BERM
1 : 20



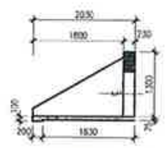
TYPICAL DOWN CHUTE DETAILS (OFFICES)
1:20



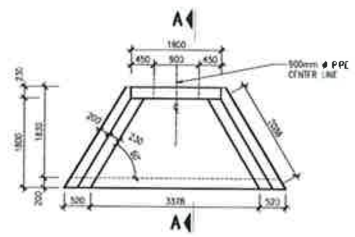
TYPICAL EARTH "V"-DRAIN
SCALE 1:10



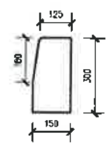
ELEVATION
SCALE 1: 50



ELEVATION A–A
SCALE 1: 50



PLAN – CULVERT
SCALE 1: 50



TYPICAL KERB –SABS 927
SCALE 1: 10

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DRAWING DATE: 20 / 05 / 2016	DWG NO: GC-HEN-011-01	Rev 00
DRAWING REVIEW	TITLE:	**HENDRINA UNDERGROUND PROJECT**
Drawn By: / Project Engineer:		SURFACE INFRASTRUCTURE
Project Manager: / General Manager:		STORMWATER BERMS & DRAINS DETAIL