Surface Water Hydrological Study for the Beeshoek Iron Ore Mine Optimisation Project

Project Number:

ENG013

Prepared for:

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DOCUMENT CONTROL

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DECLARATION OF INDEPENDENCE

I, Andy Pirie declare that:

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

Andy Pirie
Hydrologist
Pr.Sci.Nat (reg no. 114988)

ACRONYMS AND ABBREVIATIONS

BPG	Best Practice Guideline
DEM	Digital Elevation Model
DMRE	Department of Mineral Resources and Energy
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DTM	Digital Terrain Model
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
GIS	Geographical Information Systems
GN704	Government Notice No. 704 - Regulations on the Use of Water for Mining and Related Activities aimed at the Protection of Water Resources
km	Kilometres
LoM	Life of Mine
mamsl	metres above mean sea level
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	Metres below ground level
MRA	Mining Right Area
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
mtpa	Million tons per annum
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PCD	Pollution Control Dam
Pr.Sci.Nat.	Professional Natural Scientist
ROM	Run of Mine
RWD	Return Water Dam
SACNASP	South African Council for Natural Scientific Professions
SAWS	South African Weather Service
SCS	Soil Conservation Service
S-Pan	Symons Pan
SWMP	Stormwater Management Plan
WMA	Water Management Areas
WR2012	Water Resources of South Africa, 2012 Study
WRD	Waste Rock Dump
WUL	Water Use Licence
WULA	Water Use Licence Application

EXECUTIVE SUMMARY

Hydrospatial (Pty) Ltd was appointed by EnviroGistics to undertake a surface water hydrological study for the proposed Beeshoek Optimisation Project. The Optimisation Project includes a number of projects within the Beeshoek Mining Right Area (MRA) to ensure continued and sustainable mining of iron ore reserves. These include:

- Consolidation of the Run of Mine (ROM) stockpiles on South Mine;
- Increase in height and footprint area of existing Waste Rock Dumps (WRDs);
- Increase of open pit footprint areas and detrital mining;
- Low-grade beneficiation optimisation projects;
- Construction of water management infrastructure; and
- Construction of a railway line link.

The railway link was investigated as part of a Basic Assessment process and is therefore not assessed in this study.

The climate of Beeshoek can be described as semi-arid to arid, with evaporation far exceeding rainfall. The Mine is located in an endoreic catchment, and therefore, surface water runoff is limited. The general topography of the MRA is flat and the soils consist mostly of semi-permeable to permeable soils. Shallow ephemeral drainage lines occur in the south-east of the MRA and drain towards the Groenwaterspruit. A number of pan like features occur in the west and south of the MRA and have been classified as Cryptic wetlands and seasonal depressions in the Freshwater Ecological Assessment (SAS, 2021).

Surface water quality is monitored at the dams/tanks, pits and pipelines. According to Aquatico (2021), the general surface water quality during the 2020 period was classified as being neutral, saline and very hard. Low salt concentrations, metal concentrations and nutrient concentrations were detected at all of the sampling localities. Elevated bacteriological counts occurred at some of the sampling locations. According to GPT (2021), groundwater levels range between 5 metres below ground level (mbgl) in the unaffected mining areas, to 180 - 200 mbgl in the dewatered areas due to groundwater abstraction for dewatering and water supply. The effect of dewatering is more pronounced to the south of the mine. The direction of groundwater flow is south to south easterly from the mining area. A cone of depression has developed within the active mining area with flow directed towards the mining excavation due to the active mining areas. The general groundwater quality is good, however, elevated nitrate does occur at some of the sampling boreholes due to expected mining related impacts (Aquatico, 2021).

The only natural defined drainage channel occurs in the south-east of the MRA. A 1:50 and 1:100 year floodline determination was undertaken on this drainage line, as according to Regulation 4 (b) of GN704, prospecting should not take place within the 1:50 year floodline unless exemption is obtained from the DWS. The determined floodline is connected to what has been delineated as a recharge zone in the Freshwater Ecological Assessment (SAS, 2021). It is recommended that future prospecting activities do not take place within the 1:50 year floodline as required by GN704 Regulations. It is further recommended that future

prospecting activities remain outside of the recharge zone pending further investigation and understanding of this area.

The following are proposed stormwater measures:

- Berms should be placed around the proposed ROM Stockpile consolidation area, as is the case with other ROM Stockpiles onsite. Waste rock can be used to construct the berms, as it has been authorised for such purposes in the Mines amended WUL. This will ensure that any clean water runoff is diverted away.
- No stormwater measures to contain runoff were recommended around the existing WRDs due to the low rainfall, high evaporation and waste classification which indicated non-hazardous material (SWS, 2016). Furthermore, waste rock has been exempted from regulation 5 of GN704 (which pertains to "Restrictions on the use of material") for the construction of berms and haul roads. Based on the above, it is not foreseen that runoff from the WRD expansion areas would need to be contained. However, WRDs close to sensitive areas such as wetlands and depressions should be contained.
- Berms should be placed around the proposed pits and Detrital mining areas, as is the case with the other existing pits, to ensure that no clean water flows into the voids. Seepage and dirty water runoff collected within the voids should be managed by recycling and reusing dirty water as far as practicably possible.
- The WHIMS and Jig Plants should be operated as dirty areas. Dirty water runoff from the WHIMS and Jig Plants should be directed via lined channels to lined sumps or Pollution Control Dams (PCDs). The water collected within the sumps/PCDs should be recycled and reused as process water. Both the WHIMS and Jig Plants will be located on topographically elevated areas surrounded by disturbed areas, and therefore, the diversion of clean runoff around these areas is not foreseen.
- Water levels and sufficient freeboard within the proposed dirty water dams/tanks, should be monitored and reported on. Dirty water storage facilities must be sufficiently lined with adequate capacity, in accordance with GN704 regulations.

The impact assessment indicated that all identified impacts would have a medium significance pre-mitigation, and that these impacts can be mitigated to a low significance should mitigation measures be adhered to.

Monitoring plans have been proposed under section 7 of this report.

Based on the findings and outcomes of this study, it is the opinion of the specialist that from a surface water perspective, the proposed projects and activities can commence, provided that the recommendations and mitigation measures provided in this report are adhered to. It is important that future prospecting activities in the southern and western extent of the MRA should avoid the wetlands, depressions, recharge zone and drainage lines.

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1 INTRODUCTION AND BACKGROUND

1.1 Terms of Reference

Hydrospatial (Pty) Ltd was appointed by EnviroGistics (Pty) Ltd (hereafter "EnviroGistics") to undertake a surface water hydrological study for the proposed Beeshoek Iron Ore Mine (hereafter "Beeshoek" or the "Mine") Optimisation Project (hereafter the "project"). This report has been prepared for EnviroGistics, who are currently undertaking an Environmental Authorisation process for the proposed project.

1.2 Project Location

Beeshoek is located approximately 7 kilometres (km) west of the town of Postmasburg in the Northern Cape (Figure 1-1). The Mine is divided into two areas that are separated by the R385 regional road that runs in a north-westerly direction between the towns of Postmasburg and Olifantshoek. The North Mine is located to the north of the R385, whilst the South Mine is located to the south.

1.3 Mining Operation Background

Assmang (Pty) Ltd is the holder of the new order rights in terms of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) in respect of high-grade hematite iron ore deposits at Beeshoek. Mining was established in 1964 with a basic hand sorting operation. In 1975, a full washing and screening plant was installed. Because of increased production, Beeshoek South, a southern extension of the Mine, was commissioned in 1999. The mining method currently entails open pit mining, which consists of five (5) active open pits (Village Pit, HF Pit, BF Pit, East Pit, and BN Pit). The iron ore is exploited by means of conventional open pit mining techniques (drilling-blasting-load-haul). Backfilling of numerous existing pits is employed, where possible, in order to minimise both the final voids left at the end of mining as well as the size of waste dumps. Waste with a potential future use is stockpiled separately in order to be accessible and ready to be processed by the future user. Although other open pits at the Mine are dormant at this time, these are continuously assessed in terms of their economic value. The current resources of the Mine is approximately 97.17 million tonnes with a reserve of about 26.18 million tonnes.

Beeshoek can be broadly categorised as follows:

- Northern mining area (North Mine): This area comprises active as well as historical mining areas. A number of small quarries and Mine residue dumps of various categories are located within this area. The area also includes the existing iron ore beneficiation plant, tailings storage facility (slimes dam), as well as the North Opencast Pits;
- Main Offices, village (since demolished) and recreational area; and
- Southern mining area (South Mine): This area comprises large opencast pits and associated Waste Rock Dumps (WRDs). The Village Pit and associated WRD are the main activities in this area. This area also includes a crushing and screening area as

pre-preparation of the Run of Mine (ROM) iron ore before being routed by overland conveyor to the Iron Ore Beneficiation Plant located at North Mine.

1.4 Mine Water Management

1.4.1 Potable and Process Water

Potable water for use by the Mine is obtained from various boreholes on site. Boreholes are licensed for domestic supply and others for both domestic and process water supply, as well as for the purposes of dewatering for safe mining conditions.

Twelve boreholes are licensed in the Water Use Licence (WUL), 2018 to abstract a total volume of 5 655 371 m^3/annum. Of these boreholes, five are licensed for dewatering specifically (of which two are in-pit dewatering). The Mine plans to add the HF Pit Borehole (WG74) currently licensed for potable water supply as a dewatering borehole for the HF Opencast Pit in the near future. This intercepted groundwater forms part of the Mine's clean water circuit.

The potable water is collected in two concrete reservoirs at the entrance to the southern mining area where the water is disinfected for further distribution on the Mine site. With the addition of the new water balance components, there are 11 clean water dams included in the WUL (this excludes the two fire water tanks). Most of these dams are not used to store water on a daily basis, but only to transfer water from where groundwater is abstracted to where it is required for use.

1.4.2 Clean Water Storage

Clean water resources at the Mine include:

- Water dewatered directly from groundwater; and
- Water obtained from the Vaal Gamagara Water Supply Scheme (only utilised when the need arises).

Beeshoek is authorised to store water in various tanks (steel and plastic) on site. The water is sourced from the main water supply systems (either the supply boreholes or the pipeline scheme). Dams currently approved for clean water storage include the:

- Airfield Tank;
- Dam D94 and Dam D92 (previously known as the Golf course dam)
- Dam D96 (also known as the Tommy's Field Tank),
- Dam 301A and 301B (also known as Midsouth 3 Tanks);
- Dam D300 (also known as Mid-South 1 Tanks);
- Dam D90 (also known as Main Reservoir);
- Dam D91 (also known as Main Reservoir);
- Dam D97 (also known as the Uitsig Tank); and

Tank 25KT02A &B.

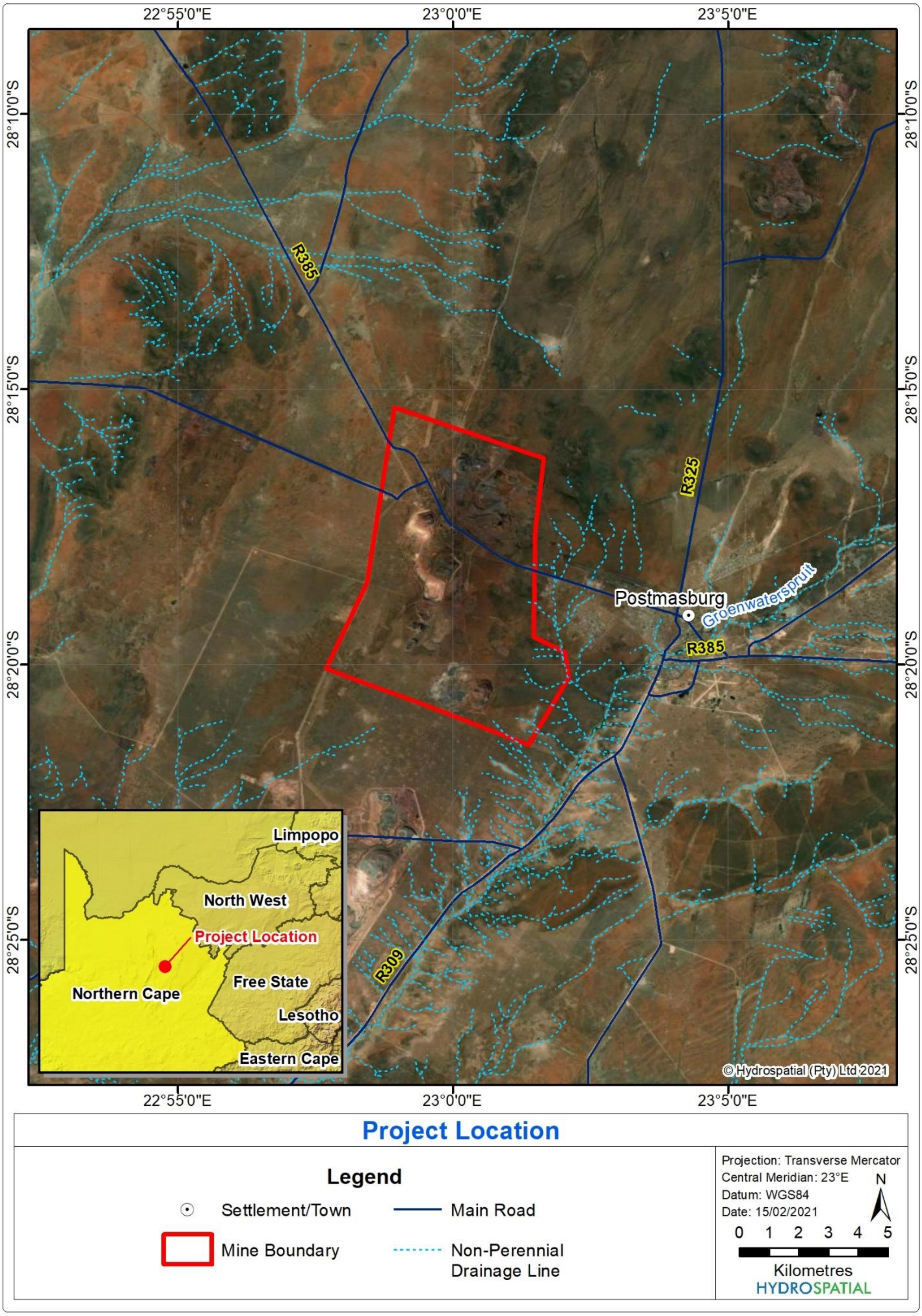

Figure 1-1: Location of the project

1.4.3 Dirty Water Storage

Dirty water on site includes:

- Water runoff from Plant and workshop areas;
- Water circulated through the Plant, Thickener, Clarifier and Slimes Dam process; and
- In-pit water dewatering.

Limited dams are used to manage water on the Mine and include:

- Blue Dam (Dam D86);
- South Evaporation Ponds;
- Tank 26TK01A & B (also known as the BN Dam);
- Clarifier and Thickener System; and
- Storm Water Dam North.

The Mine is operating within an internal closed water circuit and operates on the strategy of maximising the utilisation of dirty water in the mining area.

1.5 Proposed Projects and Activities

Beeshoek are investigating opportunities for the continued and sustainable mining of iron ore reserves. The following proposed projects and activities indicated on Figure 1-2 form part of the Environmental Authorisation process and are assessed in this study:

1.5.1 Consolidation of ROM Stockpiles on South Mine

Iron ore rich material removed from the Beeshoek open pits are stored on ROM Stockpiles (both on-grade and off-grade) on site. ROM stockpiles are processed through the plant. The on-grade and off-grade ROM are blended when required to meet the specific market requirements. The area between the stockpiles on the South Mine, namely, the ROM Stockpile, South Contaminated ROM 1, Contaminated Dump 2 and BIS Stockpile will be consolidated to allow for further stockpile capacity and operational management.

1.5.2 Increase in Height and Footprint Area of Existing WRDs

The Mine indicated the need to update the heights and designs of various WRDs on site to take into consideration rehabilitation requirements. The increase in the heights will also require an increase in the footprint areas to allow for the correct slope at closure. Table 1-1 indicates the approved/current and proposed heights and footprint areas of the WRDs.

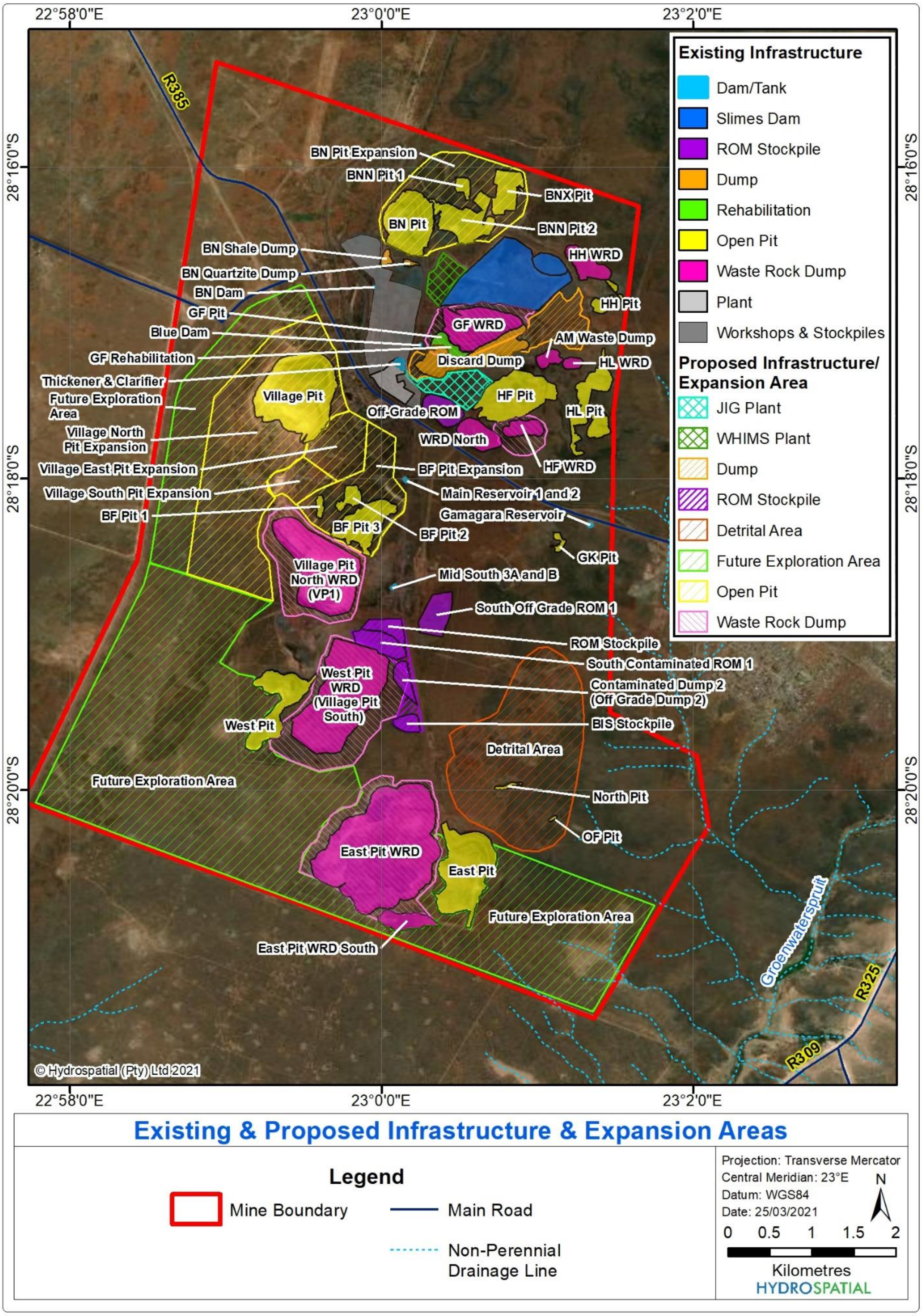

Figure 1-2: Existing and proposed infrastructure and expansion areas

Table 1-1: Approved/current and proposed dimensions of the WRDs

Facility	Approved/Current Dimensions	Proposed Dimensions	Comment
Village Pit North WRD (VP1)	Footprint: 70 ha Height: 93 m	Footprint: 96 ha Height: 111 m operational height but 112 m upon rehabilitation	Clearance of about 25 ha of vegetation
GF WRD	Footprint: 48 ha Height: 55 m	Footprint: 54 ha Height: 82 m operational height but 84 m upon rehabilitation	No clearance of vegetation foreseen
East Pit WRD	Footprint: 144 ha Height: 39 m	Footprint: 170 ha Height: 94 m for both operation and rehabilitation	Clearance in excess of 25 ha of vegetation
West Pit WRD (now referred to as the Village Pit South WRD)	Footprint: 80 ha Height: 0-1 m	Footprint: 135 ha Height: 98 m operational height but 106 m upon rehabilitation	Clearance of about 35 ha of vegetation
HF WRD	Footprint: 20 ha Height: 26 m	Footprint: Same footprint area Height: 39 m operational height but 63 m upon rehabilitation	No clearance of vegetation required
Discard Dump	Footprint: 28 ha Height: 29 m	Footprint: 60 ha Height: 60 m	No clearance of vegetation required

1.5.3 Increase of Open Pit Footprint Areas and Detrital Mining

The Mine would like to increase the approved footprints of the active pits to include:

- BN Pit Expansion;
- Village North Pit Expansion;
- Village East Pit Expansion;
- Village South Pit Expansion;
- BF Pit Expansion; and

- Detrital Area.

Detrital ore are shallow deposits that are scooped out of the ground for processing as opposed to employing more extensive open pit mining methods. The earlier approved Environmental Management Programmes (EMPr's) of the Mine did not demarcate the required detrital mining areas, or stipulated required management measures. For this reason, the dolomite karst areas will be explored and where possible mined. The depth can vary from 4 m to 25 m deep. The detrital mining strategy and the depth is only determined once excavation starts and the quality of iron ore is inspected within a karst deposition area.

One additional haul road of 1.1 km (approximately 3.3 ha) will be required between the current Village Pit and proposed Village South Pit Expansion.

The Mine will backfill the pits as far as practically possible as part of the ongoing development of the annual and long-term rehabilitation plans, but in some areas voids may remain where enviroberms will be established for safety purposes.

The areas to the west and south of the MRA have been earmarked for future exploration activities.

1.5.4 Low-Grade Beneficiation Optimisation Project

Beeshoek Mine has identified the opportunity to recover and economically beneficiate existing and arising low-grade resources. The intent being the construction, commissioning and bringing into production two additional beneficiation plants capable of producing approximately 1 million tons per annum (mtpa) of export quality sinter fines product.

The proposed Beeshoek Low-Grade Beneficiation Optimisation Project will allow Beeshoek Mine to optimise the mining process and reduce Mineral waste on site, by implementing two additional Beneficiation Projects, namely, a new WHIMS Plant to rework the existing slimes from the Slimes Dam, and a new Jig Plant to rework the existing low-grade Discard Dump.

The WHIMS Project will consist of the following:

- WHIMS Plant which will beneficiate slimes from the Slimes Dam and arising material from the existing Beeshoek Plant;
- WHIMS Construction Laydown Area of approximately 1.5 ha;
- Within the laydown area, a 2 500 m^2 Staging Stockpile comprising low grade feed material will be located. This will be a designed facility which will feed the WHIMS Plant. This material will be processed material (i.e. raw material) derived from the Slimes Dam. All waste (oversize from the Oversize Discard Bunker and slimes) will be disposed of onto the existing Slimes Dam and no new mine residue Stockpile will be developed;
- WHIMS Plant footprint, including an access road of 160 m, no wider than 30 m: approximately 4 ha in size;
- WHIMS Plant Central Process Water Dam: 0.4 ha, capacity planned at 5 000 m^3;
- WHIMS Plant Clarifier: tank diameter 56 m, capacity 9 700 m^3;
- WHIMS Plant Emergency Product Stockpile: 21 m^2 within WHIMS Plant footprint area;

- WHIMS 1 mm Product Stockpile: 300 m^2 within the WHIMS Plant footprint area;
- Tailings Pipeline HDPE: 315 mm diameter at 750 m^3/hr (208.3 l/s):
  - 1.1 km (new WHIMS Plant clarifier to northern perimeter of Slimes Dam;
  - 1.4 km (new WHIMS Plant clarifier to southern perimeter of Slimes Dam; and
  - Existing pipeline of 1.3 km to be rerouted from existing thickener directly to the new WHIMS Plant.
- Return Water Pipeline HDPE, 280 mm diameter at 400 m^3/hr (111 l/s): - 1.1 km (re-routing of existing pipeline from Slimes Dam to WHIMS Plant clarifier;
- Process Water Pipelines: 350 mm diameter - 1.3 km (replacement of existing pipeline with new pipeline from Central Water Dam to new Process Water Tank (2 000 m^3) adjacent to existing Clarifier);
- Water from Central Process Dam to Existing Beeshoek Plant: 200 mm mild steel – 1.3 km at 400 m^3/hr (111 l/s);
- New potable water pipeline 140 mm diameter - 1.6 km 100 m^3/hr (28l/s) from steel potable water tank (100 m^3) at the new Jigs Plant to combined steel potable water/fire water tank (approximately 1 000 m^3, still to be confirmed pending final designs) at WHIMS Plant;
- Process water tank (1000 m^3) adjacent to new WHIMS Plant Clarifier; and
- Overland Powerline: 22 kV powerline approximately 700 m in length.

The Jig Plant Project will comprise of the following:

- New Jig Plant footprint: approximately 2.6 ha;
- New Jig Plant Construction Laydown Area: 2 ha on existing Discard Stockpile footprint.
- Feed from the existing Discard Dump (low-grade material fed into a loading bin by means of front-end loaders and conveyed to the Washing and Screening Plant);
- Washing and Screening Plant;
- Crusher building containing a high-pressure grind roll (HPGR) crusher;
- Jig located in the Jig building;
- MCC and transformer bay;
- Re-routed existing water pipelines (buried, internal diameter 450 mm);
- Slurry from the new Jig Plant will be pumped to the existing Plant Thickener;
- New process water tank (located near existing Plant Thickener) – 2,000 m^3 (this forms part of project 5);
- Stockpiles [comprising of both material from the Discard Dump (also referred to as a Low Grade Stockpile] and arising low grade material from the existing Jig Beneficiation Plant). The stockpiles created from material reclaimed from the existing Low-Grade

Stockpile (Discard Dump) and the stockpile created with the arising material (low grade) from the existing Jig Beneficiation Plant are intermediate stockpiles created within the footprint of the existing Discard Dump (the Low-Grade Intermediate Stockpile and the Arising Stockpile). Material from these intermediate stockpiles is transported to and fed into the new Jig Plant loading bin located south of the existing Low-Grade Stockpile. Low low-grade material from the new Jig Plant is then conveyed back to the Low Grade Stockpile footprint, deposited onto the ground and then moved back towards the existing Discard Dump. The three (3) stockpiles associated with the new Jig Plant includes the following:

- Low Grade -32+1 mm Stockpile (Intermediate) (0.5 ha) located between the existing Low-Grade Stockpile (Discard Dump) and the new Jig Plant loading bin on the existing Low Grade Stockpile foot print. Low grade material transported to and from the intermediate stockpile by means of front-end loaders;
- Arising -32+1mm Stockpile (Intermediate) (0.6ha) located between the to be constructed arisings conveyor discharge position and the new Jig Plant loading bin and within the existing Low Grade Stockpile footprint. Low grade material transported from the Arising -32+1mm Stockpile by means of front end loaders; and
- Low low-grade material from the new Jig Plant will be conveyed by means of earth moving equipment to positions adjoining the existing Discard Dump within the existing footprint (i.e. waste from the new Jig Plant to return to the approved Discard Dump footprint). No new stockpiles will be constructed outside of the demarcated Discard Dump or other Type 3 Stockpile footprints, these will however be demarcated as part of the EMPr and WUL processes. The area of the Low low Grade Dump (stockpile) (115 m^2).

- New Jig Plant Conveyors:
  - Approximately 25 m conveyor from existing plant conveyor system to feed Jig Plant with low grade arising material; and
  - Approximately 330 m conveyer to feed the new Jig Plant from Discard Dump to feed Discard feed bin.
- New Jig Plant Roads, which are all connected:
  - Road 1: 240m with a width of 30 m;
  - New Jig Plant Road 2: 700 m with a width of 30 m;
  - Road 3: 280 m with a width of 30 m;
  - Road 4: 135 m with a width of about 30 m; and
  - Decommissioning of existing plant haul road: approximately 1000 m in length and 30 m wide.
- Overhead Powerline: 22 kV powerline of approximately 620 m; and
- Rerouting of underground electrical cable: 22 kV of approximately 380 m.

1.5.5 Water Management Infrastructure

The Mine will establish additional water storage tanks on site which will include:

- A new storage tank near the existing BN Tank of 500 m^3. The purpose is to provide sufficient storage space for water from the approved in-pit dewatering activities;
- 4 x 10 m^3 plastic tanks at the current Beneficiation Plant, to assist with day-to-day operational water transfer and use;
- 1 x 2000 m^3 process water tank adjacent to the existing Clarifier connected with a "balancing pipe". This will allow for the storage of water in the water balance system of the Mine to capacitate the plant process to start up without delay;
- Existing Dam: Steel Dam 250 m^3 capacity to store process water and allow for the storage of top-up water;
- Existing Dam: Zinc Dam: 90 m^3 capacity to store input water where required; and
- A new dewatering tank at the Village Pit.

1.5.6 Railway Line Link

Beeshoek propose to construct a 2.8 km railway line linking the existing Beeshoek siding to the existing Transnet Freight Rail (TFR) to transport iron ore to the Saldanha Port in the Western Cape for export. This project has been investigated as part of a Basic Assessment process and is therefore not assessed in this study.

1.6 Legislative Requirements and Guidelines

The following key legislative requirements and guidelines are relevant to this study:

- National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- Regulations on the Use of Water for Mining and Related Activities aimed at the Protection of Water Resources (published under Government Notice 704 (GN704) in Government Gazette 20119, 4 June 1999);
- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and associated Environmental Impact Assessment (EIA) 2014 Regulations;
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA); and
- Department of Water and Sanitations (DWS) Best Practice Guideline documents.

1.7 Site Investigation

The areas associated with the proposed projects and activities for this study were assessed on the following dates:

- 4 July 2019;
- 27 October 2020; and
- 3 February 2021.

1.8 Details of the Specialist

The study was undertaken by Andy Pirie who is a senior hydrologist at Hydrospatial (Pty) Ltd. Andy graduated with a Master of Science (M.Sc.) in Water Resource Management (cum laude). He is registered as a Professional Natural Scientist (Pr.Sci.Nat) (registration number: 114988) in Water Resources Science with the South African Council for Natural Scientific Professions (SACNASP). Work experience includes rainfall – runoff modelling, floodline determinations, stormwater management plans, water and salt balance modelling, setup of water monitoring networks and programmes, analysis of surface water quality and quantity, and surface water specialist studies for environmental and social impact assessments. He has worked on projects in South Africa, Cameroon, Senegal, Mali, Democratic Republic of the Congo (DRC), Botswana, Zambia and Namibia. He has more than 9 years' experience. A curriculum vitae is provided in Appendix A.

2 SCOPE OF WORK

The scope of work for this study included the following:

- Assessment and description of the current baseline hydrology;
- Development of a conceptual Stormwater Management Plan (SWMP) in accordance with the DWS Best Practice Guideline G1: Storm Water Management and GN704 regulations. The primary purpose of the SWMP is to ensure that clean (non-impacted water) and dirty water (mine affected water) are clearly separated and controlled in accordance with the above-mentioned guideline and regulations;
- Determination of the 1:100 year floodlines for any watercourses within close promixity to proposed infrastructure. According to GN704 regulations, no mine infrastructure should be developed within the floodlines unless exemption is obtained from the DWS to do so;
- An assessment of the potential surface water impacts and recommended mitigation measures; and
- Development of monitoring plans that can be used to monitor potential impacts resulting from the proposed project.

3 HYDROLOGICAL SETTING AND BASELINE HYDROLOGY

3.1 Climate

Rainfall data for the period of 1920 – 2010 was obtained from the Postmasburg weather station (0321110 W), whilst Symon's Pan (S-Pan) evaporation data was obtained from the Olifantshoek Dam weather station (D4E002) for the period of 1960 – 2000.

Figure 3-1 indicates the mean monthly rainfall and evaporation of the area. Majority of the rainfall occurs over the summer months of November to April, with February and March being the highest rainfall months. Evaporation follows a similar trend to rainfall, with the warmer summer months of September to March having the highest evaporation. The Mean Annual

Precipitation (MAP) of the area is 317 mm, whilst the Mean Annual Evaporation (MAE) is 2 213 mm. The area can be described as having a semi-arid to arid climate, with evaporation far exceeding rainfall.

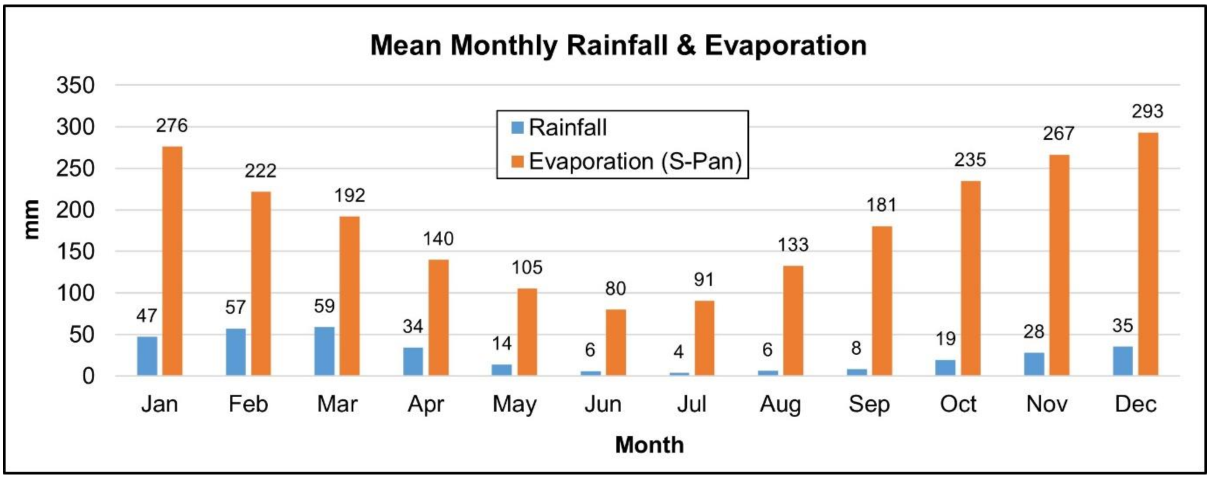

Figure 3-1: Mean annual rainfall and evaporation for the area

3.2 Regional Catchments

Beeshoek is located in quaternary catchment D73A within the Vaal Water Management Area. According to the Water Resources of South Africa Study 2012 (WR 2012), quaternary catchment D73A is endoreic, meaning that surface water runoff does not flow out of the catchment, and that water is lost to evaporation and infiltration. This is mostly due to the low rainfall and high evaporation of the area.

3.3 Topography and Drainage

An elevated ridge runs in a north to south direction along the eastern Mine boundary and reaches a maximum height of 1 480 metres above mean sea level (mamsl) in the north of the Mine (Figure 3-3). Elevation drops off gradually towards the west, reaching a height of 1 300 mamsl near the western Mine boundary. The general topography of the site can be described as flat. Water to the west of this ridge will drain in a westerly and south-westerly direction, and to the east of this ridge, water drains in an easterly and south-easterly direction towards the Groenwaterspruit. Drainage occurs via shallow channels that rarely flow and are ephemeral in nature (Figure 3-2). The flat topography, fairly permeable soils and deep groundwater levels below the bed of drainage lines do not allow for baseflow contribution. Some of these drainage lines are very shallow and would therefore act as preferential flow paths.

Figure 3-2: Ephemeral drainage line located in the south-eastern area of the Mine

3.4 Vegetation and Soils

According to Mucina and Rutherford (2006), three vegetation types occur within the Mine boundary, namely, Postmasburg Thornveld to the west, Kuruman Thornveld to the east, and Kuruman Mountain Bushveld along the elevated ridge on the eastern Mine boundary (Figure 3-3). These vegetation types are characterised by shrubby and grass vegetation. Following the same boundaries as the vegetation, three land types occur at Beeshoek, namely, Ag110 to the west, Ag111 to the east, and Ib238 along the eastern elevated ridge. According to the land type database (Land Type Survey Staff, 1972 - 2006), Ag110 and Ag111 are dominated by Hutton and Mispah soils, that are generally shallow, and semi-permeable to permeable in nature, whilst Ib238 is dominated by rocky areas, followed by Hutton and Mispah soils.

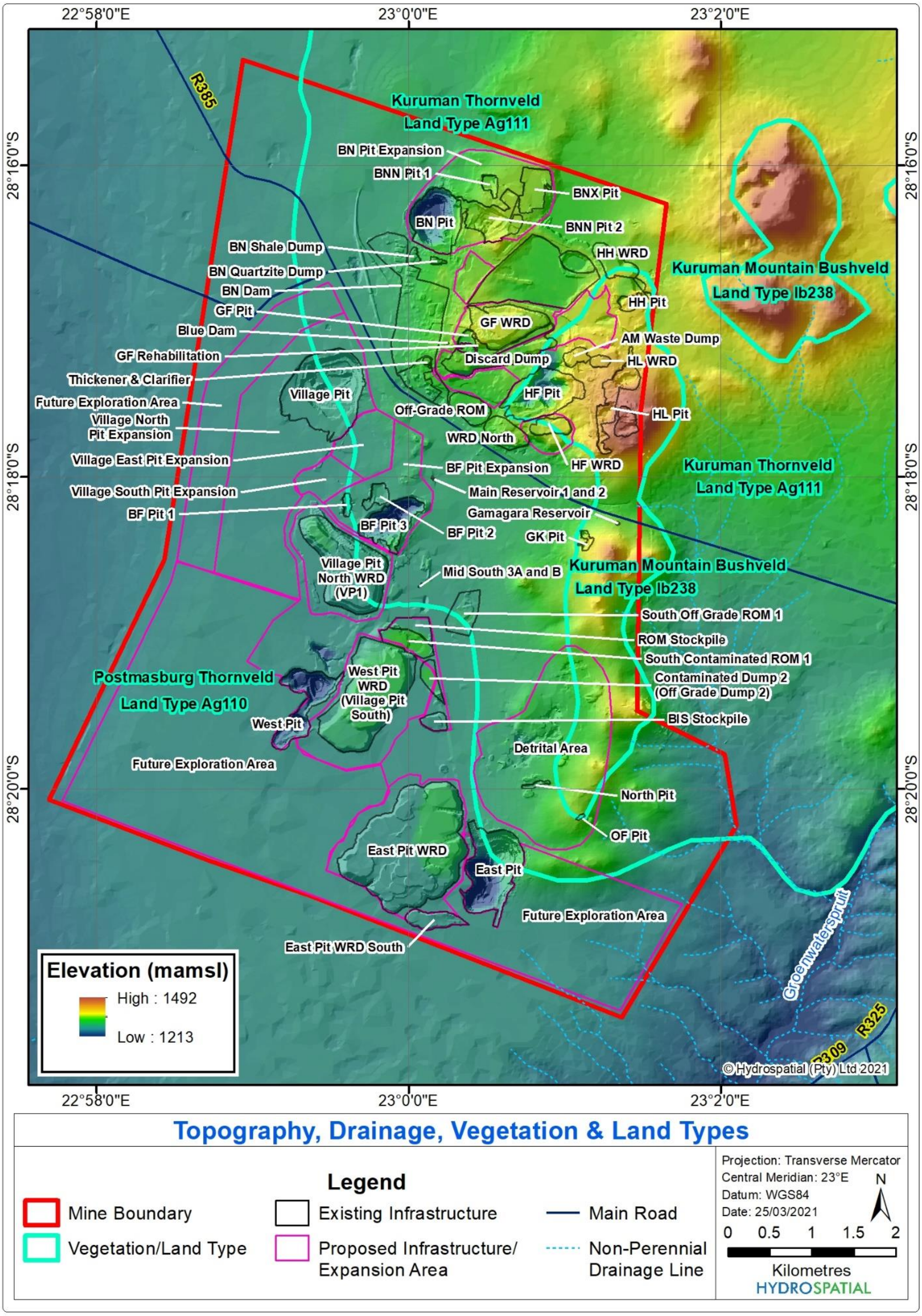

Figure 3-3: Mine Layout, topography, vegetation and land types

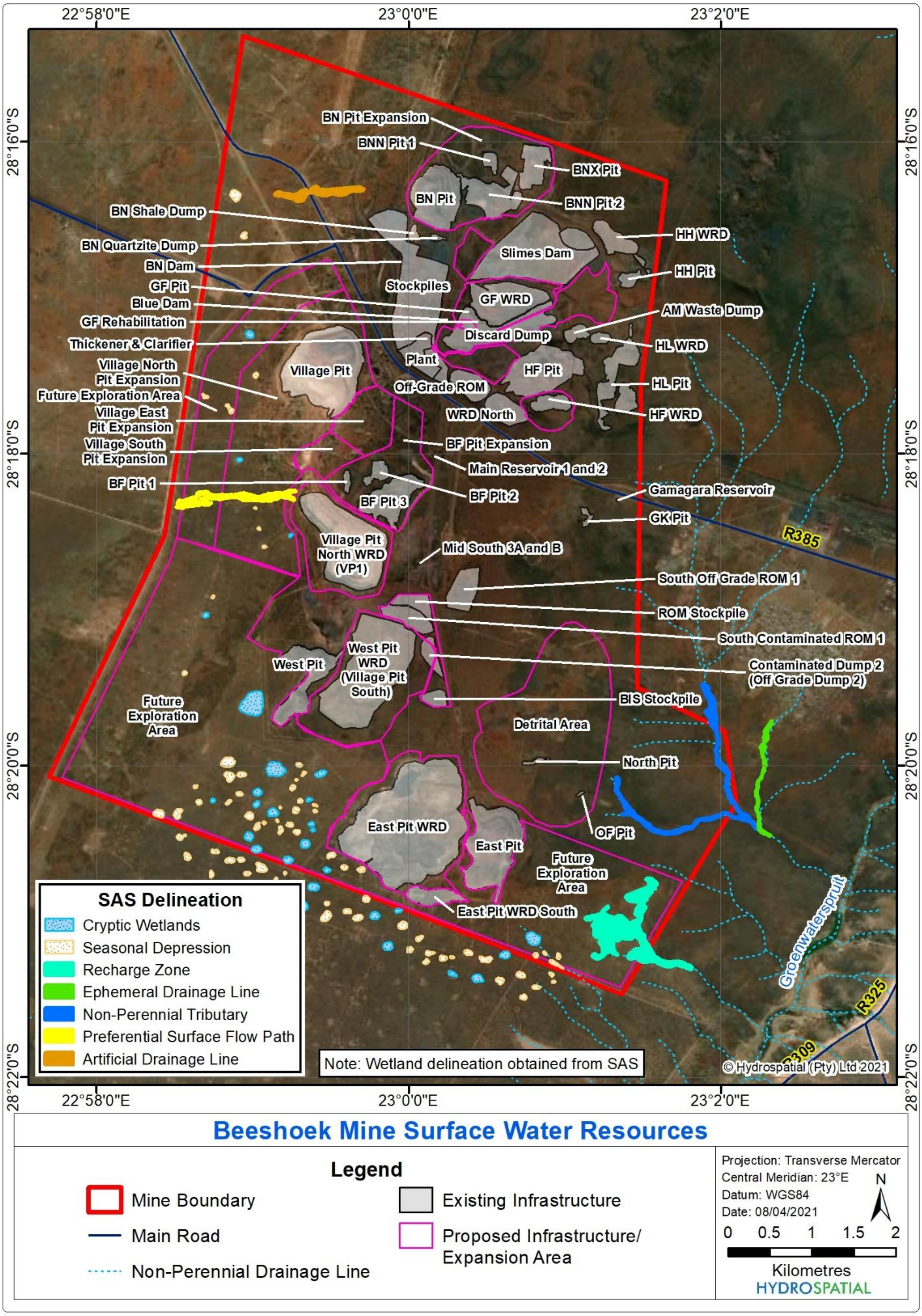

Figure 3-4: Beeshoek Mine surface water resources

3.5 Wetlands and Depressions

A number of pan/depression like features were noted to occur to the west and south of the Mine on the site visits. The location of these features is indicated on Figure 3-4. The Freshwater Ecological Assessment (SAS, 2021) has delineated these features and classified them as follows:

- Cryptic wetlands – which are those which don't necessarily conform to the DWS or NWA definitions of a wetland, as they generally don't have hydrophytic vegetation. However, they can hold water for a reasonable period of time and during that time, aquatic vegetation may emerge and egg banks of various macroinvertebrates can hatch out. Cryptic wetlands have several key identifying features in common, including specific floral indicators, the fact that woody species if present tend to occur only around the perimeter of the depression, and leached soils which don't necessarily develop mottles but which are not the same well-draining, high chroma soils of the surrounding areas. Figure 3-5 indicates a Cryptic wetland located to the west of the East Pit WRD, which was visited on 3 February 2021, after the area had received high rainfall in the preceding weeks.
- Seasonal depressions – these are the features that topographically look like depression wetlands, but don't have any of the indicators. Floral species composition is usually very different, and woody species tend to occur within them, rather than just lining the outer perimeter of the depression. Additionally, they usually have similar soils to the surrounding upgradient areas, rather than leached soils.

Figure 3-5: Cryptic wetland located to the west of the East Pit WRD

In addition to the above, a preferential flow path, recharge zone and non-perennial tributaries were also delineated (Figure 3-4).

3.6 Geology

According to GPT (2021), the Mine is located on the Maramane Dome, which is dominated by carbonate rocks of the Campbellrand Subgroup and the iron formations of the Asbesheuwels Subgroup of the Transvaal Supergroup. The dome dips gently, at less than 10 degrees, in an arc to north and south. Only the eastern half of the dome is exposed, while the western part is covered by red beds, conglomerate, shale and quartzite of the Gamagara Formation. The Beeshoek-Olynfontein iron ore deposits are situated along the contact between the Gamagara Formation and the underlying Manganore Iron Formation.

3.7 Surface Water and Groundwater Qualities and Levels

Due to the high evaporation and low rainfall of the area, the generation of surface water rarely occurs, and is therefore only monitored at the tanks, pits and pipelines. According to Aquatico (2021), the general surface water quality during the 2020 period was classified as being neutral, saline and very hard. Low salt concentrations, metal concentrations and nutrient concentrations were detected at all of the sampling localities. Elevated bacteriological counts occurred at some of the sampling locations.

According to GPT (2021), groundwater levels range between 5 metres below ground level (mbgl) in the unaffected mining areas, to 180 - 200 mbgl in the dewatered areas due to groundwater abstraction for dewatering and water supply. The effect of dewatering is more pronounced to the south of the mine. The direction of groundwater flow is south to south easterly from the mining area. A cone of depression has developed within the active mining area with flow directed towards the mining excavation due to the active mining areas. The general groundwater quality is good, however, elevated nitrate does occur at some of the sampling boreholes due to expected mining related impacts (Aquatico, 2021).

4 FLOODLINE DETERMINATION

The proposed projects and activity areas were assessed for potential watercourses on the site visits. Only one defined non-perennial drainage channel was evident on the site visit and is indicated in Figure 3-2. The drainage channel is located in the south-eastern corner of the Mine and is an ephemeral tributary of the Groenwaterspruit. It is unlikely that this tributary will result in any flood hazard, however, a floodline determination was undertaken, as future exploration in the form of prospecting activities is proposed in this area. According to regulation 4 (b) of GN704, prospecting should not take place within the 1:50 year floodline or within a 100 m horizontal distance of a watercourse, unless exemption is obtained from the DWS.

4.1 Methodology and Data Sources

4.1.1 Elevation Data

Elevation data in the form of 0.5 m contour intervals for the year 2019 were obtained from Beeshoek. The contours were used to generate a 1 m spatial resolution Digital Terrain Model (DTM). The DTM was used to extract the longitudinal and cross-sectional stream and bank elevations. The DTM was further used in the post processing to undertake the floodplain delineations.

4.1.2 Catchments

The contributing catchment of the watercourse were delineated from the above-mentioned 0.5 m contours.

4.1.3 Land Cover and Soils

Land cover and soil data form an important component in the hydrological assessment undertaken to calculate the peak flows. The vegetation was assessed on the site visit as well as from GIS layers and satellite imagery. The potential soil characteristics were estimated from the land type database.

4.1.4 Manning's Roughness Coefficients

The Manning's roughness coefficients are values that represent the channel and adjacent floodplains resistance to flow. The vegetation and terrain were assessed during the site investigation, to estimate suitable Manning's roughness coefficients. A Manning's roughness coefficient of 0.04 was used to represent the channel and adjacent areas.

4.1.5 Peak Flows

Peak flow calculations were undertaken using the Soil Conservation Service (SCS) method which has been adapted for South African conditions and is known as the SCS-SA. The calculation of peak discharge by SCS-SA method is based on the triangular unit hydrograph concept. This unit hydrograph represents the temporal distribution of stormflow for an incremental unit depth of stormflow, ΔQ, occurring in a unit duration of time, ΔD.

Peak discharge for an increment of time $\Delta \mathrm{D}$ is defined by the equation:

$$\Delta q_p = \frac{0.2083 \mathrm{A} \Delta Q}{\frac{\Delta D}{2} + L}$$

Where:

Δq_p = Peak discharge of incremental unit hydrograph (m³/s)

A = Catchment area (km²)

ΔQ = Incremental stormflow depth (mm)

ΔD = Unit duration of time (h), used with the distribution of daily rainfall to account for rainfall intensity variations

L = Catchment lag (h), an index of the catchment's response time to the peak discharge

To determine the hydrograph response to a given rainfall total, incremental hydrographs are superimposed according to the distribution of stormflow over time, as determined from the time distribution of rainfall intensity and the stormflow response characteristics of the catchment. More details on the SCS-SA method are provided in Schmidt and Schulze (1987).

4.1.6 Software

The following software's were used:

- ArcMap 10.2 is a GIS software programme used to view, edit, create and analyse geospatial data. ArcMap was used to view spatial data and to create maps. Its extension 3D Analyst was used for terrain modelling purposes, for converting the contour data into a DTM grid format;

- HEC-GeoRAS utilises the ArcMap environment and is used 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 in post processing to import HEC-RAS results back into ArcMap, to perform flood inundation mapping; and
- 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.

4.1.7 Hydraulic Model Setup

Development of the hydraulic model included the following steps:

- Preparation of geometric data (cross-sections, stream centre line, bank lines and flow paths) in HEC-GeoRAS;
- Importing of geometric data into HEC-RAS;
- Entering HEC-RAS model parameters such as the Manning's roughness coefficients, boundary conditions and peak flows;
- Performing steady, mixed flow (combination of subcritical, supercritical, hydraulic jumps and drawdowns) modelling within HEC-RAS to calculate the flood water elevations at cross-sections; and
- Importing flood level elevations at cross-sections into HEC-GeoRAS to perform floodplain delineations.

4.2 Catchments

The delineated catchment for the watercourse is indicated on Figure 4-1.

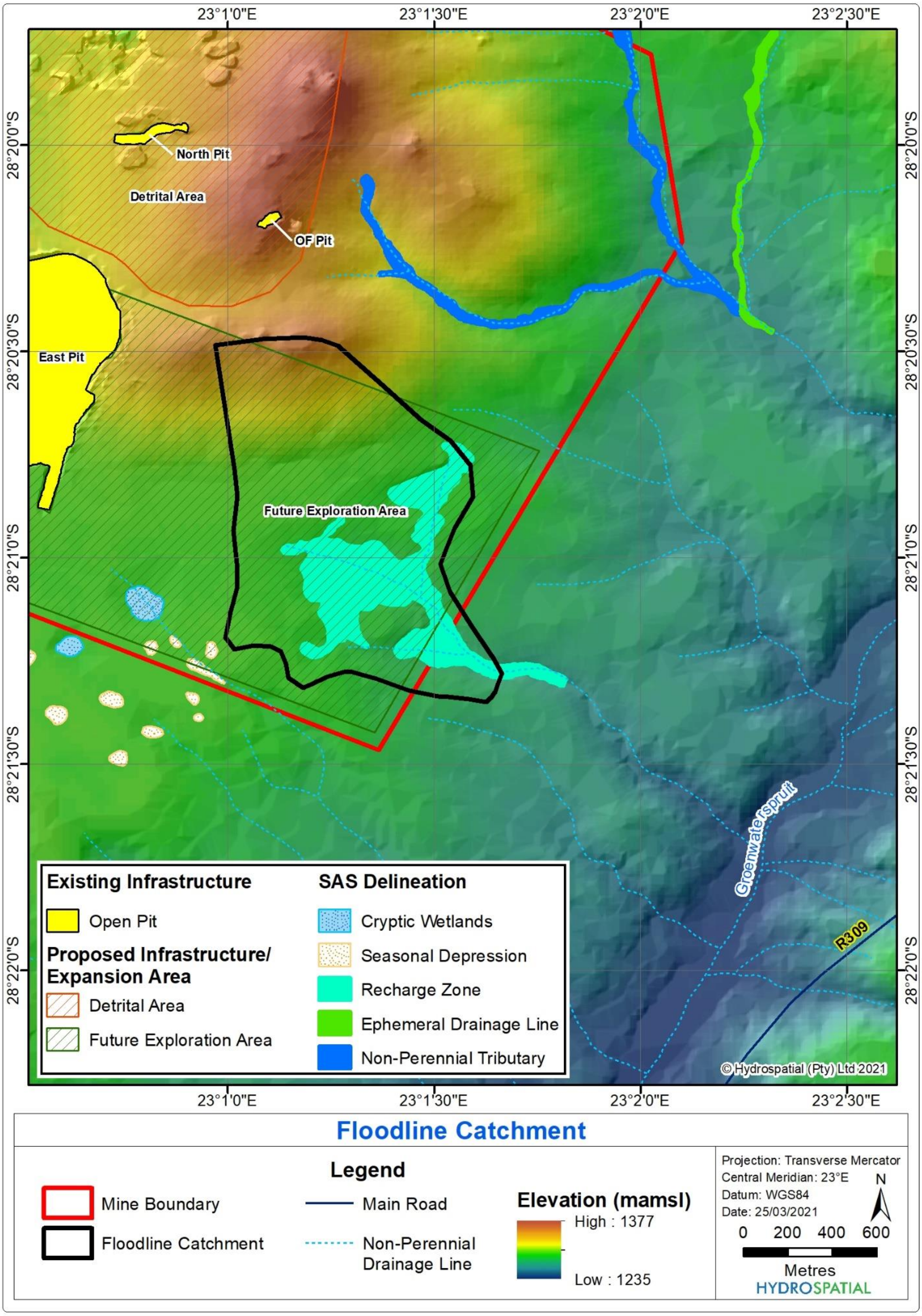

Figure 4-1: Floodline catchment

4.3 Results

4.3.1 Peak Flows

The SCS-SA parameters and calculated peak flows are indicated in Table 4-1.

Table 4-1: Parameters and peak flows

Return Period (years)	1:2	1:5	1:10	1:20	1:50	1:100	1:200
Design Daily Rainfall Depth (mm)	40	57	69	81	97	110	124
Stormflow Volume (m^3)	7.8	17.4	25.7	34.9	48.3	60	73.2
Curve Number	70	70	70	70	70	70	70
Peak Flow (m^3/s)	**1.7**	**4**	**6**	**8.3**	**11.6**	**14.5**	**17.8**

4.3.2 Floodlines

The 1:50 and 1:100 year floodlines are indicated on Figure 4-2. It is recommended that future prospecting activities do not take place within the 1:50 year floodline as required by GN704 Regulations. It is further recommended that future prospecting activities remain outside of the recharge zone pending further investigation and understanding of this area.

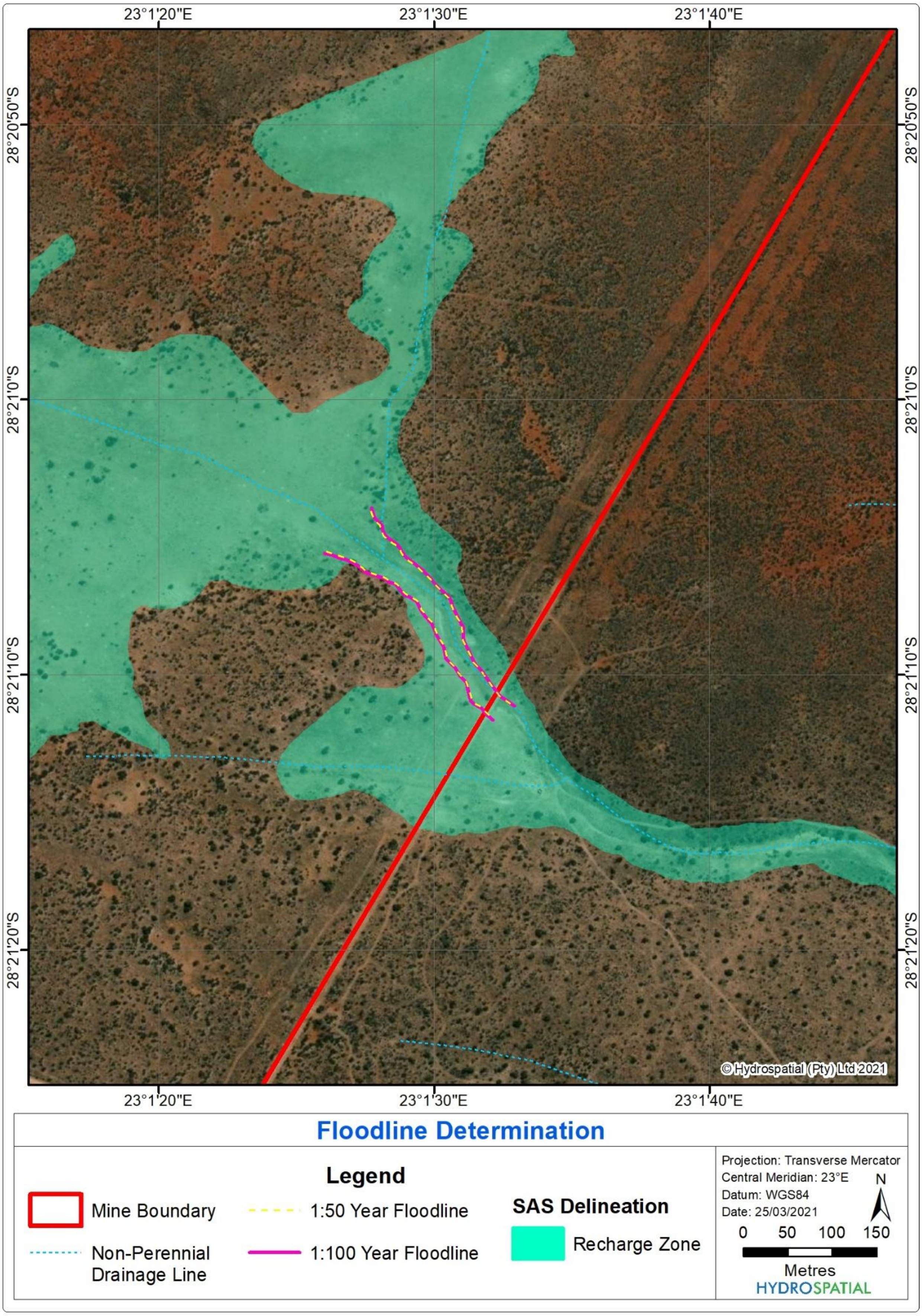

Figure 4-2: Floodline determination

5 STORMWATER MANAGEMENT

The purpose of mine stormwater management is to ensure that clean and dirty water are adequately separated, by diverting clean water away from dirty areas, and ensuring that dirty water is captured, contained and managed appropriately in accordance with GN704 Regulations and DWS best practice guidelines.

5.1 Terminology

The following definitions are relevant to stormwater management at mines:

- **Activity:** 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;
- **Clean area:** This refers to any area at or near a mine or activity, which is not impacted by mining activities, but has the potential to become contaminated if not managed appropriately;
- **Clean water system:** This includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of clean unpolluted water;
- **Dam:** This includes any return water dam, settling dam, tailings dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste;
- **Dirty area:** This refers to any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource (i.e. generate contaminated water as a result of mining activities);
- **Partially dirty area:** These are areas that are unlikely to produce contaminated runoff other than elevated suspended solids;
- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste; and
- **Watercourse:** This is defined in the NWA as -
  - A river or spring;
  - A natural channel in which water flows regularly or intermittently;
  - A wetland, lake or dam into which, or from which, water flows; and
  - Any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

5.2 Stormwater Management Principles

The following are the main principles relevant to effective stormwater management at mines, and are based on GN704 regulations and DWS Best Practice Guideline (BPG) G1: Storm Water Management:

- Confine or divert any unpolluted water to a clean water system, away from a dirty area;
- Runoff from dirty areas must be captured, contained and managed appropriately;
- Clean and dirty water systems must be designed and constructed to prevent cross contamination;
- Dirty water must, as far as possible, be recycled and reused;
- Clean and dirty water systems must convey/contain runoff from the 50 year storm event, and should preferably not lie within the 100 year floodline; and
- Appropriate maintenance and management of stormwater related infrastructure should always be ensured.

5.3 Current Stormwater Management

The Mines Stormwater Management Plan (SWMP) was prepared by Storm Water Solutions (SWS, 2016). Clean and dirty areas were delineated and are indicated on Figure 5-1. The green areas indicate the dirty areas and are associated with those areas where the natural surface has been altered by mining activities. These include:

- Open pits;
- Slimes Dam;
- Workshops;
- Crushers; and
- Plant area.

The light blue areas indicate the clean areas, which are still natural and generally in the same state as before mining occurred (SWS, 2016).

Current stormwater measures include the following:

- Safety berms have been placed around the pits and ensure that no clean water flows into the pits;
- Dirty water is contained within the Slimes Dam and water levels are monitored to ensure that there is sufficient freeboard at all times in line with GN704 regulations;
- Dirty water generated at the workshops is captured within lined channels and sumps;
- Dirty water generated at the crushers is recycled and reused or evaporated at the evaporation ponds; and
- Dirty water generated at the plant is captured within lined sumps and either recycled and reused or gravitated to the stormwater dam.

No stormwater measures to contain runoff were recommended around the WRDs due to the low rainfall, high evaporation and waste classification which indicated non-hazardous material (SWS, 2016).

5.4 Proposed Stormwater Measures

5.4.1 ROM Stockpile Consolidation

Berms should be placed around the proposed ROM Stockpile consolidation area, as is the case with other ROM Stockpiles onsite. Waste rock can be used to construct the berms, as it has been authorised for such purposes in the Mines amended WUL. This will ensure that any clean water runoff is diverted away.

5.4.2 Waste Rock Dump Expansion

As previously mentioned, no stormwater measures to contain runoff were recommended around the existing WRDs due to the low rainfall, high evaporation and waste classification which indicated non-hazardous material (SWS, 2016). Furthermore, waste rock has been exempted from regulation 5 of GN704 (which pertains to “Restrictions on the use of material”) for the construction of berms and haul roads. Based on the above, it is not foreseen that runoff from the WRD expansion areas would need to be contained. However, WRDs close to sensitive areas such as wetlands and depressions should be contained.

5.4.3 Open Pit and Detrital Area Expansion

Berms should be placed around the proposed pits and Detrital mining areas, as is the case with the other existing pits, to ensure that no clean water flows into the voids. Seepage and dirty water runoff collected within the voids should be managed by recycling and reusing dirty water as far as practicably possible.

5.4.4 WHIMS and JIG Plant

The WHIMS and Jig Plants should be operated as dirty areas. Dirty water runoff from the WHIMS and Jig Plants should be directed via lined channels to lined sumps or Pollution Control Dams (PCDs). The water collected within the sumps/PCDs should be recycled and reused as process water. Both the WHIMS and Jig Plants will be located on topographically elevated areas surrounded by disturbed areas, and therefore, the diversion of clean runoff around these areas is not foreseen.

5.4.5 Water Management Infrastructure

Water levels and sufficient freeboard within the proposed dirty water dams/tanks, should be monitored and reported on. Dirty water storage facilities must be sufficiently lined with adequate capacity, in accordance with GN704 regulations.

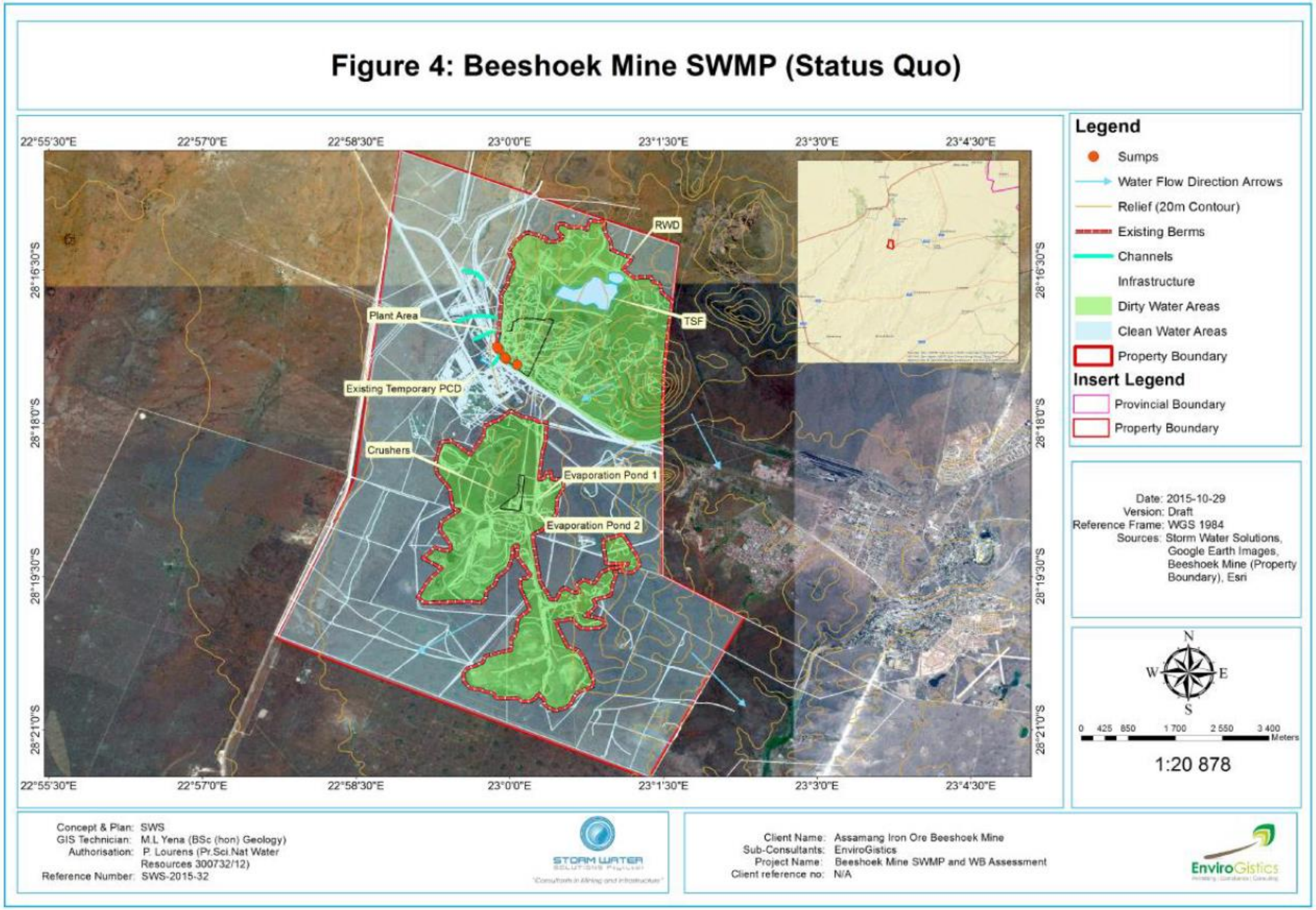

Figure 5-1: Current stormwater management plan and clean and dirty areas (SWS, 2016)

6 SURFACE WATER IMPACT ASSESSMENT

6.1 Methodology

The impact assessment methodology used to rate the potential surface water impacts pre- and post-mitigation is provided below. The evaluation of impacts is conducted in terms of the criteria detailed in Table 6-1 to Table 6-6. The various impacts of the project are discussed in terms of impact status, extent, duration, probability and intensity. Impact significance is the sum of the impact extent, duration, probability and intensity, and a numerical rating system is applied to evaluate impact significance. Therefore, an impact magnitude and significance rating is applied to rate each identified impact in terms of its overall magnitude and significance in Table 6-6. The various components of impact methodology are discussed below.

6.1.1 Impact Status

The nature or status of the impact is determined by the conditions of the environment prior to construction and operation. The nature of the impact can be described as negative, positive or neutral (Table 6-1).

Table 6-1: Impact status

Rating	Description	Quantitative Rating
Positive	A benefit to the receiving environment.	P
Neutral	No cost or benefit to the receiving environment.	-
Negative	A cost to the receiving environment.	N

6.1.2 Impact Extent

The extent of an impact is considered as to whether impacts are either limited in extent or affects a wide area. Impact extent can be site-specific (within the boundaries of the development area), local, regional or national and/or international (Table 6-2).

Table 6-2: Extent of the impact

Rating	Description	Quantitative Rating
Low	**Site-specific**; occurs within the site boundary.	1
Medium	**Local**; extends beyond the site boundary; affects the immediate surrounding environment (i.e. up to 5 km from the project site boundary).	2
High	**Regional**; extends far beyond the site boundary; widespread effect (i.e. 5 km and more from the project site boundary).	3
Very High	**National and/or international**; extends far beyond the site boundary; widespread effect.	4

6.1.3 Impact Duration

The duration of the impact refers to the time scale of the impact or benefit (Table 6-3).

Table 6-3: Duration of the impact

Rating	Description	Quantitative Rating
Low	**Short-term**; quickly reversible; less than the project lifespan; 0 – 5 years.	1
Medium	**Medium-term**; reversible over time; approximate lifespan of the project; 5 – 17 years.	2
High	**Long-term**; permanent; extends beyond the decommissioning phase; >17 years.	3

6.1.4 Impact Probability

The probability of the impact describes the likelihood of the impact actually occurring (Table 6-4).

Table 6-4: Probability of the impact

Rating	Description	Quantitative Rating
Improbable	Possibility of the impact materialising is negligible; chance of occurrence <10%.	1
Probable	Possibility that the impact will materialise is likely; chance of occurrence 10 – 49.9%.	2
Highly Probable	It is expected that the impact will occur; chance of occurrence 50 – 90%.	3
Definite	Impact will occur regardless of any prevention measures; chance of occurrence >90%.	4
Definite and Cumulative	Impact will occur regardless of any prevention measures; chance of occurrence >90% and is likely to result in in cumulative impacts.	5

6.1.5 Impact Intensity

The intensity of the impact is determined to quantify the magnitude of the impacts and benefits associated with the proposed project (Table 6-5).

Table 6-5: Intensity of the impact

Rating	Description	Quantitative Rating
Maximum Benefit	Where natural, cultural and / or social functions or processes are positively affected resulting in the maximum possible and permanent benefit.	+5

Rating	Description	Quantitative Rating
Significant Benefit	Where natural, cultural and / or social functions or processes are altered to the extent that it will result in temporary but significant benefit.	+4
Beneficial	Where the affected environment is altered but natural, cultural and / or social functions or processes continue, albeit in a modified, beneficial way.	+3
Minor Benefit	Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are only marginally benefited.	+2
Negligible Benefit	Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are negligibly benefited.	+1
Neutral	Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are not affected.	0
Negligible	Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are negligibly affected.	-1
Minor	Where the impact affects the environment in such a way that natural, cultural and / or social functions or processes are only marginally affected.	-2
Average	Where the affected environment is altered but natural, cultural and / or social functions or processes continue, albeit in a modified way.	-3
Severe	Where natural, cultural and / or social functions or processes are altered to the extent that it will temporarily cease.	-4
Very Severe	Where natural, cultural and / or social functions or processes are altered to the extent that it will permanently cease.	-5

6.1.6 Impact Significance

The impact magnitude and significance rating is utilised to rate each identified impact in terms of its overall magnitude and significance (Table 6-6).

Table 6-6: Impact magnitude and significance rating

Impact	Rating	Description	Quantitative Rating
Positive	**High**	Of the highest positive order possible within the bounds of impacts that could occur. +	+12 to -16

Impact	Rating	Description	Quantitative Rating
	Medium	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Other means of achieving this benefit are approximately equal in time, cost and effort	+6 to -11
	Low	Impacts is of a low order and therefore likely to have a limited effect. Alternative means of achieving this benefit are likely to be easier, cheaper, more effective and less time-consuming	+1 to –5
No Impact	No Impact	Zero Impact	
Negative	**Low**	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural, and economic activities of communities can continue unchanged.	-1 to -5
	Medium	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and fairly possible. Social cultural and economic activities of communities are changed but can be continued (albeit in a different form). Modification of the project design or alternative action may be required	-6 to -11
	High	Of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could offset the impact, or mitigation is difficult, expensive, time-consuming or a combination of these. Social, cultural and economic activities of communities are disrupted to such an extent that these come to a halt.	-12 to -17

6.2 Impact Assessment Ratings and Mitigation Measures

The impact description, impact ratings pre- and post-mitigation, and mitigation measures are provided in Table 6-7.

Table 6-7: Impact assessment

Phase	Activity	Impact Description	Pre-Mitigation					Mitigation/Management Measures & Recommendations	Post-Mitigation				
			Extent	Duration	Probability	Intensity	Significance		Extent	Duration	Probability	Intensity	Significance
Construction Phase	Removal of vegetation for the pits, WRDs and associated infrastructure. Stripping and stockpiling of topsoils.	Erosion of exposed soils leading to siltation and sedimentation of downslope drainage channels.	Local (2)	Short-term (1)	Probable (2)	Minor (-2)	Medium (-6 to -11)	Vegetation clearance should be kept to an absolute minimum. Temporary erosion measures should be employed at exposed areas. Exposed areas should be vegetated as soon as possible. The topsoil stockpiles must be managed according to a topsoil management plan and should be vegetated.	Site-specific (1)	Short-term (1)	Improbable (1)	Negligible (-1)	Low (-1 to -5)
Construction Phase	Use of heavy machinery, trucks and vehicles for construction purposes.	Potential hydrocarbon spillages washed into downslope drainage channels.	Local (2)	Short-term (1)	Probable (2)	Average (-3)	Medium (-6 to -11)	Machinery, trucks and vehicles must be well maintained and serviced regularly as per a recommended service guide. Refuelling must be undertaken over hard park bunded areas that adequately sized to capture and contain spillages. Machinery and vehicles should be parked on appropriately lined areas. Drip trays must be employed under stationary machinery. Spillages should be reported immediately, and spill kits should be readily available at all times.	Site-specific (1)	Short-term (1)	Improbable (1)	Negligible (-1)	Low (-1 to -5)
Operational Phase	Alteration in the natural topography through the development of the pits and WRDs.	Alteration in natural drainage patterns leading to erosion and siltation.	Local (2)	Long-term (3)	Highly Probable (3)	Average (-3)	Medium (-6 to -11)	Pits and WRDs should be kept to minimum footprint area. The creation of steep slopes should be avoided as far as possible. Culverts should be placed at topographically low positions to allow for suitable drainage.	Site-specific (1)	Medium-term (2)	Improbable (1)	Negligible (-1)	Low (-1 to -5)

Phase	Activity	Impact Description	Pre-Mitigation					Mitigation/Management Measures & Recommendations	Post-Mitigation				
			Extent	Duration	Probability	Intensity	Significance		Extent	Duration	Probability	Intensity	Significance
Operational Phase	Prospecting activities taking place within or near non-perennial drainage channels.	Loss of hydrological connection and water quantity.	Local (2)	Long-term (3)	Probable (2)	Average (-3)	Medium (-6 to -11)	Avoidance of prospecting activities taking place within the 1:50 year floodlines or within a 100m horizontal distance of a drainage line as required by GN704 Regulations.	Site-specific (1)	Medium-term (2)	Improbable (1)	Negligible (-1)	Low (-1 to -5)
Operational Phase	Prospecting activities taking place within or near wetlands, seasonal depressions and recharge zone.	Loss of natural seasonal storage areas.	Local (2)	Long-term (3)	Highly Probable (3)	Average (-3)	Medium (-6 to -11)	Avoidance of prospecting activities taking place near or within wetlands, seasonal depressions and recharge zone.	Site-specific (1)	Medium-term (2)	Improbable (1)	Negligible (-1)	Low (-1 to -5)
Operational Phase	Use of heavy machinery, trucks and vehicles during the operational phase.	Potential hydrocarbon spillages washed into drainage lines and depressions	Local (2)	Long-term (3)	Probable (2)	Average (-3)	Medium (-6 to -11)	Machinery, trucks and vehicles must be well maintained and serviced regularly as per the recommended service guide. Refuelling must be undertaken over hard park bunded areas that adequately capture and contain spillages. Machinery and vehicles should be parked on appropriately lined areas. Drip trays must be used under leaking machinery. Spillages should be reported immediately and spill kits should be readily available at all times.	Site-specific (1)	Short-term (1)	Probable (2)	Negligible (-1)	Low (-1 to -5)
Operational Phase	Loss of contributing catchment area due to the development of the pits	Loss of water quantity to downstream users. Due to the arid climate this is likely to be a very small to negligible impact.	Local (2)	Long-term (3)	Probable (2)	Negligible (-1)	Medium (-6 to -11)	Berms placed around the pits to divert runoff around the pits. Backfilling of the pits. Reuse of runoff captured in the pits.	Site-specific (1)	Medium-term (2)	Improbable (1)	Negligible (-1)	Low (-1 to -5)

Phase	Activity	Impact Description	Pre-Mitigation					Mitigation/Management Measures & Recommendations	Post-Mitigation				
			Extent	Duration	Probability	Intensity	Significance		Extent	Duration	Probability	Intensity	Significance
Closure, Decommissioning & Rehabilitation Phase	Removal of infrastructure and rehabilitation of disturbed areas and WRDs	The removal of infrastructure and rehabilitation activities can potentially result in exposed soils leading to erosion and sedimentation.	Local (2)	Long-term (3)	Probable (2)	Average (-3)	Medium (-6 to -11)	Temporary erosion measures should be employed at exposed areas until vegetated. The topography should be returned to its former state (as far as practically possible). Exposed areas should be vegetated as soon as possible. The topsoil stockpiles should be used to fill in areas and to create a suitable substrate to re-vegetate areas.	Site-specific (1)	Medium-term (2)	Improbable (1)	Negligible (-1)	Low (-1 to -5)

7 MONITORING PLANS

7.1 Surface Water Quality

It is recommended that the proposed dams/tanks and pit expansion areas are included into the current water quality monitoring programme should the project be approved.

7.2 Stormwater Infrastructure

Stormwater infrastructure must be monitored on a monthly basis during the dry season, and on a weekly basis during the wet season. The freeboard of the proposed dirty water containment facilities must be inspected daily and records must be kept. Water infrastructure should further be monitored immediately after any large storm event. Should blockages, silted up structures or breaches occur, then immediate action must be undertaken to remove debris and repair breaches. Monitoring should be undertaken by the onsite Environmental Control Officer (ECO) or maintenance manager. Inspections must be recorded and should include the following:

- Date of inspection;
- Rainfall amount received in a 24-hour period prior to inspection;
- Photographs of blockages, silted up structures or breaches witnessed;
- Actions taken to fix issues and the amount of time taken to address them; and
- Photographs post action taken.

Inspection reports should be prepared on a monthly/quarterly basis and should be kept ready and supplied to the DWS when requested, or as part of the WUL conditions.

8 CONCLUSIONS AND RECOMMENDATIONS

Hydrospatial (Pty) Ltd was appointed by EnviroGistics to undertake a surface water hydrological study for the proposed Beeshoek Optimisation Project. The Optimisation Project includes a number of projects within the Beeshoek MRA to ensure continued and sustainable mining of iron ore reserves. These include:

- Consolidation of ROM stockpiles on South Mine;
- Increase in height and footprint area of existing WRDs;
- Increase of open pit footprint areas and detrital mining;
- Low-grade beneficiation optimisation projects;
- Construction of water management infrastructure; and
- Construction of a railway line link.

The railway link was investigated as part of a Basic Assessment process and is therefore not assessed in this study.

The climate of Beeshoek can be described as semi-arid to arid, with evaporation far exceeding rainfall. The Mine is located in an endoreic catchment, and therefore, surface water runoff is limited. The general topography of the MRA is flat and the soils consist mostly of semi-permeable to permeable soils. Shallow ephemeral drainage lines occur in the south-east of the MRA and drain towards the Groenwaterspruit. A number of pan like features occur in the west and south of the MRA and have been classified as Cryptic wetlands and seasonal depressions in the Freshwater Ecological Assessment (SAS, 2021).

Surface water quality is monitored at the dams/tanks, pits and pipelines. According to Aquatico (2021), the general surface water quality during the 2020 period was classified as being neutral, saline and very hard. Low salt concentrations, metal concentrations and nutrient concentrations were detected at all of the sampling localities. Elevated bacteriological counts occurred at some of the sampling locations. According to GPT (2021), groundwater levels range between 5 metres below ground level (mbgl) in the unaffected mining areas, to 180 - 200 mbgl in the dewatered areas due to groundwater abstraction for dewatering and water supply. The effect of dewatering is more pronounced to the south of the mine. The direction of groundwater flow is south to south easterly from the mining area. A cone of depression has developed within the active mining area with flow directed towards the mining excavation due to the active mining areas. The general groundwater quality is good, however, elevated nitrate does occur at some of the sampling boreholes due to expected mining related impacts (Aquatico, 2021).

The only natural defined drainage channel occurs in the south-east of the MRA. A 1:50 and 1:100 year floodline determination was undertaken on this drainage line, as according to Regulation 4 (b) of GN704, prospecting should not take place within the 1:50 year floodline unless exemption is obtained from the DWS. The determined floodline is connected to what has been delineated as a recharge zone in the Freshwater Ecological Assessment (SAS, 2021). It is recommended that future prospecting activities do not take place within the 1:50 year floodline as required by GN704 Regulations. It is further recommended that future prospecting activities remain outside of the recharge zone pending further investigation and understanding of this area.

The following are proposed stormwater measures:

- Berms should be placed around the proposed ROM Stockpile consolidation area, as is the case with other ROM Stockpiles onsite. Waste rock can be used to construct the berms, as it has been authorised for such purposes in the Mines amended WUL. This will ensure that any clean water runoff is diverted away.
- No stormwater measures to contain runoff were recommended around the existing WRDs due to the low rainfall, high evaporation and waste classification which indicated non-hazardous material (SWS, 2016). Furthermore, waste rock has been exempted from regulation 5 of GN704 (which pertains to “Restrictions on the use of material”) for the construction of berms and haul roads. Based on the above, it is not foreseen that runoff from the WRD expansion areas would need to be contained. However, WRDs close to sensitive areas such as wetlands and depressions should be contained.
- Berms should be placed around the proposed pits and Detrital mining areas, as is the case with the other existing pits, to ensure that no clean water flows into the voids. Seepage and dirty water runoff collected within the voids should be managed by recycling and reusing dirty water as far as practicably possible.

- The WHIMS and Jig Plants should be operated as dirty areas. Dirty water runoff from the WHIMS and Jig Plants should be directed via lined channels to lined sumps or Pollution Control Dams (PCDs). The water collected within the sumps/PCDs should be recycled and reused as process water. Both the WHIMS and Jig Plants will be located on topographically elevated areas surrounded by disturbed areas, and therefore, the diversion of clean runoff around these areas is not foreseen.
- Water levels and sufficient freeboard within the proposed dirty water dams/tanks, should be monitored and reported on. Dirty water storage facilities must be sufficiently lined with adequate capacity, in accordance with GN704 regulations.

The impact assessment indicated that all identified impacts would have a medium significance pre-mitigation, and that these impacts can be mitigated to a low significance should mitigation measures be adhered to.

Monitoring plans have been proposed under section 7 of this report.

Based on the findings and outcomes of this study, it is the opinion of the specialist that from a surface water perspective, the proposed projects and activities can commence, provided that the recommendations and mitigation measures provided in this report are adhered to. It is important that future prospecting activities in the southern and western extent of the MRA should avoid the wetlands, depressions, recharge zone and drainage lines.

9 REFERENCES

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APPENDIX A: CURRICULUM VITAE

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Curriculum Vitae – Andy Pirie – Hydrologist

Details

Name and Surname:	Andy Pirie
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Company:	Hydrospatial (Pty) Ltd
Address:	17 Sonop Place, Randpark, Johannesburg, 2194
Nationality:	South African
First Language:	English
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Andy Pirie is a senior hydrologist at Hydrospatial (Pty) Ltd. Andy graduated with a Master of Science (M.Sc.) in Water Resource Management (cum laude). He is registered as a Professional Natural Scientist (Pr.Sci.Nat.) in Water Resources Science with the South African Council for Natural Scientific Professions (SACNASP). He has worked on projects in South Africa, Cameroon, Senegal, Mali, Democratic Republic of the Congo (DRC), Botswana, Zambia and Namibia, for clients such as Assmang, Anglo American, Randgold Resources (now Barrick Gold), Sibanye-Stillwater, Birimian, Exxaro, Sasol, Eskom, Assore and SAFCOL. He has more than 9 years' experience in hydrological assessments and Geographical Information Systems (GIS). His expertise include the following:

- Floodline determinations;
- Mine water and salt balance modelling;
- Stormwater management plans;
- Surface water quality monitoring and assessment;
- Rainfall - runoff modelling;
- Catchment yield assessments;
- Sizing of dams and channels;
- Crop irrigation requirement calculations;
- Environmental flow requirement assessments;
- Surface water impact assessments; and
- GN704 Regulation audits.

Education

- 2013: M.Sc. Water Resource Management (cum laude) (University of Pretoria).

Membership in Professional Associations

- Registered as a Professional Natural Scientist (Pr.Sci.Nat.) in Water Resources Science with the South African Council for Natural Scientific Professions (SACNASP). Registration number: 114988.

Employment

- March 2018 – Present: Senior Hydrologist at Hydrospatial (Pty) Ltd.
- June 2012 – February 2018: Hydrologist and GIS specialist at Digby Wells Environmental.

Selected Project Experience

Company	Position	Project Location	Client	Project	Responsibilities
Hydrospatial (Pty) Ltd	Senior Hydrologist	Gauteng / North-West Province	Sibanye Gold	Hydrological Study for the Sibanye Driefontein Operations EMP and WULA Update	• Baseline hydrological assessment. • Water quality assessment. • Stormwater management plan update. • Water and salt balance update. • GN704 and GN509 exemption assessment.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo South Africa	African Realty Trust	Hydrological Opinion on an Unsuccessful Water Use Licence Application for Two Proposed Balancing Dams at Letaba Estates	• Letaba catchment water resource assessment. • Catchment runoff modelling using the Pitman model. • Assessment of the impact of the dams on the Letaba catchment hydrology. • Testimony at the Water Tribunal hearing.

Company	Position	Project Location	Client	Project	Responsibilities
Hydrospatial (Pty) Ltd	Senior Hydrologist	Mpumalanga South Africa	SAFCOL	Streamflow Reduction Modelling due to Genus Exchange of Eucalyptus for Pine at the SAFCOL Berlin Plantations	• Setup of the WRSM/Pitman model. • Calculation of the allowable genus exchange area using the Gush Tables. • Reporting. • Presentation of study and hand over of reports.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Mpumalanga South Africa	Transvaal Gold Mining Estates	Hydrological Study for the Proposed Theta Mine Project	• Calculation of the water use freed up through the proposed removal of pine, eucalyptus and wattle in the Blyde River catchment for an offset strategy for the mine. • Baseline hydrological study. • Surface water impact assessment. • Water quality sampling and analysis. • Setup of a water monitoring network and programme. • Stormwater structure placement and sizings of structures. • Development of a water balance model. • 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 to determine the 1:50 and 1:100 year floodlines. • Reporting.

Company	Position	Project Location	Client	Project	Responsibilities
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo, South Africa	Lunsklip Farming	Hydrological Study for the Lunsklip Irrigation Dam	• Catchment runoff modelling using the WRSM/Pitman model which included afforested areas. • Calculation of the farm irrigation requirements. • Quantification of the irrigation dam water balance.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Mpumalanga South Africa	Anglo American	Surface Water Assessment for the Proposed Leslie 1 Coal Mine	• Baseline hydrological study. • Surface water impact assessment. • Water quality sampling and analysis. • Setup of a water monitoring network and programme. • Stormwater structure placement and sizings of structures. • Development of a water balance model. • 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 to determine the 1:50 and 1:100 year floodlines. • Reporting.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo South Africa	Assmang	GN704 Legal Compliance Audit of the Dwarsrivier Chrome Mine	• Site audit of the mine to GN704 regulations. • Reporting on findings and recommendations for improvement to comply with GN704 regulations.

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Company	Position	Project Location	Client	Project	Responsibilities
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo South Africa	Assmang	Floodline Determination for the Resource and Reserve Drilling Project at the Dwarsrivier Chrome Mine	• Catchment delineation. • Hydrological assessment to calculate the 1:50 and 1:100 year peak flows. • Hydraulic modelling of 18 river reaches to determine the 1:50 and 1:100 year flood water elevations.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo South Africa	Assore	GN704 Legal Compliance Audit of the Rustenburg Minerals Development Company Chrome Mine	• Site audit of the mine to GN704 regulations. • Reporting on findings and recommendations for improvement to comply with GN704 regulations.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Gauteng South Africa	Fry's Metals	Stormwater Management Plan for the Fry's Metal Factory	• Audit of site stormwater infrastructure. • Calculation of peak flows and stormwater volumes. • Calculation of stormwater channel capacities to assess whether capacities comply with regulatory requirements.
Hydrospatial (Pty) Ltd	Senior Hydrologist	North West South Africa	Assore	Hydrological Study for the Wonderstone Mine	• Baseline hydrological study. • Surface water impact assessment. • Water quality Assessment. • Development of a stormwater. management plan. • River diversion assessment.
Hydrospatial (Pty) Ltd	Senior Hydrologist	KwaZulu-Natal, South Africa	The Biodiversity Company	Water Quality Monitoring and Assessment for the Edendale	• Setup of a water monitoring network. • Surface water sampling. • Assessment of water quality results.

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Company	Position	Project Location	Client	Project	Responsibilities
				Bulwer Housing Development	
Hydrospatial (Pty) Ltd	Senior Hydrologist	Gauteng South Africa	Eskom	Hydrological Assessment of a Tributary of the Braamfonteins pruit near Sandton, Johannesburg	• Site assessment. • Peak flow calculations. • Storm event assessment. • Hydraulic structure assessment. • Assessment of gabion retaining wall failure. • Hydraulic modelling of watercourse.
Hydrospatial (Pty) Ltd	Senior Hydrologist	Limpopo South Africa	Assore	GN704 Legal Compliance Audit of the Zeerust Chrome Mine	• Site audit of the mine to GN704 regulations. • Reporting on findings and recommendations for improvement to comply with GN704 regulations.
Digby Wells Environmental	Hydrologist	Mali	Birimian	Hydrological Study for the Environmental and Social Impact Assessment for the Goulamina Lithium Project	• Baseline hydrological study. • Development of a water and salt balance. • Modelling of catchment flood hydrology. • Calculation of storm rainfall depths. • Stormwater management plan. • Surface water impact assessment.
Digby Wells Environmental	Hydrologist	Senegal	Randgold Resources	Hydrological Study for the Randgold Massawa Gold Project ESIA	• Baseline hydrological study. • Floodline determination. • Development of a water and salt balance. • Modelling of catchment hydrology. • Environmental flow requirement calculations. • Stormwater

Company	Position	Project Location	Client	Project	Responsibilities
					management plan. • Surface water impact assessment.
Digby Wells Environmental	Hydrologist	Cameroon	Caminex SA	Hydrological Study for the Environmental and Social Impact Assessment for the Ntem Iron Ore Project	• Baseline hydrological study. • Surface water impact assessment.
Digby Wells Environmental	Hydrologist	Gauteng South Africa	Sibanye-Stillwater	Sibanye Gold Millsite TSF Reclamation Project EIA	• Audit of existing stormwater management controls. • Development of a stormwater management plan to satisfy GN704 Regulation requirements. • Development of a stormwater control monitoring programme. • Water conservation and water demand management plan
Digby Wells Environmental	Hydrologist	Gauteng South Africa	Sibanye-Stillwater	Sibanye Gold Kloof Floodline Determination	• Site visit to assess channel and floodplains and to measure hydraulic structures. • DEM creation from lidar dataset. • Catchment delineation. • Catchment assessment of soils, vegetation, slope and land cover to obtain suitable runoff coefficients. • Calculation of peak flows using Rational and SDF methods. • Hydraulic modelling in HEC-RAS for approximately 25 river reaches to determine the 1:50

Company	Position	Project Location	Client	Project	Responsibilities
					and 1:100 year surface water elevations.
Digby Wells Environmental	Hydrologist	Free State South Africa	Bothma and Son Transport	Stormwater management plan for the Bothma Sand Mine	• Audit of existing stormwater management structures. • Rainfall assessment. • Sizing of channels. • Development of a stormwater management plan to satisfy GN704 conditions. • Development of a stormwater structure monitoring programme. • Development of a PCD rehabilitation action plan. • Reporting.
Digby Wells Environmental	Hydrologist	Free State South Africa	Sasol Mining	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 flow directions and accumulations to determine areas that are not free draining.
Digby Wells Environmental	Hydrologist	Gauteng South Africa	DRD Gold	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.

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Company	Position	Project Location	Client	Project	Responsibilities
Digby Wells Environmental	Hydrologist	Mpumalanga South Africa	Exxaro	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	Limpopo South Africa	Exxaro	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.

Company	Position	Project Location	Client	Project	Responsibilities
Digby Wells Environmental	Hydrologist	Botswana, Zambia and Namibia	Botswana Government	Kazungula Bridge Project Surface Water Quality Monitoring	• Setup of a water quality monitoring network and programme. • Monthly water sampling from the Zambezi and 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 for the month and identifying possible sources of pollution as well as providing mitigation measures.
Digby Wells Environmental	Hydrologist	Free State South Africa	Sibanye-Stillwater	Sibanye Beatrix ESIA	• Baseline hydrological study. • Surface water impact assessment. • Water quality and trend analysis.
Digby Wells Environmental	Hydrologist	Mpumalanga South Africa	Anker Coal	Anker Coal Elandsfontein Colliery Stormwater Management Plan	• Site visit audit of stormwater structures. • Review of existing stormwater management plan. • Recommendations for the improvement of existing stormwater management plan
Digby Wells Environmental	Hydrologist & GN704 Auditor	Northern Cape, South Africa	Assmang	GN704 Legal Compliance Audit for the Khumani Iron Ore Mine	• 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

Company	Position	Project Location	Client	Project	Responsibilities
					regulations.
Digby Wells Environmental	Hydrologist	Okavango, Botswana	Botswana Government	Mohembo Bridge Surface Water Baseline and Monitoring Programme	• Setup of a surface water quality monitoring network and programme. • Surface water quality sampling and analysis of results. • Analysis of streamflows from the Mohembo discharge gauging station. • Climate assessment.
Digby Wells Environmental	Hydrologist	Mpumalanga South Africa	Sasol Mining	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	North-west South Africa	Sun International	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	De Groote Boom Minerals	Surface Water Study for the Mining Permit Application for the De Groote Boom Project	• Baseline hydrological study. • Surface water impact assessment. • Water quality sampling and assessment of water quality results. • Setup of a water quality monitoring programme. • Reporting.

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Company	Position	Project Location	Client	Project	Responsibilities
Digby Wells Environmental	Hydrologist	South Africa	Fountain Capital	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	Pamish Investments No. 39	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	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.

Company	Position	Project Location	Client	Project	Responsibilities
Digby Wells Environmental	Hydrologist	Mpumalanga South Africa	Msobo Coal	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 determine the 1:50 and 1:100 year floodlines. • Reporting.
Digby Wells Environmental	Hydrologist	Mali	Randgold Resources	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 post mine closure.