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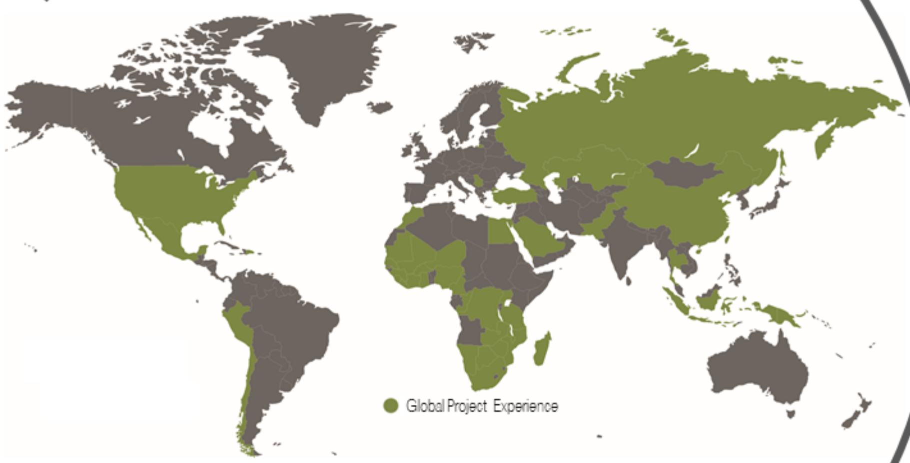

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Basic Assessment Process for the Closure of the Cooke Underground Operations

Hydropedology and Surface Water Quality Impact Assessment

Prepared for:
Sibanye Gold Limited

Project Number:
SIB6297

October 2020

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

- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist *Date 06/10/2020*

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EXECUTIVE SUMMARY

Digby Wells Environmental [DWE] (hereinafter Digby Wells) was appointed by Sibanye Gold Limited, a subsidiary of Sibanye-Stillwater Ltd. (hereinafter Sibanye), Rand Uranium Operations to conduct a wetland impact assessment for the decommissioning activities associated with the Cooke Underground Closure Project. The project entails decommissioning of the Cooke 1, 2 and 3 shafts and associated infrastructure, rewatering of the underground workings, cessation of pumping and discharge of extraneous groundwater into the Wonderfonteinspruit and Magazine Pan and rehabilitation activities associated with the proposed closure.

The project area is situated in the Vaal Water Management Area 5 (WMA5) within the C23D quaternary catchment. The Wonderfonteinspruit is the main river supporting multiple water users. Runoff emanating from this quaternary catchment drains in a south westerly direction into the Wonderfonteinspruit. C23D quaternary catchment is a contributing catchment to C23E, and therefore all runoff from C23D eventually drains into Mooirivierloop of the C23E quaternary catchment. The topography of the study area ranges between approximately 1538 to 1760 metres above mean sea level (mamsl).

The investigation of the study included a site visit to assess the soil characteristics in the study area and to verify preliminary investigations that were conducted at desktop level. The soil forms identified in the study area are the oakleaf (76%), katspruit (8%), mispah (6%) and shortlands (10%). The hydrological soil types identified include the interflow (soil/bedrock) (76%), responsive (saturated) (8%), responsive (shallow) (6%) and interflow (A/B) (10%).

The Cooke Underground Operations are in a complex catchment that is influenced by several water users including mines, aquatic ecosystems, agricultural uses and urban residential developments. This presents a challenge for the quantification of the potential impact of Sibanye's activities in the Wonderfonteinspruit catchment as end user requirements (i.e. Resource Quality Objectives) have not been set by the Government (Sibanye-Stillwater, 2018). Therefore, Sibanye developed a site-specific long-term plan of target water quality limits to be adhered to in order to inform post closure requirements on downstream water users. The approach adopted takes into account all existing water quality data, comparing upstream (before Sibanye's discharge) and downstream (after potential Sibanye-related impacts), comparing water quality to the Water Use Licence limits, Resource Quality Objectives (RQO's) for Mooi Rivier Catchment, which is the nearest downstream catchment with available RQO's, South African Target Water Quality Range for aquatic ecosystems, livestock watering, irrigation, and other limits from literature as applicable.

The water quality assessment was benchmarked against the discharge limits that were developed by Sibanye for the protection of downstream water users (Sibanye-Stillwater, 2018) and the issued Water Use License (WUL) limits (Licence No.: 03/A21D/AFGJ/2382) for the operation. Both guidelines indicated exceedances of some water quality parameters at the Cooke discharge points including EC, TDS, SS, Ca, Na, Cl, SO_4, F, U, Cd, Cu, Mn, Ni and Zn. Based on historical analysis between the Cooke 1 discharge point into the

Wonderfonteinspruit and the downstream water quality monitoring point (W15), although the effluent contained some contaminants, these were shown to have minimal water quality impacts on the Wonderfonteinspruit in its current state. The cessation of discharging partially treated mine effluent is anticipated to improve water quality within the Wonderfonteinspruit and the water quality in aquifers underlying the Magazine Pan over time. However, in the interim before these positive impacts are realised, other upstream water users discharging into the Wonderfonteinspruit need to be monitored closely in terms of discharged metals, salts, nutrients and pathogens as the cessation in discharge at Cooke 1 will temporarily reduce flow and hence the dilution capacity of upstream nutrients, which is currently observed.

Simultaneously, the cessation of treated effluent discharge will cause a reduction of the water flowing into the pan, consequently reducing the wetland area of the Magazine Pan, which is currently an artificial system. However, land reprofiling during rehabilitation will restore close to natural surface flows into the Magazine Pan which will be beneficial for the wetland system. Furthermore, the recharge of the dolomite aquifers will restore the historic water table, which will facilitate the observed shallow groundwater and surface water interactions through the soil bedrock interface that dominates the Cooke shaft areas.

The hydrogeology assessment findings concluded that the potential decant from the Cooke shafts is unlikely to contaminate groundwater sources as the water quality within the shaft areas was considered acceptable when benchmarked with the South African National Standards (SANS): 241 Drinking Water Quality Guidelines.

Therefore, the main concerns that remain for the proposed activities pertain mostly to the potential contamination of receiving waterbodies during the decommissioning phase due to spillages and leaks of hydrocarbons and contaminated residue in the infrastructure to be decommissioned. This impact may be controlled most effectively by keeping the storm water infrastructure in place while decommissioning potential sources of contaminants and by prioritizing decommissioning during the low rainfall or dry periods (i.e. between May to October). Strict record keeping of waste removal and appropriate disposal must be kept.

Additionally, the wetland area between the Cooke 1 discharge point and monitoring point 15 may have become a settling area for suspended solids, including metals emanating from the Cooke 1 discharge. Dissolved solids are not a major concern as they are typically in solution and become diluted. On the contrary, settled solids may mobilise as a result of change in pH and redox potential which will likely occur as a result of ceasing discharge. Therefore, sediments were collected as part of a separate specialist study to assess sediment quality and to determine the way forward for appropriate mitigation measures and rehabilitation to minimize the potential mobility of metals.

Based on the impact assessment, mitigation measures and recommendations proposed it is the opinion of the specialist that the project should proceed. It is anticipated that the potential positive impacts will outweigh negative impacts in the long term and thus the associated closure activities would ultimately be beneficial for the receiving water environment in the long term.

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ACRONYMS, ABBREVIATIONS AND DEFINITION

EC	Electrical Conductivity
EIA	Environmental Impact Assessment
ET	Evapotranspiration
HST	Hydrological Soil Type
mamsl	Meters Above Mean Sea Level
mg/l	Milligrams per litre
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
MRA	Mining Rights Area
MTIS	Mineable tonnes in-situ
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
PCD	Pollution Control Dam
RQO	Resource Quality Objective
SANS	South African National Standards
SS	Suspended Solids
TDS	Total Dissolved Solids
WMA	Water Management Area
WRC	Water Research Commission
WUL	Water Use Licence

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) was appointed by Sibanye Gold Ltd (a subsidiary of Sibanye-Stillwater Ltd., hereinafter Sibanye), owners of Rand Uranium (Pty) Ltd (hereafter Rand Uranium), to undertake the closure and rehabilitation studies in support of the environmental regulatory process to authorise the decommissioning, rehabilitation and ultimate closure of the Cooke 3, 2 and 1 Shafts. Underground mining activities associated with these shafts are authorised under Mining Right (GP) 30/5/1/2/2 (07) MR (hereinafter referred to as the Cooke Underground Operations).

A Basic Assessment Process has been undertaken in terms of the EIA Regulations, 2014 (GN R326 of 7 April 2017), as amended, promulgated under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). It is noted that the environmental regulatory process also includes an application for a Water Use Licence (WUL) in terms of the National Water Act, 1998 (Act No. 36 of 1998) (NWA).

This report constitutes the Hydropedology Specialist Impact Assessment Report to identify and quantify positive- and negative impacts on the surface - groundwater interactions as a result of decommissioning and rehabilitation activities to be undertaken within the Cooke Underground Operations, cessation of the associated groundwater pumping, treating and discharge regime as well as the ultimate closure state of the shafts.

2 Project Description

Rand Uranium is the holder of a converted Mining Right for the Cooke Underground Operations which are located within the West Rand District Municipality, approximately 10 kilometres (km) south-east of the town Randfontein.

The operations comprise three underground mine shaft complexes, namely: Cooke No. 1, 2 and 3 Shafts. The underground workings are accessible through vertical shafts at each of these complexes. Infrastructure in the underground workings includes water pumping and treatment systems including clarifiers, attenuation and settling dams as well as storage areas, underground walkways and conveyors. Ancillary surface infrastructure including administrative and workshop buildings water management structures (e.g. attenuation dams, trenches, berms etc.) are also in place at each of the complexes.

Underground mining at all three shafts ceased in May 2018. Sibanye has maintained an extensive groundwater pumping and treatment scheme to keep the underground workings dry in case of the recommencement of mining in future. Following extensive investigations, no sustainable mining plans were found to be feasible and as such, a permanent closure solution is now being sought out.

The scope of final decommissioning, rehabilitation and closure activities being applied for by Rand Uranium are described below.

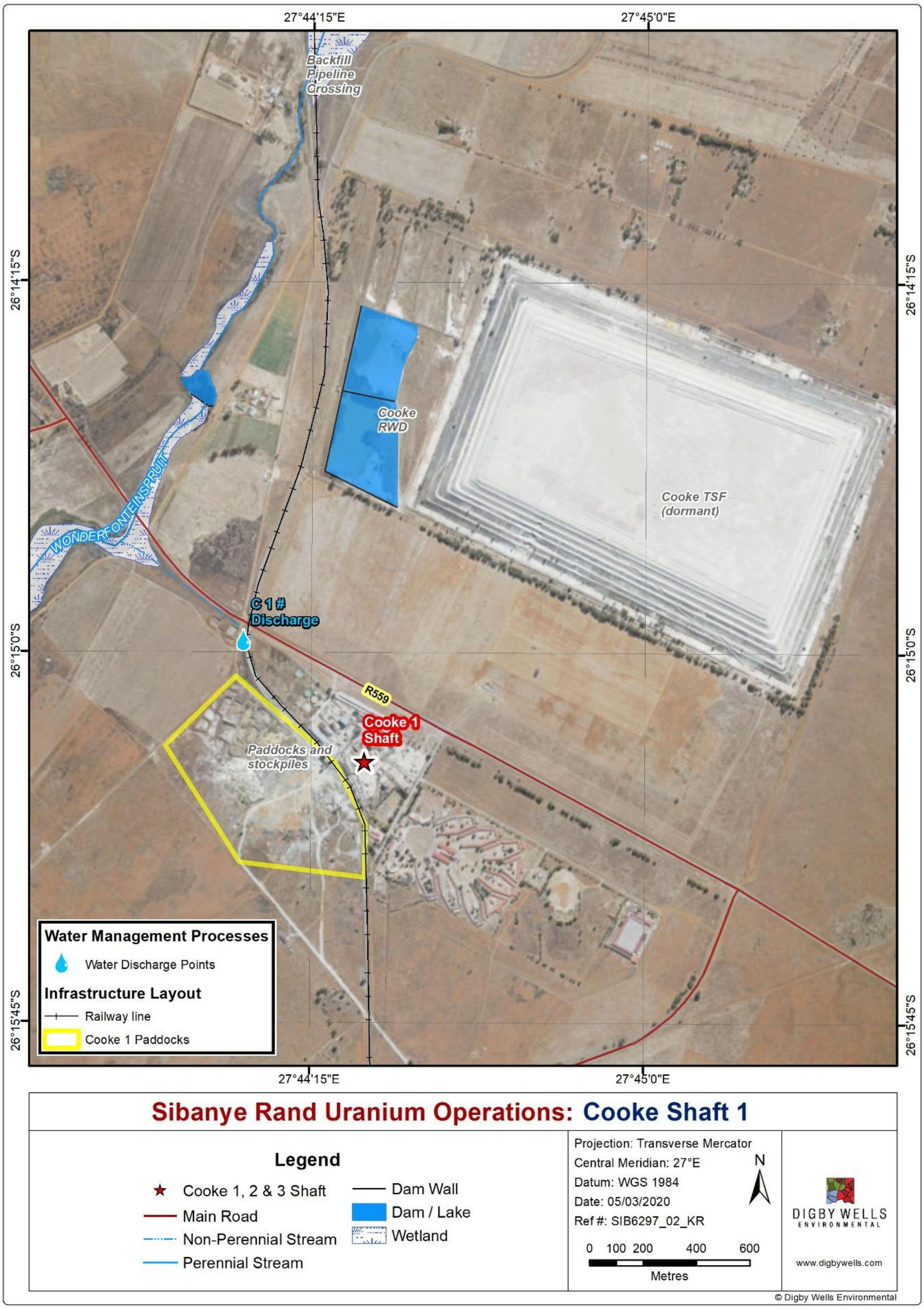

Figure 2-1: Cooke Shaft 1 and discharge point into the Wonderfonteinspruit

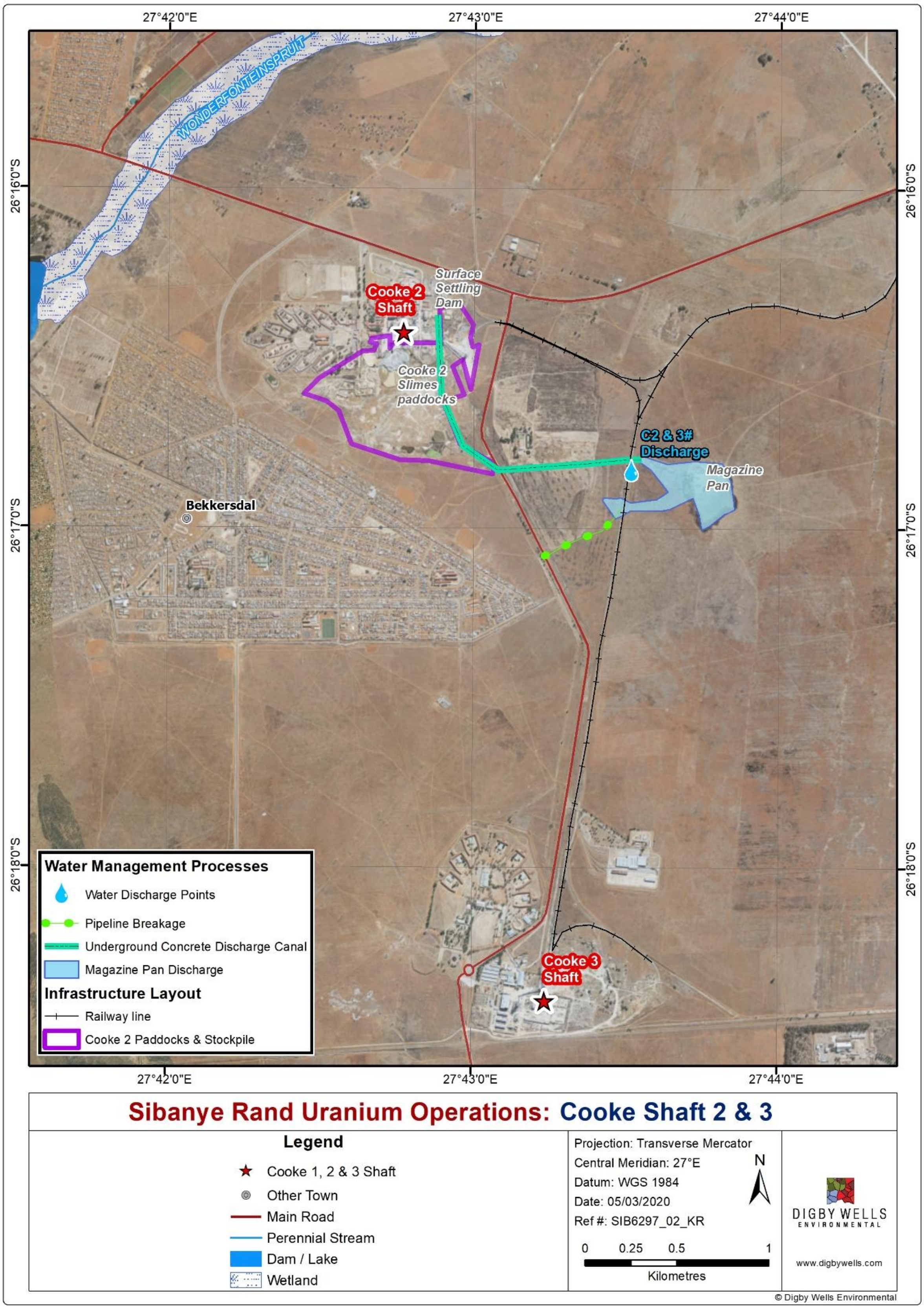

Figure 2-2: Cooke Shafts 2 and 3 and discharge point into the Magazine Pan

2.1 Cessation of Groundwater Pumping- and Discharge Regime

During this time, Rand Uranium maintained an extensive groundwater pumping and treatment scheme to continue access to the underground mine workings through the prevention of the flooding of mining areas due to groundwater ingress. Extraneous water collected from underground is treated in a series of settlers after which it is transported to surface for further settlement, evaporation and discharge to the environment.

An overview of the process is described in Table 2-1 and depicted in Figure 2-3 below.

Table 2-1: Water Management Process at the Cooke Shaft Complexes

Process step	Cooke 1 Shaft	Cooke 2 and 3 Shafts
Collection and treatment of extraneous groundwater	Groundwater from Cooke 1 Shaft is pumped to and treated through a series of settlers and stored in underground dams located at Cooke 1 Shaft.	Groundwater water from Cooke 3 Shaft is pumped and gravitated to Cooke 2 Shaft. The groundwater is treated through a series of settlers and stored in underground dams located at Cooke 2 Shaft.
Surface treatment	From the underground dams, water is pumped to surface for settling of suspended solids as well as for attenuation purposes.	From the underground dams, water is pumped to surface for settling of suspended solids as well as for attenuation purposes.
Transport and end-destination	Water is discharged by means of a concrete canal into the Wonderfonteinspruit a discharge point located below Cooke 1 Shaft.	Water is discharged through a short pipeline and a concrete channel into the Magazine Pan, an artificial depression wetland where there is evaporation and recharge to underground aquifers.
Sediment disposal	The settled solids are disposed of in paddocks on surface at the shaft.	The settled solids are disposed of in paddocks on surface at the shaft.

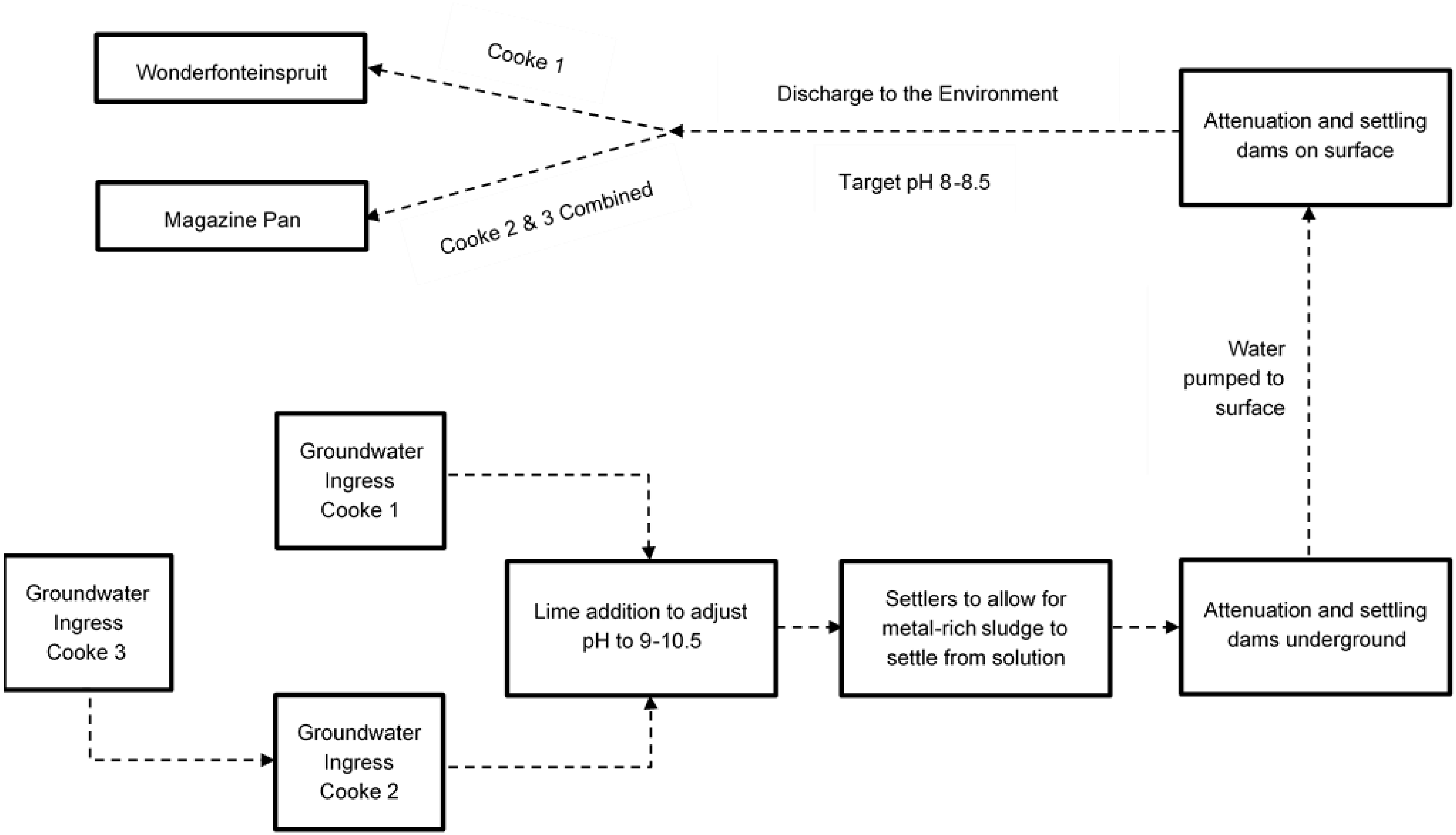

Figure 2-3: Water Management Process

The scope of decommissioning, rehabilitation and closure activities to be undertaken as a result of the cessation of groundwater pumping- and discharge regime include:

- Removal and decontamination of underground infrastructure containing hydrocarbons and other contaminants from the Cooke 1, 2 and 3 underground workings;
- Refurbishment of plugs between Cooke 3 and Cooke 4 Shafts, as well as between Cooke 1 and Doornkop Mine;
- Recharging of underground workings;
- Potential capping of the shaft barrel below the dolomitic aquifer, dependent on specialist studies regarding the groundwater quality;
- Decommissioning of surface dams and rehabilitation of dam footprints;
- Removal of settled solids from surface paddocks and mud ponds for processing through the Plant and/or disposal into the Pits;
- Rehabilitation of surface paddocks and mud ponds;
- Decommissioning and rehabilitation of concrete channels; and
- Rehabilitation of Magazine Pan, an artificial pan used for water management.

2.2 Removal of Shaft Infrastructure

The scope of decommissioning, rehabilitation and closure activities for shaft infrastructure at Cooke 1, 2 and 3 Shafts include:

- Decommissioning of shaft headgear and surface infrastructure;
- Capping of shafts;
- Sale of salvageable items;
- Disposal of waste; and
- Rehabilitation of infrastructure footprints.

It is proposed to remove all surface infrastructure to reduce the risk of vandalization and theft by illegal miners prevalent in the area. The shafts will be capped to make the area safe and prevent access to underground workings, which will be recharged at closure.

2.3 Alternatives Considered

As indicated above, Rand Uranium has maintained an extensive groundwater pumping, treating and discharge regime at the Cooke Underground Operations while investigating alternatives for the continuation of the operation. No sustainable mining plans were found to be feasible and as such, a permanent closure solution is now being sought. The decommissioning, rehabilitation and closure activities discussed above are the only way to achieve sustainable closure.

3 Relevant Legislation, Standards and Guidelines

The table below summarises the legal framework applicable to this Hydropedology and Surface Water Quality Impact Assessment. The assessment includes the Underground Operations within the Cooke Shaft in which the proposed decommissioning, closure and rehabilitation is set to take place. The proposed activities include the cessation of groundwater pumping and the removal of shaft infrastructure within the Cooke Shaft Complexes as detailed in Section 2.

Table 3-1: Applicable Legislation, Regulations, Guidelines and By-Laws

Legislation, Regulation, Guideline or By-Law	Applicability
National Water Act, 1998 (Act No. 36 of 1998)	The NWA is applicable for the protection and prevention of pollution of water resources that may arise as a result of the proposed activities within the Cooke Shaft Complexes. The hydropedology and water quality study will form part of the impact assessment to minimize and remedy the pollution and degradation of the water resources in the proposed closure and rehabilitation of the Cooke Shaft Complexes.
Section 21 of the National Water Act, 1998 (Act No. 36 of 1998) All water uses listed in terms of Section 21 of the National Water Act (NWA) need to be licenced, unless it is a permissible water use in terms of Section 22 of the NWA.	The water use within the Cooke Shaft Complexes during the planned decommissioning and closure does not constitute as permissible water use in terms of Section 22 of the NWA.
Regulation 7 of the General Authorisation for Section 21(c) and (i) water uses (GN R 509 of 2016) A risk assessment should be undertaken to determine whether the General Authorisation (GA) applies to Section 21 (a), (c), (f), (g), (i) and (j) water uses at Rand Uranium, or whether a WUL will be required	Even though these water uses will cease post-closure, it is imperative to understand any potential residual impacts that might result from the cessation to ensure corrective measures are in place until total rehabilitation has been established.
Environmental Impact Assessment Regulations, 2014 Government, Gazette No 40772 including GNR 327 and GNR 328 dated 7 April 2017 The purpose of this Notice is to identify activities that would require environmental authorisations prior to commencement of that activity and to identify competent authorities in terms of sections 24(2) and 24D of the Act.	The decommissioning activities trigger a licence and may result in the release of effluent or pollution of receiving waterbodies. The decommissioning of underground and surface infrastructure may cause contamination of receiving waterbodies by generating runoff with

Legislation, Regulation, Guideline or By-Law	Applicability
	hydrocarbons and chemicals. Furthermore, the infrastructure may contain residual contaminants that may potentially contaminate receiving waterbodies.
Section 2 (4) (a) (ii) of the National Environmental Management Act (Act 107 of 1998) (NEMA) Requires that the Environmental Management Plan (EMP) to include a rehabilitation plan, decommissioning plan and mine closure strategy. It must demonstrate pollution control measures and management of mining waste.	The hydropedology and water quality study will form part of the impact assessment to minimize and remedy the pollution and degradation of the water resources in the proposed closure and rehabilitation of Cooke shafts 1, 2 and 3.
National Environmental Management: Waste Act (Act 59 of 2008) (NEMWA) Requires that waste generators classify waste material and appropriate handling of waste based on the classification must be adhered to based on the regulations that have been set out in within the Act, unless the waste has been listed under the waste activities that do not require a waste management licence.	The proposed decommissioning and removal of infrastructure in the Cooke complexes will result in waste that needs to be classified and handled appropriately.
Environmental Management Frameworks (EMF) and Integrated Development Plans (IDP, 2015/2016) for West Rand District Municipality (WRDM) According to the NEMA EMF Regulations, an EMF is defined as a study of the biophysical and socio-cultural systems of a geographically defined area to reveal where specific land uses may best be practiced and to offer performance standards for maintaining appropriate use of such land.	The soil management plan considered the best land use post mining as it is unlikely that the rehabilitation will restore the natural conditions within the Cooke complexes. Therefore, the aim of the rehabilitation is to ensure that the land is most suitable for the intended use post closure.

4 Assumptions, Limitations and Exclusions

The quantification of the potential impact of Sibanye's activities in the Wonderfonteinspruit catchment presented a challenge for Sibanye since the complex catchment does not have end user requirements (i.e. Resource Quality Objectives) set by the Government. Sibanye, therefore, developed a site-specific long-term plan of target water quality limits to be adhered to in order to inform post closure requirements on downstream water users. These guidelines were applied in the study to assess compliance with historical water quality.

The methodology applied to derive these target water quality limits was reviewed and it is considered comprehensive and acceptable by Digby Wells as the approach includes consideration of downstream water users, water use licence limits and resource quality objectives for the Mooi Rivier Catchment. This furthermore takes into consideration the guidelines outlined in the Mine Closure Series in terms of water quality management (DWAF, 2008). The approach considers the pre-mining, current and post-mining water quality to derive the target water quality limits.

5 Methodology

A detailed hydropedological assessment was conducted to assess and identify potential impacts that may arise from the proposed decommissioning and closure of the Cooke Shaft Complexes. This section provides the scope of work and methodology that was undertaken during the EIA phase of this project.

5.1 Desktop Assessment and Literature Review

The following literature and reports were reviewed for better understanding of hydrological processes within the Cooke Underground Operations:

5.1.1 Soil Management Plan

The soil management plan report (Digby Wells Environmental, 2017) was reviewed to provide insight into the post mining land use as the surface and hydropedological processes of the mine area were permanently altered during construction by deep excavations. The rehabilitation of the site should be aligned to the post mining land use as the pre-mining conditions are unlikely to be restored.

5.1.2 Wetlands Report

The wetlands report (Digby Wells Environmental, 2020) was reviewed as part of the hydropedology assessment to provide wetland delineations in the Cooke Shaft Complexes which have an impact on the anticipated hydropedological functions.

5.1.3 Hydrogeological Report

The hydrogeological report conducted by MvB Consulting (2020) was reviewed to determine the potential impacts of the proposed closure mine activities on the groundwater regime and provide a better understanding of the surface-groundwater interaction of the water regime within the Cooke Shaft Complexes.

5.1.4 Agricultural Research Council (ARC) Land type inventories

Existing Land Type data was used to obtain generalised soil patterns and terrain types for the proposed project site. Land Type data exists in the form of published 1:250 000 maps. These maps indicate delineated areas of relatively uniform terrain, soil pattern and climate (Land Type Survey Staff, 1972 - 2006). These maps and their accompanying reports provide a statistical estimate of the different soils that can be expected in the area.

5.2 Site Visit

The site assessment was undertaken between 26th May and 4th June 2020 to understand and verify hillslope hydrology which determines the dominant water flow paths within the demarcated landscape units. Soil characteristics which indicate water residence times and leaching effects were assessed during the site visit. 19 sampling points were selected within the area of interest and augering of the soil profile was done until approximately 80 to 100 cm, although for most sampling points, refusal was met between 60 to 80 cm (Table 6-1). Physical and chemical soil characteristics which indicate water residence times (for example, signs of wetness include, grey, low chroma colours, leaching and mottles) were noted during the site visit. Any signs which indicate groundwater-surface water interaction were identified such as hillslope seeps, springs and wetlands.

5.3 Hydropedological Classification

Hillslopes were delineated according to methods described by (Le Roux, et al., 2011) and the conceptual hillslope hydrological behaviour determined. The hydrological behaviour was based on identified hydrological soil types as described in the table below.

Table 5-1: Hydrological Soil Types of the hillslopes (Adapted from (Le Roux, et al., 2011))

Hydrological Soil Type	Description	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration (ET).	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. The duration of drainable water depends on rate of ET, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	
Interflow (Soil/Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	

5.4 Water Quality Assessment

Sibanye has been conducting surface and groundwater monitoring at the Cooke Underground Operations and surroundings since 2012, more historical data is available however the reliability cannot be confirmed. Figure 5-1 illustrates the surface water quality monitoring points. Water quality data since the commencement of monitoring was provided to Digby Wells to complete the Water Quality Assessment. The Water Quality Assessment undertaken includes trend analysis over time and interpretation of current water quality prior to the proposed activities.

The Cooke Underground Operations are in a complex catchment that is influenced by several water users including mines, aquatic ecosystems, agricultural uses and residential developments. This presents a challenge for the quantification of the potential impact of Sibanye's activities in the Wonderfonteinspruit catchment as end user requirements (i.e. Resource Quality Objectives) have not been set by the Government (Sibanye-Stillwater, 2018). Therefore, Sibanye developed a site-specific long-term plan of target water quality limits to be adhered to in order to inform post closure requirements on downstream water users. The approach adopted takes into account the following:

- All existing water quality data;
- Comparing upstream (before Sibanye's discharge) and downstream (after potential Sibanye-related impacts);
- Comparing water quality to the following standards, guidelines and limits:
  - Water Use Licence limits (WUL);
  - Resource Quality Objectives (RQO's) for Mooi Rivier Catchment, which is the nearest downstream catchment with available RQO's;
  - South African Target Water Quality Range for aquatic ecosystems, livestock watering, irrigation; and
  - Other limits from literature as applicable.

An example of the approach undertaken by Sibanye is for Electrical Conductivity (EC). A trend analysis of EC from 2012 to 2018 along the Wonderfonteinspruit and the Cooke 1 discharge point (average of 180 mS/m) indicated non-conformance with the WUL Limits (i.e. a set Limit of 115 mS/m) or the RQO's for Mooi Rivier (i.e. a set limit of 111 mS/m) in the EC being discharged. The new limit proposed by Sibanye (130 mS/m) was formulated based on the average quality of downstream point (W15) being compliant with both the WUL and RQO Limits (i.e. average EC of 90.32 mS/m), which decreases by a factor of 1.1. The decrease of 180 to 130 mS/m is a factor of 1.3, therefore the quality criteria of downstream water users should be met by setting the limit at 130 mS/m. For aquatic ecosystems, although the Cooke discharge is higher than the recommended range it is unlikely to pose a high risk to the receiving environment as compliance is again achieved at W15. Furthermore, the TWQR for irrigation indicate the EC measurements would comply with the requirements for moderately sensitive crops. A similar approach was undertaken for all the parameters in the WUL to derive site-specific long-term plan of target water quality limits to be adhered to in order to inform post closure requirements on downstream water users (Table 6-4).

The findings of this investigation resulted in a range of water quality limits to be adhered to during the long-term implementation water quality monitoring to ensure that the potential liabilities associated with Sibanye's mining activities are adequately quantified. These limits were adopted in this study and benchmarked against water quality in the Wonderfonteinspruit (Section 6.5). For the purposes of this study, the selected points for this investigation are presented in Table 5-2 below.

The water quality assessment was undertaken to ascertain the following:

- The potential impact of the Sibanye Cooke operations on the downstream catchment to inform post closure requirements;
- To evaluate the historic water quality compliance against water user requirements; and
- Potential post closure impacts on water quality in the Wonderfonteinspruit Catchment.

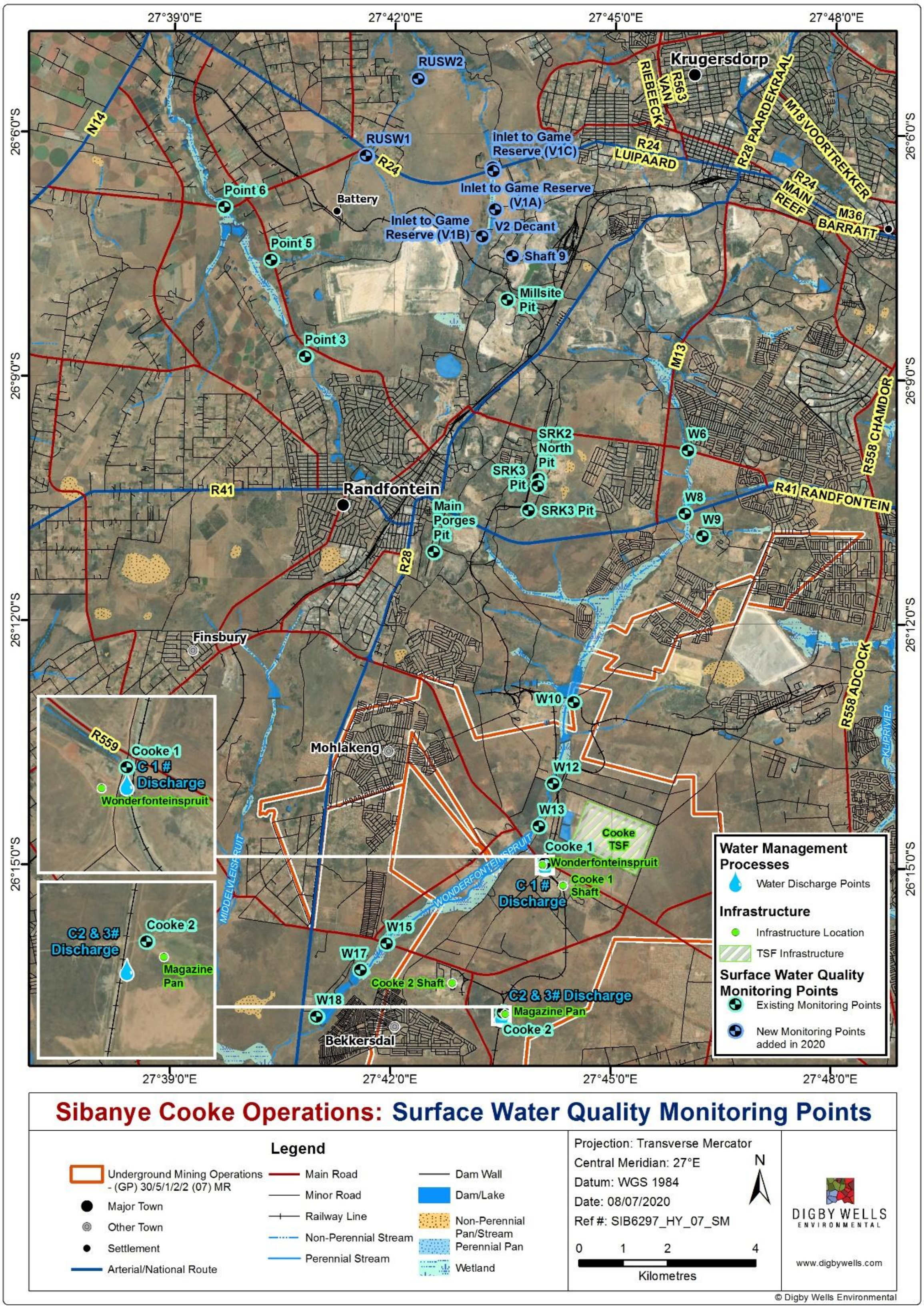

Figure 5-1: Surface Water Quality Monitoring Network in the Rand Uranium Sibanye Operations

Table 5-2: Selected Water Quality Monitoring Points

Monitoring Point	WUL Point	Description	Latitude	Longitude
Cooke 1	Yes	Cooke 1 shaft discharge to the Wonderfonteinspruit	26°14'57.30"S	27°44'05.82"E
Cooke 2	Yes	Cooke 2 shaft discharge to Magazine pan	26°16'47.64"S	27°43'32.52"E
W6	No	Wonderfonteinspruit at Rndfntn/Rdprt bridge no. 450	26°09'52.60"S	27°46'00.88"E
W8	No	Wonderfonteinspruit upstream of Flip Human STP	26°10'39.30"S	27°45'58.65"E
W9	No	Flip human STW effluent discharge	26°10'55.58"S	27°46'12.97"E
W10	Yes	Attenuation dam outlet	26°12'58.66"S	27°44'28.74"E
W12	Yes	Wonderfonteinspruit before Cooke TSF	26°13'58.66"S	27°44'12.33"E
W13	No	Wonderfonteinspruit after Cooke TSF	26°14'30.27"S	27°44'00.88"E
W15	No	Wonderfonteinspruit at bridge before Cooke 2 shaft	26°15'57.27"S	27°41'56.74"E
W17	No	Donaldson dam inflow	26°16'16.96"S	27°41'35.62"E
W18	No	Donaldson dam inflow	26°16'51.52"S	27°40'59.86"E

5.5 Impact Assessment

The methodology adopted for the water quality and hydropedology impact assessment is detailed in Appendix A.

6 Findings and Discussion

6.1 Baseline Environment

6.1.1 Climate

This section provides a summary of the climate data specifically the Water Research Commission (WRC) adopted rainfall and evaporation figures which represent the baseline climate conditions on the project area.

6.1.1.1 Rainfall

The average monthly rainfall for the quaternary catchments C23D based on the averages of monthly rainfall data from a period of 1920 to 2009 (WRC, 2015) is presented in Figure 6-1. Higher rainfall averages occur during the months of December, January and February, while the lowest average rainfall was recorded in July. The mean annual rainfall for the quaternary catchment is estimated as 714 mm.

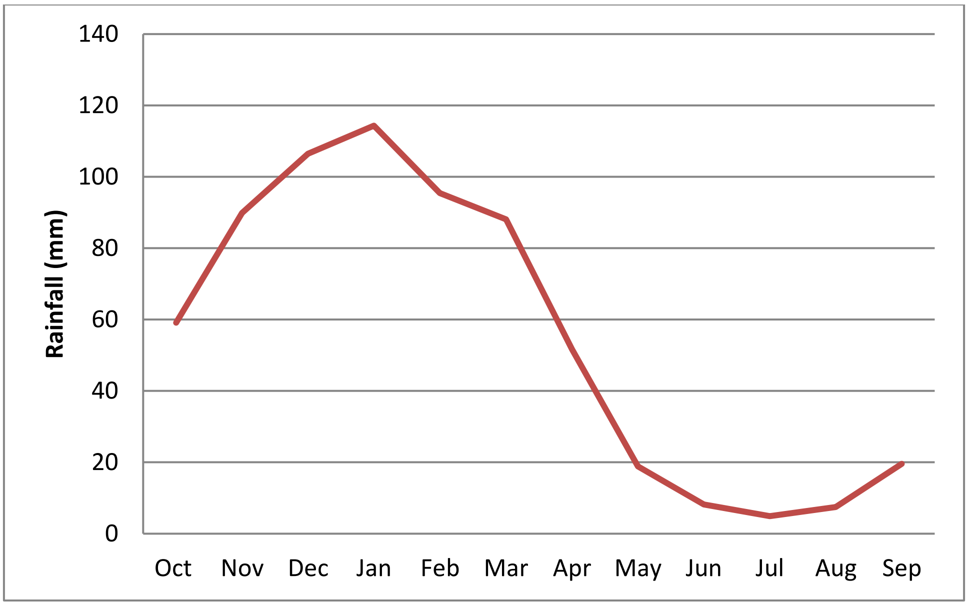

Figure 6-1: Average Monthly Rainfall for Quaternary Catchment C23D

6.1.1.2 Evaporation

The mean annual evaporation for the C23D quaternary catchment is estimated as 1385 mm and the average monthly evaporation (WRC, 2015) is presented in Figure 6-2. The months with the highest evaporation are December, January and February, while July has the lowest value. The evaporation trend correlates to the rainfall trend but clearly higher evaporation is experienced than incident rainfall.

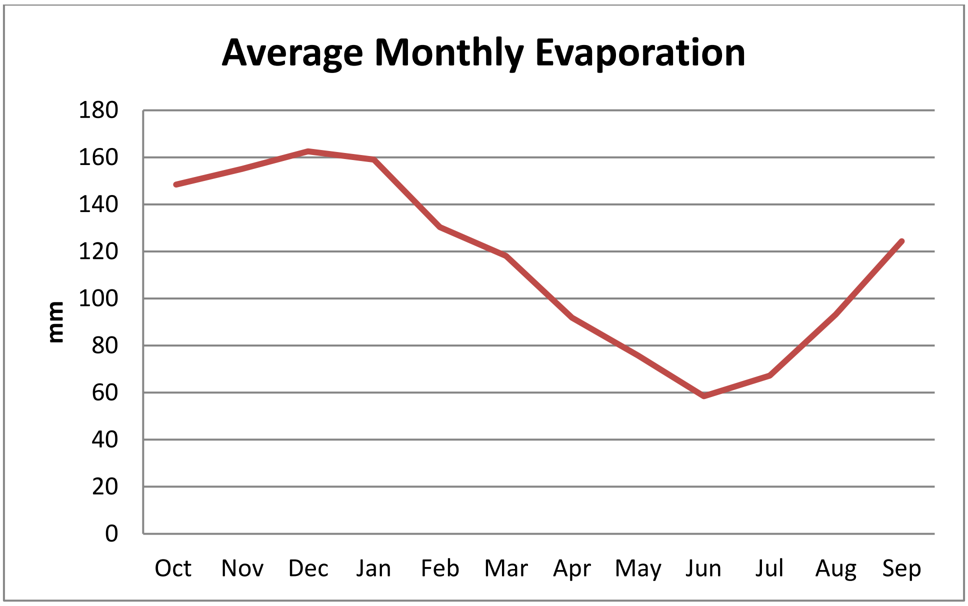

Figure 6-2: Average Monthly Evaporation for Quaternary Catchment C23D

6.1.2 Surface Water Hydrology and Topography

As per the revised Water Management Area (WMA) boundary descriptions (government gazette No. 35517) in 2012, the Cooke Underground Operations are located within C23D quaternary catchment (Figure 6-3) of the Vaal WMA (previously known as Upper Vaal). The C23D quaternary catchment area is 510 km^2 and has an MAR of 9.12 Mm^3.

Wonderfonteinspruit is the main river within the C23D quaternary catchment. Runoff emanating from this quaternary catchment drains in a south westerly direction into the Wonderfonteinspruit, which is made-up of more than 30 km of the watercourse being diverted through a pipeline and various canals. C23D quaternary catchment is a contributing catchment to C23E and, therefore, all runoff from C23D eventually drains into Mooirivierloop of the C23E quaternary catchment. The topography of the study area ranges between approximately 1538 to 1760 metres above mean sea level (mamsl) (Figure 6-4).

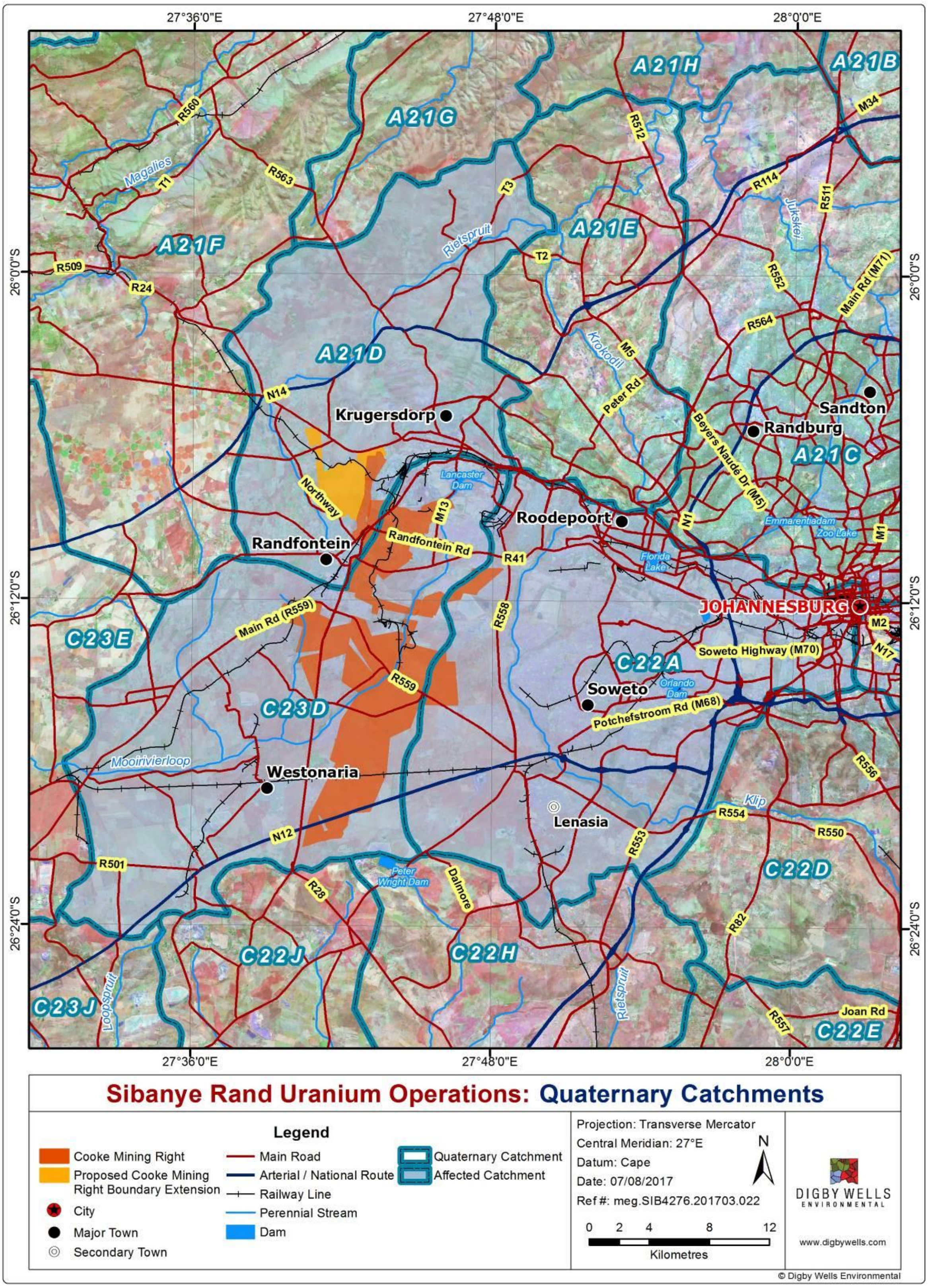

Figure 6-3: Hydrological Setting of the Rand Uranium Operations

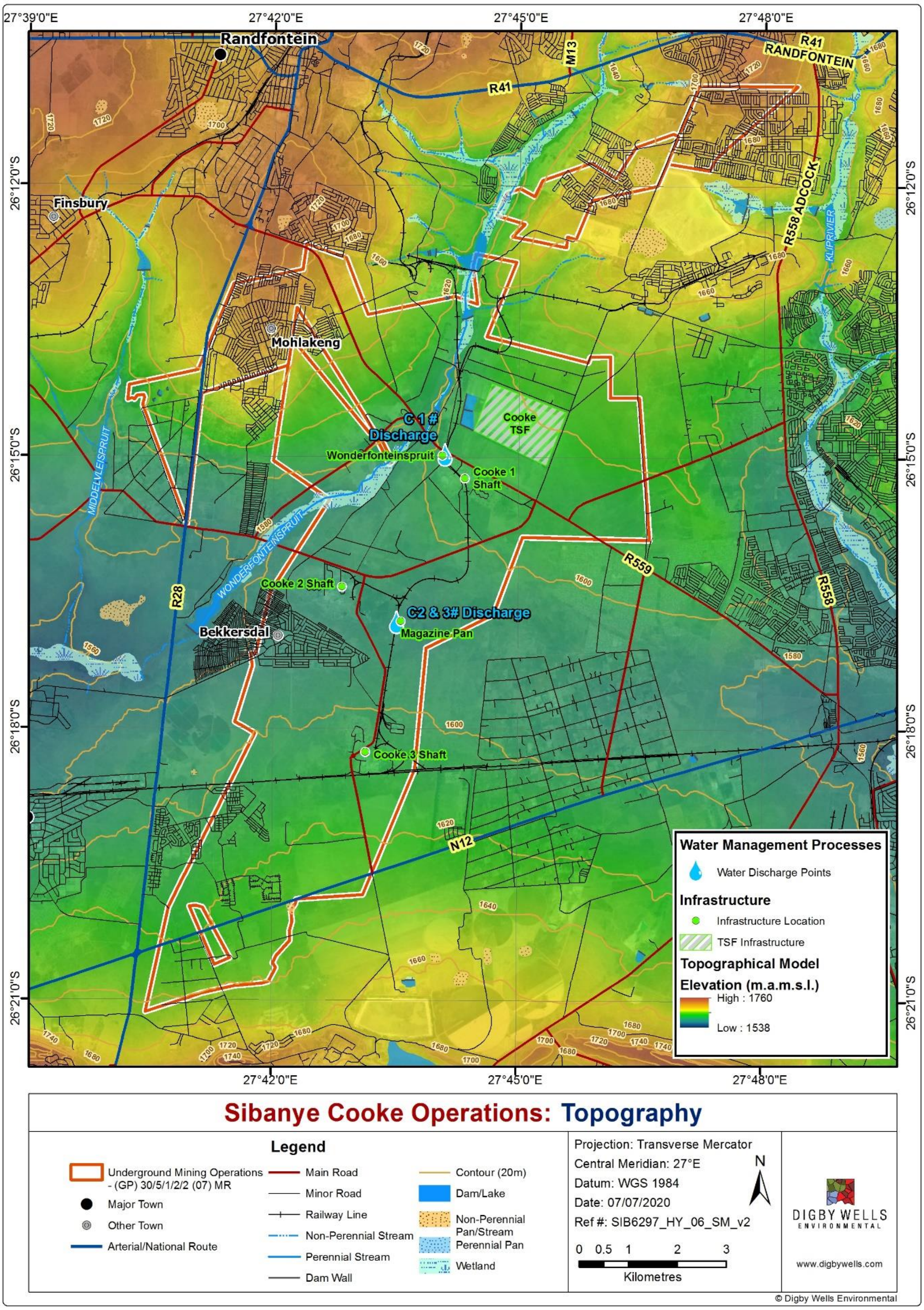

Figure 6-4: Topography Map for the Cooke Operations

6.1.3 Land Type

The land type associated with the Cooke Underground Operations is Ab7 (Figure 6-6). The area is dominated by red-apedal, well-drained soils and rocky soils, mainly Hutton and Mispah soil forms. The general structure of the Hutton and Mispah soil forms as observed in the sampled points was that of general weak structure and low clay content indicated by the friable structure. Furthermore, red soils are generally characterised by texture varying from, sand to clay, the majority being loam. Their other characteristics include porous and friable structure. However, it should be noted that accurate descriptions of soil texture and soil pH, amongst other constituents may be determined by laboratory analysis of soil samples. The general terrain type within the Ab7 land type is presented in Figure 6-5 below. The Ab7 land type is dominated by terrain unit Type 4 which indicates a gentle slope. Terrain unit 1 represents the crests while unit 5 represents the lowest point in the topography of the land type, which are the streams. These terrain units are correlated to the Land Type Inventory from which the distribution of the expected soil type within each terrain unit is given.

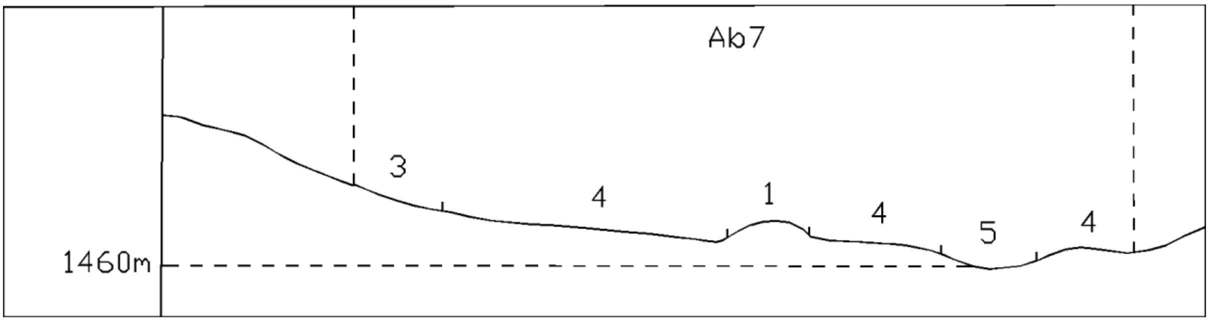

Figure 6-5: General Terrain Type for Land Type Ab7 (Adapted from (Land Type Survey Staff, 1972-2006))

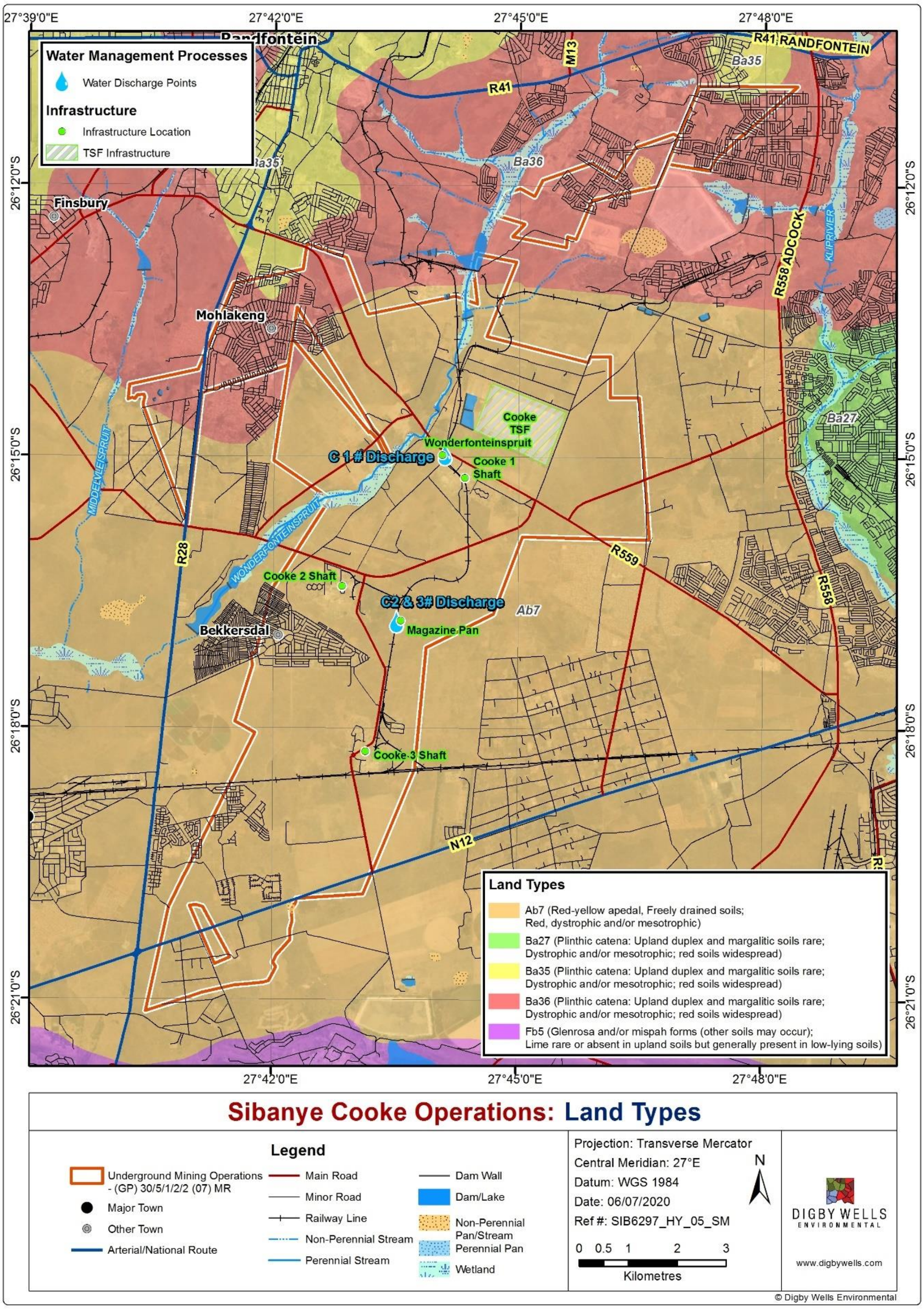

Figure 6-6: Land Type Map in the Cooke Operations

6.1.4 Land Use

The current land use was classified into the following categories by Digby Wells Environmental (2017):

- Tree plantations;
- Mines;
- Urban built-up;
- Grazing;
- Livestock farming; and
- Cultivation.

The most dominant land uses are grazing followed by mining, urban and cultivated areas. The agricultural crops include Maize, Soybean and Sunflower. Livestock farming including sheep and cattle is one of the practices resulting in degradation of the natural grassland biodiversity (Digby Wells Environmental, 2017).

6.1.4.1 Post Mining Land Use

The final land use needs to fit in with the local Spatial Development Frameworks (SDF, 2014), Environmental Management Frameworks (EMF) and Integrated Development Plans (IDP, 2015/2016) for West Rand District Municipality (WRDM).

The main agricultural products being produced in the West Rand are maize, sorghum, dry beans, sunflower, beef cattle, milk, pork and broilers.

Areas with agricultural potential should be protected and regarded as an important resource. The proposed post-mining land use within the Cooke Mining Right after decommissioning and rehabilitation include the following:

- Agriculture:
  - Cultivation; and
  - Grazing.
- Renewable Energy production:
  - Biofuel.

Figure 6-7 below depicts the present land uses as well as the post-closure land uses detailed above.

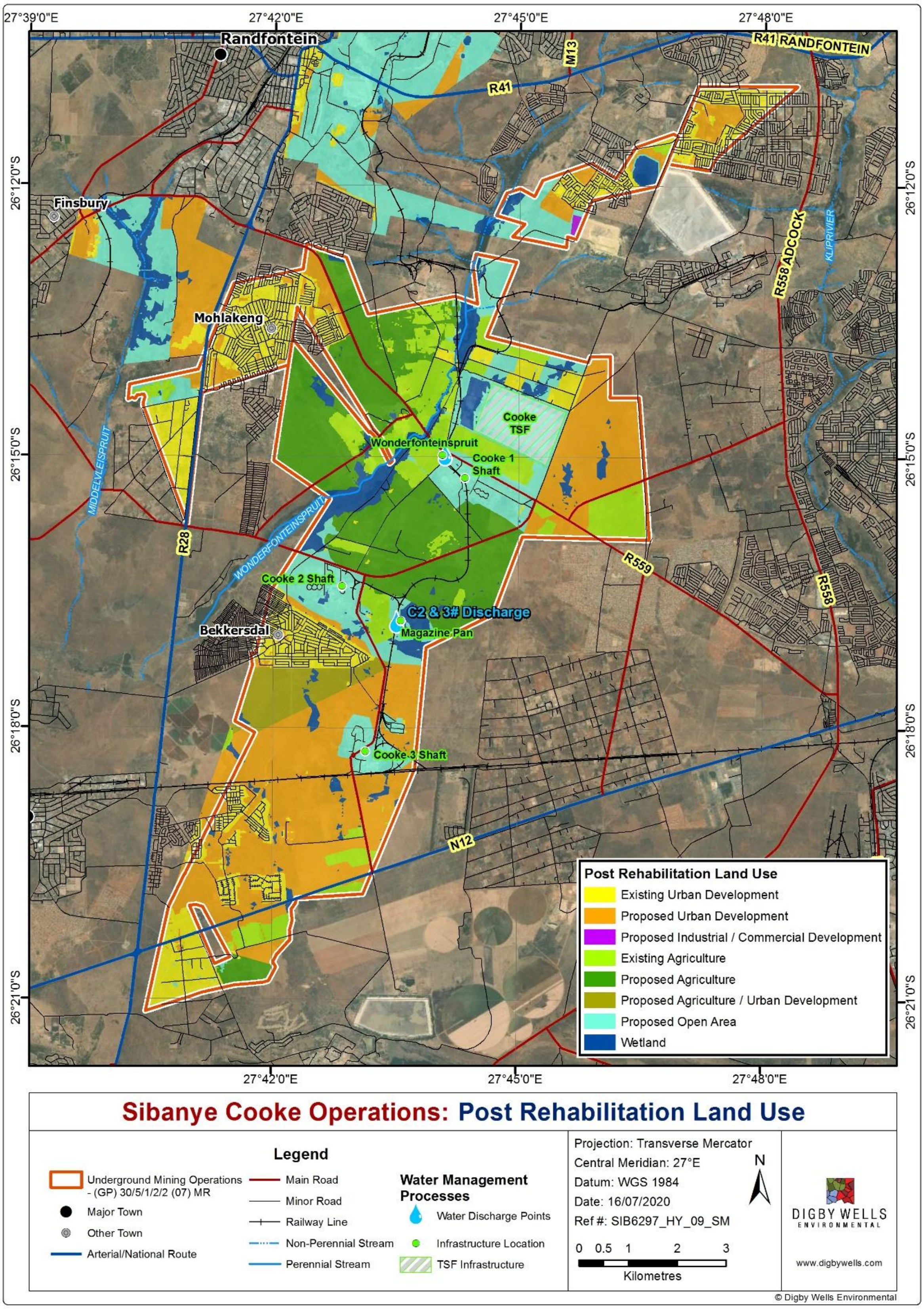

Figure 6-7: Proposed Post Mining Land Use

6.2 Wetlands

Three hydro-geomorphic (HGM) wetland units were identified within the Cooke Underground Operations, within the Wonderfonteinspruit and the Magazine Pan applicable to this assessment. The Wonderfonteinspruit was classified as a channelled valley bottom wetland, while the Magazine Pan was divided into a depression pan and hillslope seep. (Digby Wells Environmental, 2020).

The wetlands assessed have been impacted upon as a result of existing anthropogenic activity within the region of these systems. The Present Ecological State (PES) of the identified wetlands range between D and E. However, the assessment found that these wetlands still play a major role (with an Ecological Importance and Sensitivity (EIS) ranging between B and E) in controlling the hydrology of the West Rand, which has national importance as the Vaal system is downstream. They are also important as they support a range of ecological processes and biodiversity in the region. As such any activities that are undertaken within the region should consider potential ways of improving the functionality of these systems in the long term. The main or perennial river within A21D quaternary catchment is the Bloubankspruit River which flows from the south towards the north eastern side where the catchment outlet is situated. The Bloubankspruit is approximately 800 m from the Millsite Complex (associated with the Cooke Surface Operations). Hydrogeology

The hydrogeological investigations undertaken by MvB Consulting (2020) show that there is low potential for decant from the mine shafts once fully recharged and that the water quality in these shafts is expected to be within drinking water quality guidelines over the long term with the maintenance of sustained groundwater levels. The surface infrastructure associated with groundwater contamination (tailings and waste rock dumps) is in the process or has already been removed. Seepage volumes from these features are also relatively low when compared to the water volumes in the dolomite aquifer. Dilution occurs and the migration of contaminant plumes is therefore limited. Once the source is removed the remaining contamination in the groundwater dissipates very quickly. Additionally, the contaminated footprints by the mud ponds in Cooke Shafts 1 and 2 are likely to have sulphate concentrations below 250 mg/ℓ within 10 years after closure. Hence, no groundwater quality impacts are likely from these facilities (MvB Consulting, 2020).

On the contrary, the WRD and Cooke sludge material from the mud ponds is likely to generate leachate containing contaminants that could leach into the environment in concentrations exceeding regulatory guideline values (MvB Consulting, 2020).

The groundwater level in the Zuurbekom dolomitic groundwater compartment, in which the Cooke mine is situated, has not been lowered much over the years. Based on calculations it may have impacted on the baseflow of the Wonderfonteinspruit. Once pumping from the mine stops and the mine is fully recharged the groundwater levels in the aquifer will recover and flow to the Wonderfonteinspruit will be restored. The increased flow to the Wonderfonteinspruit will increase over a period of 10 years while the groundwater level recovers, until it reaches steady state (MvB Consulting, 2020).

6.3 Site Visit

The topography of the surveyed Cooke site is dominantly relatively flat, with gentle slopes. Soil augering was undertaken at selected representative sampling points (Figure 6-11) to identify any physical and chemical soil characteristics which indicate water residence times (for example, signs of wetness include, grey, low chroma colours, leaching and mottles) and general hydrological responses in the soil profile (Table 6-1). These observations were used to classify the soil forms (Figure 6-12) and Hydrological Soil Types (HSTs) of the sample points (Figure 6-13). Few indications of surface and groundwater interactions were observed, except at the discharge points for Cooke Shaft 2 and 3 (C2 and C3, respectively), and the Magazine Pan (Figure 6-10 (H and I, respectively)).

Table 6-1: Visual Assessment of Hydropedological Conditions within the Cooke Shaft Complexes

Sample Point	Coordinates (Decimal Degrees)		Observations	Soil Form	Hydrological Soil Type
	Latitude	Longitude			
S1	-26.313	27.723	Red soil with small rocks at approximately 45 cm. The rocks beyond 45 cm were bigger until refusal at approximately 100 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S2	-26.309	27.718	Very shallow soil with refusal at approximately 15 cm due to hard rock.	Mispah (Orthic A and hard rock B horizon)	Responsive (shallow)
S3	-26.301	27.715	Deep red soil (>100 cm). The texture and colour of the soil indicate good drainage and no signs of prolonged saturation were observed.	Shortlands (Orthic A and red structured B horizon)	Interflow (A/B)
S4	-26.291	27.723	Relatively deep (>80 cm) red soil with small stones observed at approximately 60 cm. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S5	-26.283	27.731	Dark brown to red soil with rocky structure at approximately 45 cm, followed by refusal shortly after the rocks were observed. No signs of wetness were observed.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S6	-26.283	27.719	Red soil with rocks at approximately 45 to 60 cm. Refusal beyond 60 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	(Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S7	-26.282	27.732	Red soil with small rocks at approximately 45 cm. The rocks beyond 45 cm were bigger until refusal at approximately 60 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S8	-26.280	27.709	Red soil with small rocks at approximately 45 cm. The rocks beyond 45 cm were bigger until refusal at approximately 60 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S9	-26.267	27.741	Relatively deep (>80 cm) red soil with some neocutans observed at approximately 60 cm. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S10	-26.261	27.729	Relatively deep (>100 cm) red soil with some yellowish soil observed at approximately 60 cm. The change from red to yellow soil indicates mineralogical transformation of iron in soil due to periodically anaerobic conditions (See Figure 6-9 (F)). However, no signs of prolonged saturation or leaching were observed within the soil profile.	Shortlands (Orthic A and red structured B horizon)	Interflow (A/B)
S11	-26.253	27.745	Red soil with small rocks at approximately 45 cm. The rocks beyond 45 cm were bigger until refusal at approximately 60 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)

Sample Point	Coordinates (Decimal Degrees)		Observations	Soil Form	Hydrological Soil Type
	Latitude	Longitude			
S12	-26.253	27.732	Red soil with small rocks at approximately 45 cm. The rocks beyond 45 cm were bigger until refusal at approximately 60 cm due to impermeable rock. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
S13	-26.246	27.737	Shallow soil with refusal at approximately 30 cm due to hard rock.	Mispah (Orthic A and hard rock)	Responsive (shallow)
S14	-26.245	27.731	A wetland soil marked by a shallow A horizon. The underlying horizon is a dark clayey soil with the G (wet horizon).	Katspruit (Orthic A and G horizons)	Responsive (saturated)
S15	-26.264	27.706	Relatively deep (>80 cm) red soil with small stones observed at approximately 60 cm. No signs of prolonged saturation or leaching were observed within the soil profile.	Oakleaf (Orthic A and neocutanic B horizon)	Interflow (soil/bedrock)
GSW1	-26.282	27.727	Wetland area observed within the magazine pan	Katspruit (Orthic A and G horizons)	Responsive (saturated)
GSW2	-26.282	27.724	Wetland area observed within the magazine pan	Katspruit (Orthic A and G horizons)	Responsive (saturated)
GSW3	-26.281	27.727	Wetland area observed within the magazine pan	Katspruit (Orthic A and G horizons)	Responsive (saturated)
GSW4	-26.280	27.726	Wetland area observed within the magazine pan. This is also the C2 and C4 discharge point and represents the outlet point from the underground concrete discharge canal.	Katspruit (Orthic A and G horizons)	Responsive (saturated)

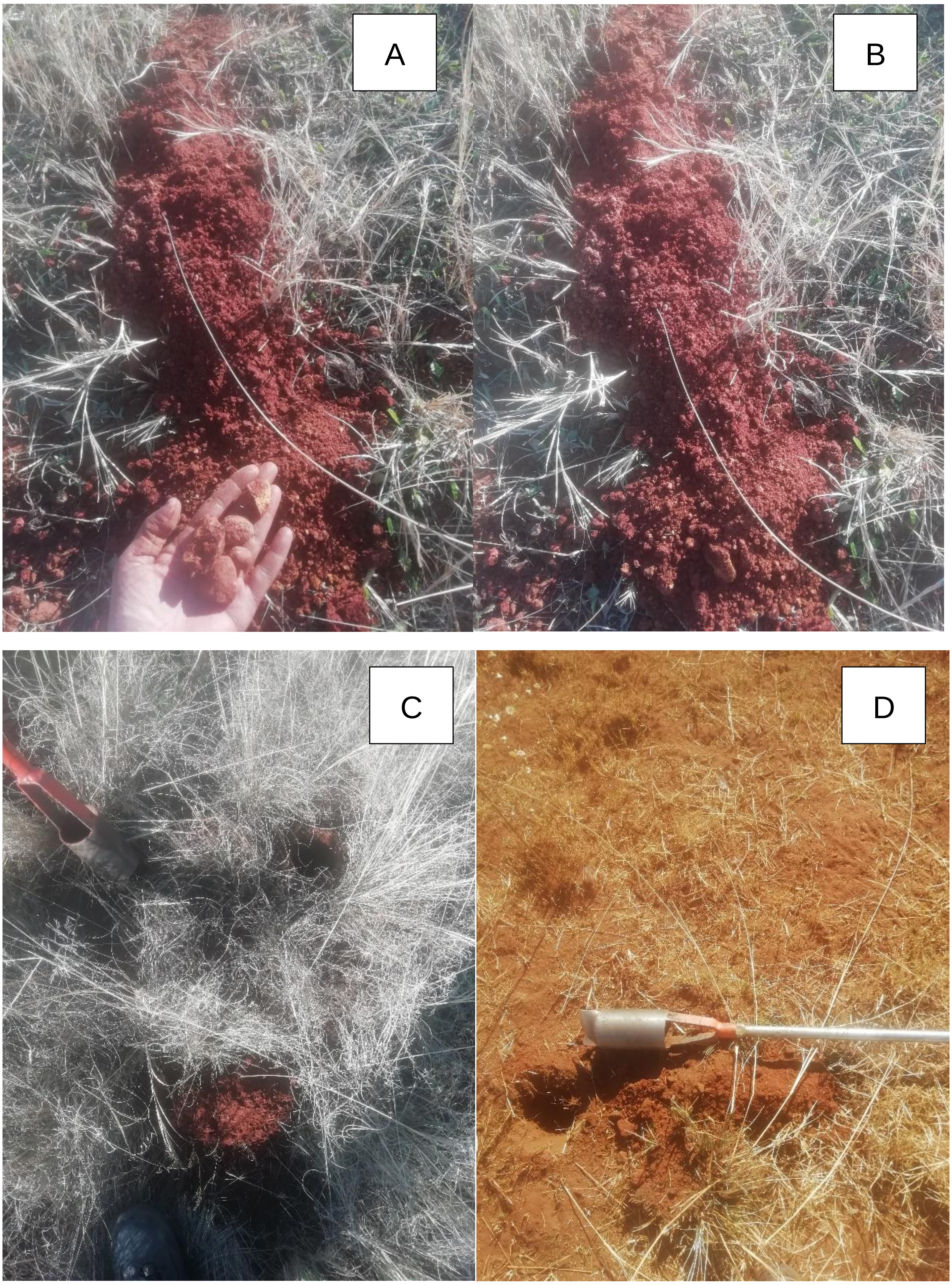

Figure 6-8: Soil profiles of the Oakleaf (A and B) and Mispah Soil Forms (C and D)

Figure 6-9: Soil Profile of the Shortlands (E and F) and the Kroonstad (G) Soil Forms

Figure 6-10: Observed Soil Profiles and Ground-Surface Water Interactions at the Cooke Site

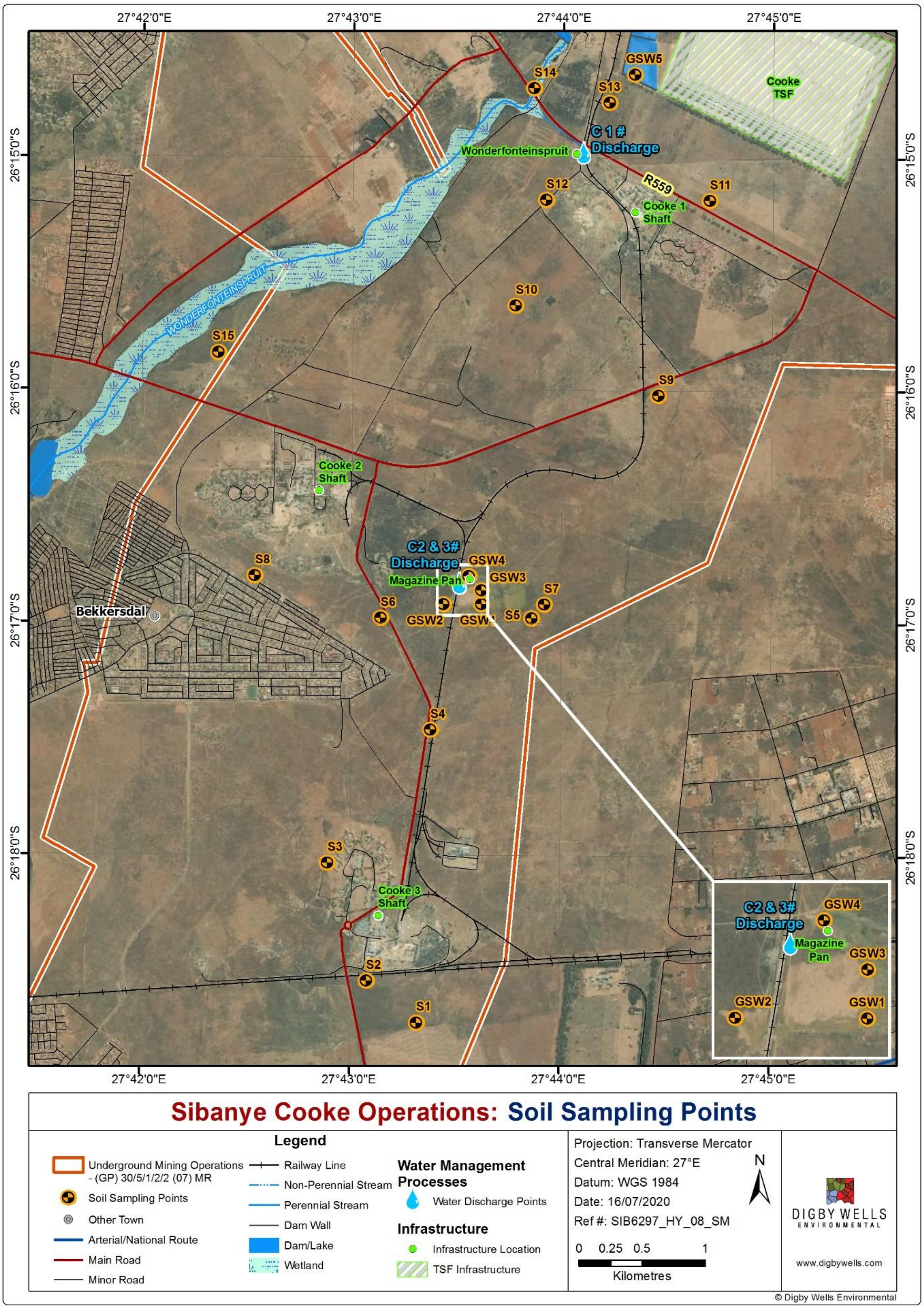

Figure 6-11: Soil Sampling Points within the Cooke Underground Operations

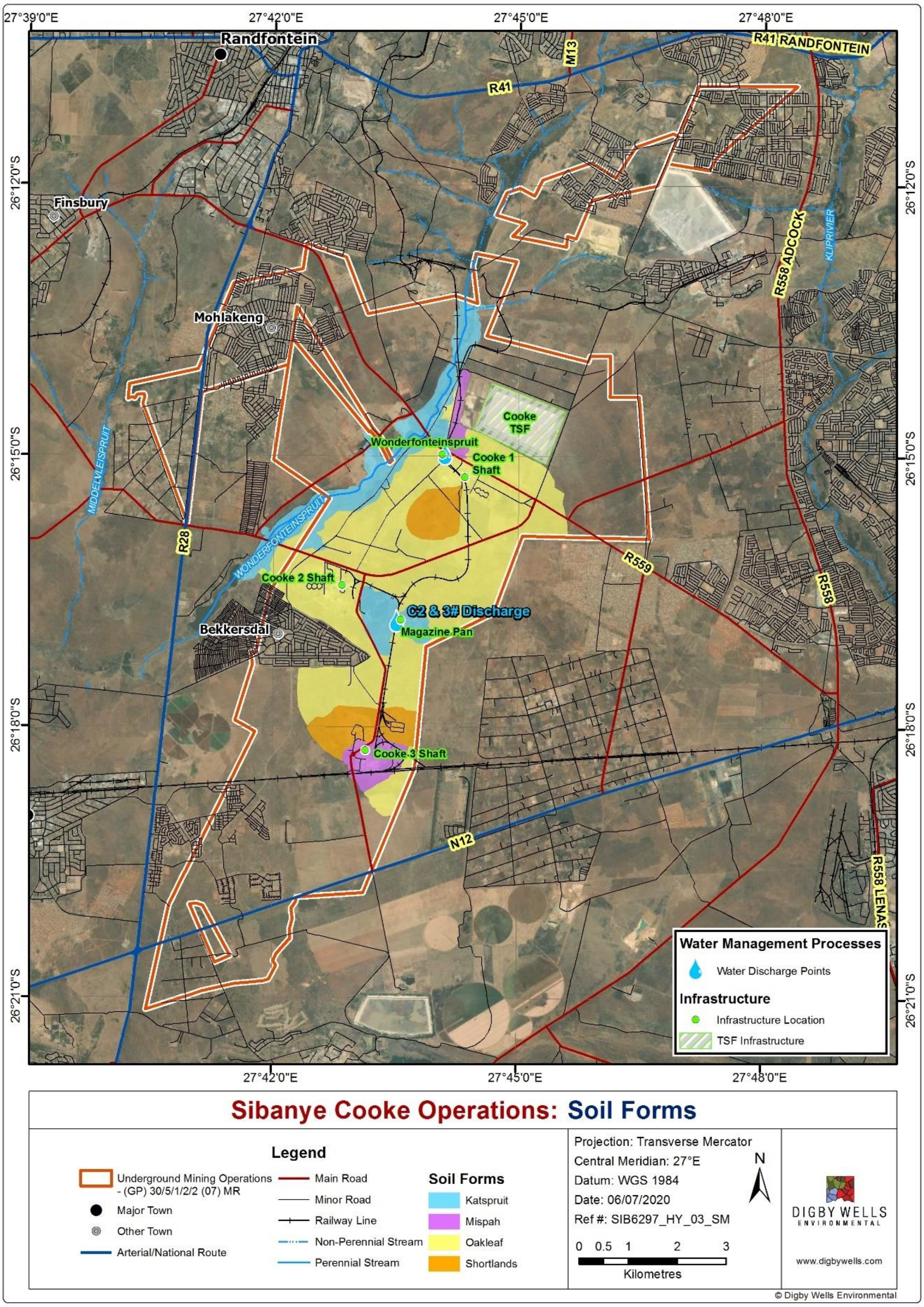

Figure 6-12: Distribution of Soil Forms within the Cooke Underground Operations

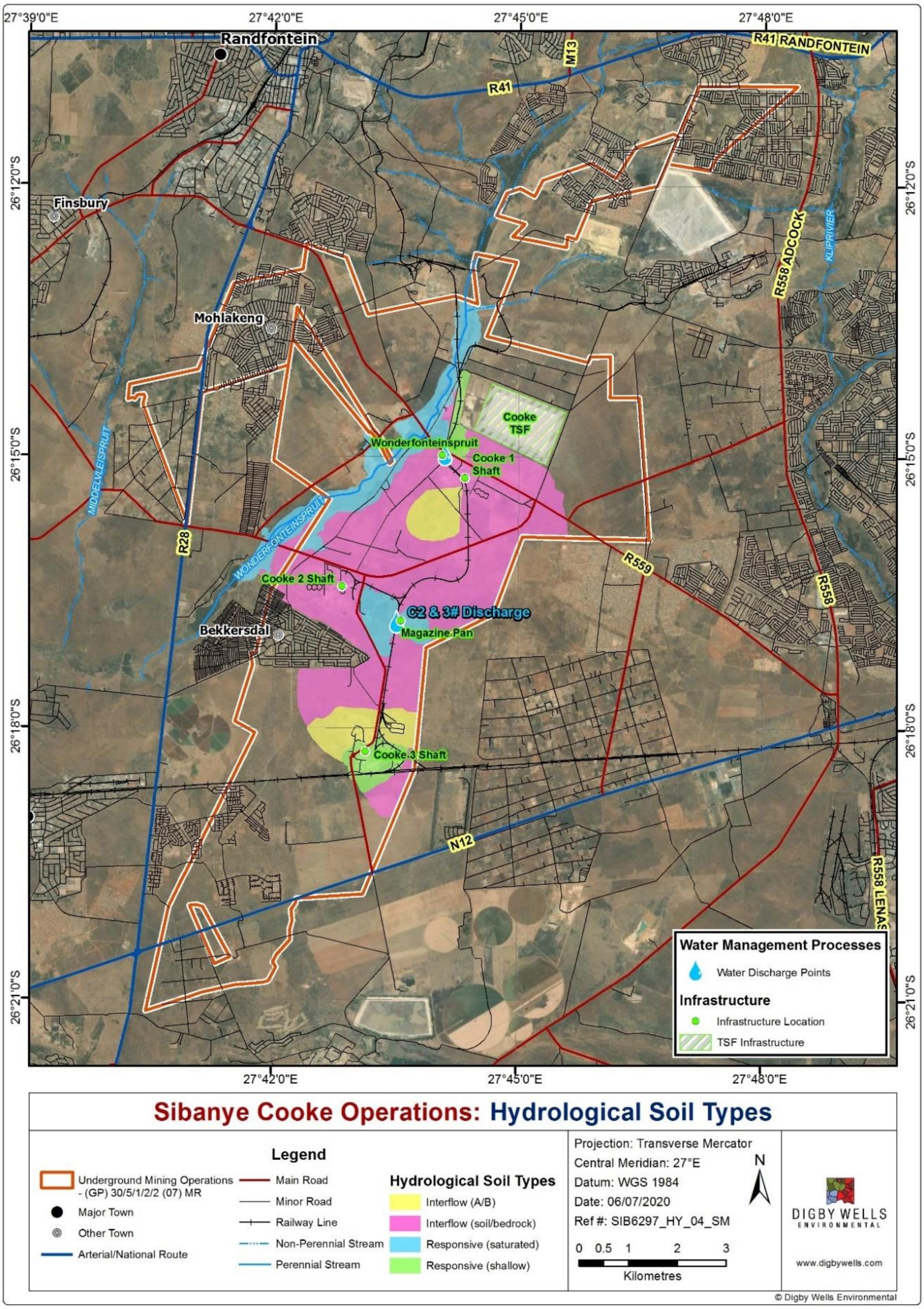

Figure 6-13: Distribution of Hydrological Soil Types within the Surveyed within the Cooke Underground Operations

6.4 Conceptual Hydropedological Responses at the Cooke Underground Operations

The dominant flow path at the Cooke Shaft Complexes is interflow at the soil/bedrock interface as indicated by the dominance of the Oakleaf soil form, which is made up of an Orthic A and neocutanic B horizon, overlain by unspecified material (Soil Classification Working Group, 1991). The flow path within each shaft area is discussed below (Figure 6-14). The dominant flows indicate the mode in which pollutants will dominantly be transported in from each of the shaft areas into receiving waterbodies during the planned decommissioning phase.

The dominance of the soil bedrock interface, with refusal predominantly between 60 and 80 cm indicates a relatively shallow groundwater and surface water interaction. With the proposed recharging within the Cooke operations, it is likely that the historic water table will be established and consequently re-establishing of historic wetland systems and the contribution of baseflow into the Wonderfonteinspruit as the dolomites will once again store water.

6.4.1 Cooke Shaft 1

The dominant flow path upstream of the Cooke Shaft 1 area is through the soil/bedrock interface in which flow is predominantly occurring in a lateral direction. Responsive shallow soils, which cause overland flow after rain events and interflow soil through the A/B interface were also observed within the Cooke 1 Shaft area. The Interflow (A/B) soils cause water flow in a predominantly lateral direction due to permeability differences (duplex soils) between the A and B horizons, allowing some temporary water storage within this interface and gravity flow downslope.

6.4.2 Cooke Shaft 2

The dominant flow in Cooke Shaft 2 area is through the soil/bedrock interflow into the Wonderfonteinspruit. When the proposed recharging of the Cooke 2 pit commences, this will result in greater contribution of flow into the Wonderfonteinspruit through groundwater ingress since the diversion of water into the magazine pan will cease as part of the closure process.

6.4.3 Cooke Shaft 3

The dominant flow path upstream of the Cooke Shaft 3 area is through the soil/bedrock interflow. Responsive shallow soils, which cause overland flow after rain events and interflow soils through the A/B interface were also observed within the Cooke 3 Shaft area. The Interflow (A/B) soils cause water flow in a predominantly lateral direction due to permeability differences between the A and B horizons, allowing some temporary water storage within this interface and gravity flow downslope into the magazine pan. Minimal flow into the Wonderfonteinspruit from Cooke Shaft 3 is envisaged due to the residential development situated downstream of Cooke 3, namely Bekkersdal. This development most likely interrupted natural flow into the Wonderfonteinspruit during development, which caused water diversion by municipal water infrastructure in place.

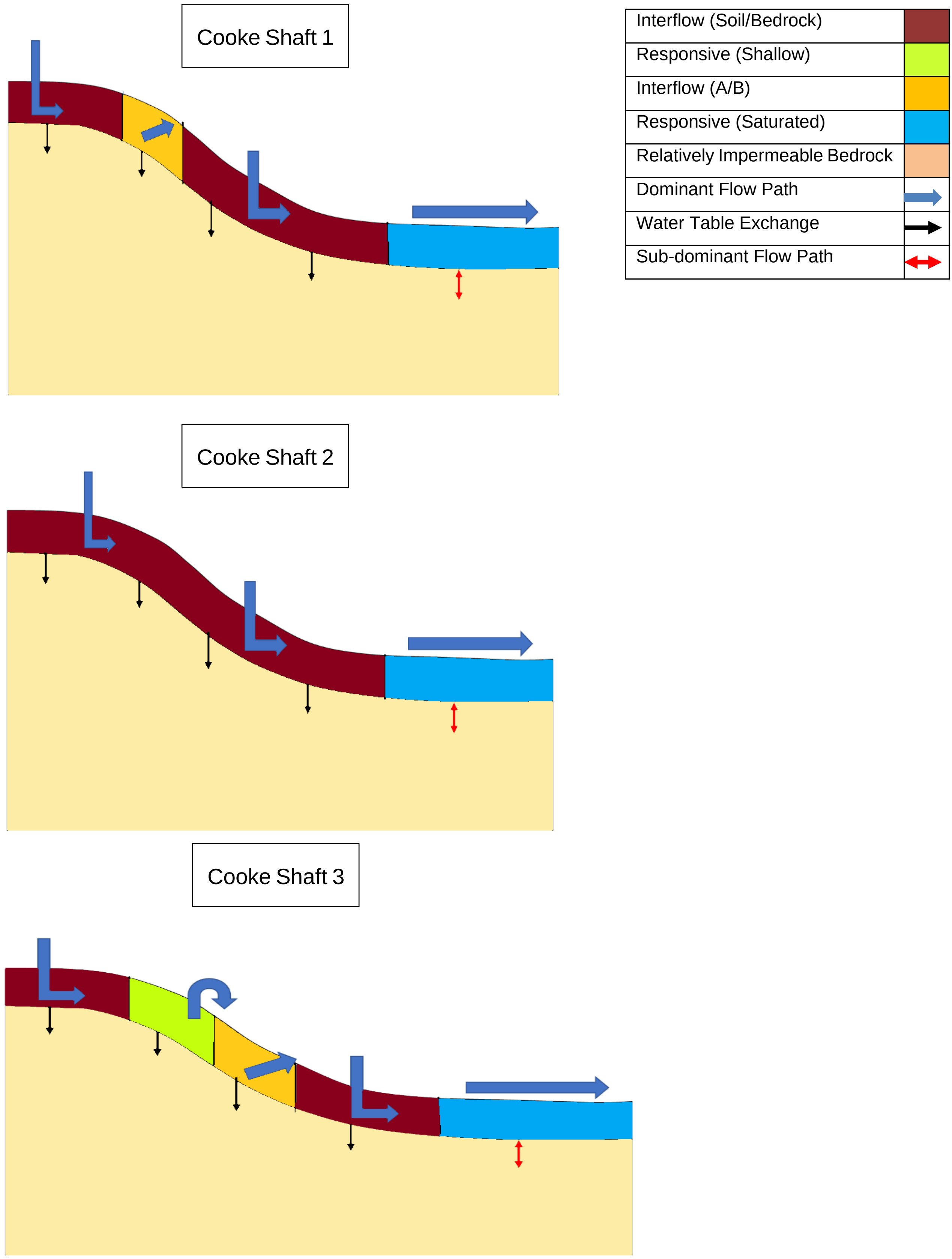

Figure 6-14: Conceptual Hydropedological Responses at the Cooke Project Site

6.5 Water Quality Assessment

As previously indicated, no clear RQOs exist for the Wonderfonteinspruit reach under investigation, however they have been promulgated for the Mooi River. There are the following critical factors to quantify in terms of the risk posed by water quality upon closure which will be addressed in the various sections below:

- Pre-mining water quality to inform restoration requirements;
- Water User requirements, including the environment;
- Current water quality results as compared to the water user requirements and mitigation requirements during the interim phase as recharging occurs; and
- Post-mining water quality predictions and management requirements.

6.5.1 Pre-mining Water Quality

Mining within the dolomitic catchment area of the Wonderfonteinspruit commenced in the 1930s, with the advent of appropriate technology to allow for mining in areas impacted by dolomites to take place. Mining focussed primarily on gold resources but later from the 1950s expanded to include uranium resources. Further to this, mining occurred in the upper reaches of the dolomites dating back to 1887 (Coetzee, 2006). Due to the historic nature of mining in the catchment no known available sources of pre-mining water quality have been found for the Wonderfonteinspruit in the catchment area within which the Cooke 1 to 3 shafts are situated.

In order to address the above limitations and considering the dolomitic nature of the reach under investigation the best available data would be the use of the water quality in the dolomitic aquifer associated with the Wonderfonteinspruit in the area under investigation. Accordingly, the Hydrogeological report included in this application provides the necessary data for the non-dewatered Zuurbekom compartment (MvB Consulting, 2020). The report indicates that historically (1970-1979 flow records) the Zuurbekom Compartment made-up approximately 35 ML/day or 51% of the total water volume in the stream, with the remainder made-up of upstream inputs from surface water inputs. The latter component is difficult to estimate in terms of quality but would be expected to not be worse than the dolomitic water quality pre-mining impacts due to the wetland nature of the upper reaches of the Wonderfonteinspruit (Javed, et al., 2019).

The following qualities (Table 6-2) are thus considered an indicative representation of pre-mining qualities, as taken from the averages for three boreholes (Z-ZM6, Z-ZM36 and Z-ZM43) in the Zuurbekom compartment not considered to be impacted by mining for the period of 2018-July 2020 (Figure 6-15). It should be noted that other impacts may have occurred from the surrounding land uses including agriculture and municipal activities.

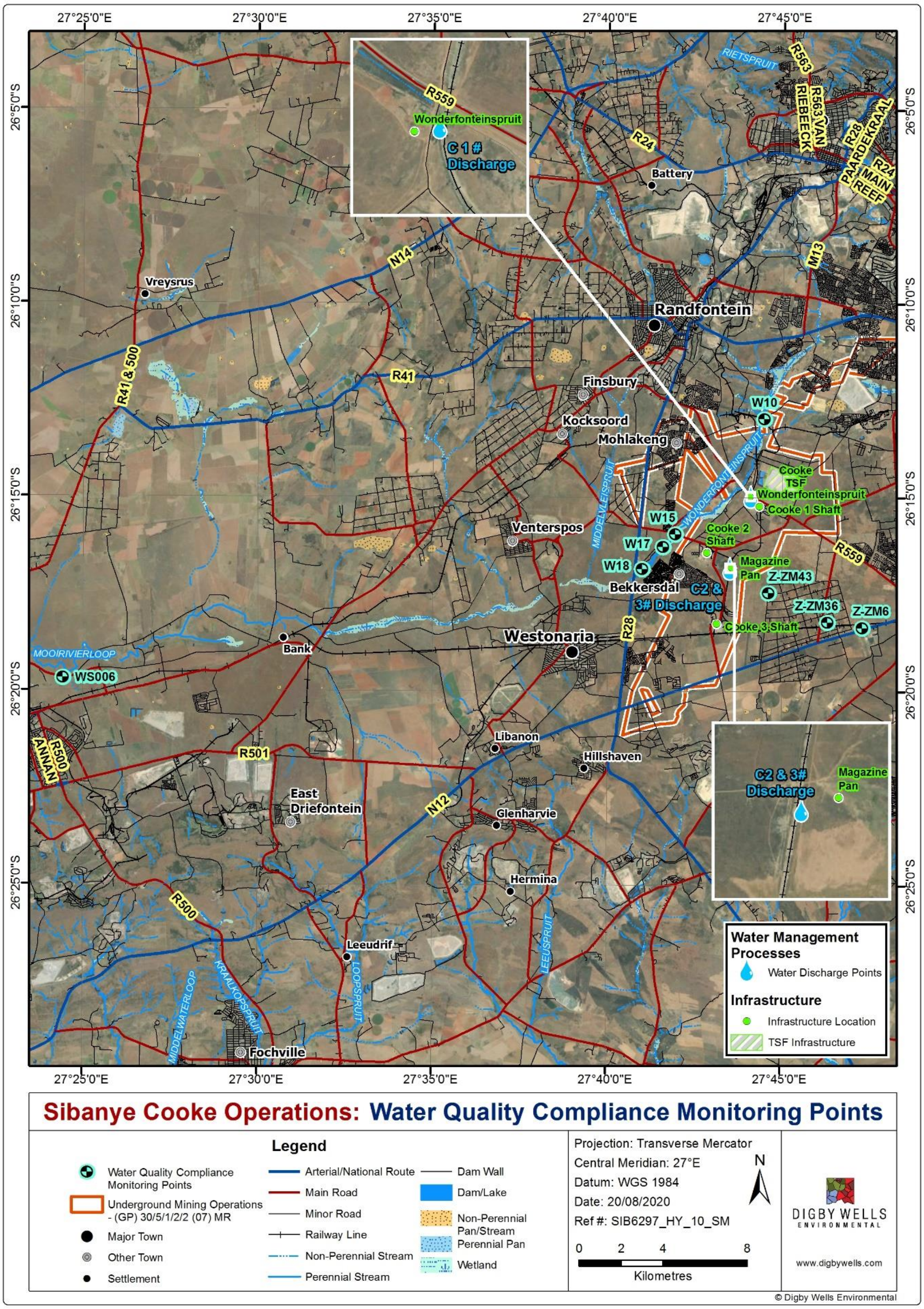

Figure 6-15: Water Quality Compliance Monitoring Points

Table 6-2: Average Water Quality for the Zuurbekom Compartment for Jan 2018 to Jul 2020

Parameter	Unit	Average Quality
Cr	mg/L	0.008
NO_3	mg/L	1.587
PO_4	mg/L	0.319
NH_4	mg/L	0.479
pH	pH	7.983
EC	mS/m	27.828
TDS	mg/L	184.333
SS	mg/L	67.111
Ca	mg/L	27.011
Mg	mg/L	16.333
Na	mg/L	11.444
K	mg/L	1.659
Cl	mg/L	2.243
SO_4	mg/L	14.944
Tot Hard	mg/L	134.683
NH_4 as N	mg/L	0.601
NO_3 as N	mg/L	0.895
PO_4 as P	mg/L	0.193
U	ug/L	4.111
Al	mg/L	0.033
Fe	mg/L	0.352
Cd	mg/L	0.003
Cu	mg/L	0.005
F	mg/L	0.220
Mn	mg/L	0.274
Ni	mg/L	0.015
Pb	mg/L	0.030
B	mg/L	0.009
Zn	mg/L	0.004

6.5.2 Water User Requirements

Water user requirements were based on the local knowledge of water users within the catchment as well as based on available literature reviews, including historical public participation processes as well as Liefferink, et al. (2015). However, before expanding upon the water user requirements it is essential that catchment bounds, or the zone of influence be considered. In this regard the points W17 and WS006 were used to determine the endpoint in terms of the area of influence. The aim is to ensure a 95% compliance to the RQO limits for the Mooi Rivier. As such the following should be considered: nutrients (PO_4 as P and NO_3 as N) are not impacted by mine water discharges, rather these concentrations are decreased due to the discharges, and thus these were excluded from the analyses.

Further refinement of the RQO limits was done to suit the catchment characteristics, with long term known uranium inputs, thus the two different limits were applied:

- SANS 241:2015: 30 ug/L, the limit currently applied in the RQOs was based on the previous potable water limit and has since been updated.
- WUL Discharge Limit: 70 ug/L, which is considered to be protective of the receiving environment and other water user requirements, excluding potable water use, as based on extensive literature reviews ((Charles, et al., 2002), (Van Dam, et al., 2012), (Riethmuller, et al., 2001), (CCME, 2011), (WHO, 2005)).

As presented in Table 6-3, the acceptable end-point from a RQO and drinking water perspective would be WS006, while W17 represents an acceptable end-point in terms of other water uses. It should be noted though that potable water use directly from the catchment is not advisable nor realistic due to the high *E. coli* (and likely other pathogens) in the stream due to untreated and partially treated sewage inputs. Thus, the primary water uses are as follows as informed by local knowledge, observations of mine personnel and specialists on site, literature reviews and aerial imagery:

- Agriculture – largely irrigation for livestock feed as well as watering of livestock, but some food crops are also grown;
- Recreational and religious use – this includes recreational catch-and-release fishing, swimming and baptisms;
- Informal mining – the stream water is often used for the washing of material from illegal mining activities;
- Construction – some small-scale abstraction for construction has been observed.

Based on the above W17 should thus represent an acceptable endpoint in terms of the criteria applied.

Table 6-3: Water Quality Compliance for the project zone of influence in the Wonderfonteinspruit as compared to the RQOs

Monitoring point	Percentage compliance to RQOs (excl. nutrients)	Percentage compliance to RQOs, Uranium limit 30 ug/L	Percentage compliance to RQOs, Uranium limit 70 ug/L
WS006 (outlet of 1m pipeline)	91%	95%	99%
W17 (inlet to 1m pipeline)	81%	82%	96%

6.5.3 Current Water Quality Requirements

Water quality results of the Wonderfonteinspruit monitoring points were benchmarked against the discharge limits that were developed by Sibanye for the protection of downstream water users (Sibanye-Stillwater, 2018) as based on the water user requirements discussed above and the WUL (Licence No.: 03/A21D/AFGJ/2382) for comparison purposes (Table 6-4).

Based on the comparison of the water quality results at Cooke 1 and Cooke 2 discharge points with the WUL requirements, exceedances in EC, TDS, SS, Ca, Na, Cl, SO_4, F, U, Cd, Cu, Mn, Ni and Zn were observed during June 2019 until June 2020 (Table 6-4). However, based on the comparison of the water quality results with proposed limits for the protection of downstream water users, EC, TDS, SO_4, Cu, Mn and Ni were exceeded during the same period within Cooke 1 and Cooke 2 discharge points. Of these parameters, Cu, U and Ni were only slightly exceeded.

A trend analysis was undertaken for the parameters of concern to indicate fluctuations for the duration of the available data period. The parameters of concern at Cooke 1 and Cooke 2 discharge points include Mn, SO4, SS and Fe. Fluctuations of these parameters were observed throughout the monitoring period (Figure 6-16 and Figure 6-17). The results indicate that, on average, the water quality for EC, TDS, SO_4 and Mn at the Cooke 1 discharge point exceeds the proposed limits for the protection of downstream water users, while the same parameters were below the proposed limits for the protection of downstream water users at Cooke 2. These fluctuations are not anticipated to cause significant impacts on downstream water users based on the improving water quality from the most upstream point (W6) to the most downstream point (W18) within the Wonderfonteinspruit as these parameters are below the proposed downstream water quality limits (Figure 6-18). Furthermore, by comparing the water quality at Cooke 1 discharge point and W15, which is the most downstream point after the Cooke 1 discharge, an improvement in water quality is observed. This may be attributed to the dilution of the effluent as it enters the Wonderfonteinspruit.

Based on historical trend analysis, the Sibanye Cooke operations have had a minimal impact on the downstream water users in the Wonderfonteinspruit.

However, it should be noted that the potential impact of effluent discharge into the Magazine Pan on the underlying water table remains unquantified and this should be addressed by the rehabilitation plan for the Magazine Pan.

6.5.4 Post Mining Water Quality

On the basis of the above discussions, the following scenario is expected upon closure:

- An average decrease in the volume discharged to the Wonderfonteinspruit (approximately 19 ML/day) will occur upon the cessation of mining;
- Over time the natural groundwater level will be restored and thus the pre-mining flows will re-establish, which will return approximately 35 ML/day to the Wonderfonteinspruit over time;
- The shallow subsurface and stormwater flows will be re-established due to the removal of surface infrastructure;
- The Magazine Pan will reduce in size due to the cessation of discharge and depending on the rehabilitation requirements will likely become more reminiscent of an unchanelled valley bottom as opposed to an open pan.

These changes to the flow characteristics over the long term, along with the associated expected good quality groundwater after the dolomitic aquifer has recharged will ultimately result in an increase in good quality water into the Wonderfonteinspruit. In turn diluting the currently very high nutrient and manganese content in the stream, with the average concentrations for the period of Jan 2018 to Jul 2020 upstream of the Cooke Operations (monitoring point W10) showing a Phosphate (PO_4 as P) concentration of 2.24 mg/L, Ammonium (NH_4 as N) of 7.46 mg/L, Nitrate (NO_3 as N) of 3.85 mg/L and Manganese of 1.65 mg/L. Furthermore, the salt and metal loads from the current discharge will be dramatically reduced due to its cessation. Despite the ultimate positive outcome of the discharge it should be noted that other water users impacting upon the catchment in the interim in terms of metals, salts, nutrients and pathogens will need to be carefully monitored and managed as the current dilution provided will be temporarily reduced due to the cessation of the Cooke 1 discharge. Currently the dilution results in the following average (same time period as above) improved concentrations downstream of the discharge (W15): Phosphate (PO_4 as P) concentration of 0.93 mg/L, Ammonium (NH_4 as N) of 0.71 mg/L, Nitrate (NO_3 as N) of 2.55 mg/L and Manganese of 0.07 mg/L.

Table 6-4: Average Water Quality at the Cooke 1 and Cooke 2 Shaft Discharge Monitoring Points for the Period June 2019 to June 2020

Parameter	Unit	Rand Uranium WUL Limits	Limit Protective of Downstream Water Users	Cooke1	Cooke 2
pH		5.5-9.5	5.5-9.5	7.98	7.39
Electrical conductivity (EC)	mS/m	115	150	171	127
Total dissolved solids (TDS)	mg/L	750	1080	1288	949
Suspended solids (SS)	mg/L	55	110	61	39
Calcium (Ca)	mg/L	90	250	170	156
Magnesium (Mg)	mg/L	70	75	57	31.5
Potassium (K)	mg/L		20	4	2.6
Sodium (Na)	mg/L	70	180	145	86
Chloride (Cl)	mg/L	50	115	77	34
Sulphate (SO_4)	mg/L	600	675	798	638
Fluoride (F)	mg/L	0.1	1.5	0.2	0.4
Phosphate (PO_4)	mg/L		NA	0	0.098
Nitrate (NO_3)	mg/L			1	0.603
Uranium (U)	mg/L	0.07	0.1	0.093	0.175
Aluminium (Al)	mg/L	0.5	0.5	0.3	0.8
Iron (Fe)	mg/L	0.2	0.5	0.1	0.1
Cadmium (Cd)	mg/L	0.01	0.003	0.003	0.003
Copper (Cu)	mg/L	0.1	0.005	0.006	0.0099
Manganese (Mn)	mg/L	0.1	0.37	0.71	0.20
Nickel (Ni)	mg/L	0.2	0.2	0.2	0.4
Lead (Pb)	mg/L	0.1	0.03	0.03	0.03
Boron (B)	mg/L	0.5	0.5	0.1	0.1
Zinc (Zn)	mg/L	0.08	0.08	0.08	0.26
Total cyanide (T CN)	mg/L	0.5	0.05	0.05	0.05

(pink)	Exceeding WUL
(green)	Exceeding Limit protective of downstream water users

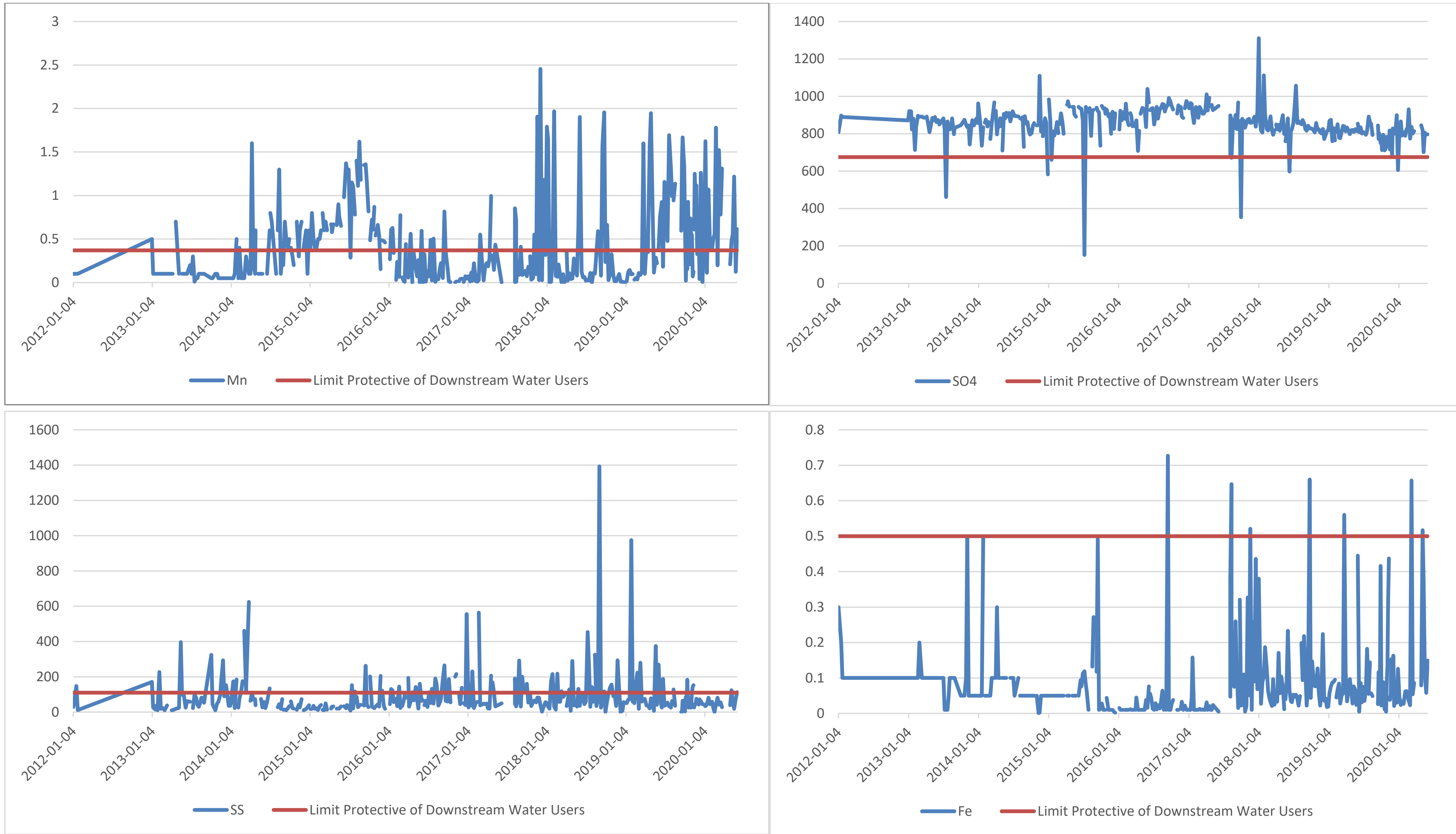

Figure 6-16: Water Quality Trend (January 2012 to June 2020) at Cooke 1 Discharge Point

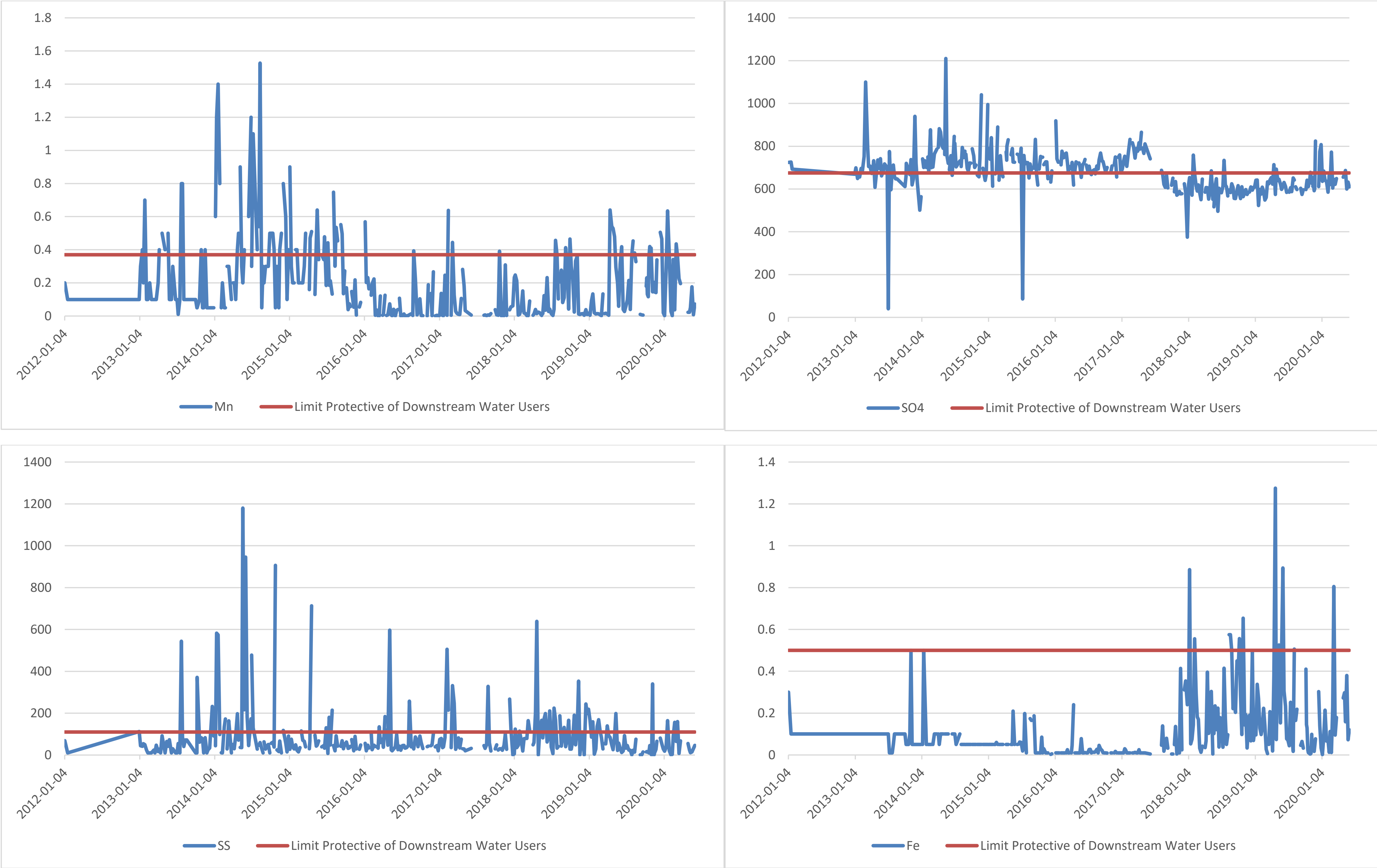

Figure 6-17: Water Quality Trend (January 2012 to June 2020) at Cooke 2 Discharge Point

Figure 6-18: Summarised average water quality trends from upstream to downstream of the Wonderfonteinspruit (January 2012 to June 2020)

7 Impact Assessment

7.1 Decommissioning Phase

Activities, during the Decommissioning Phase (including some rehabilitation) that may have potential impacts on surface water quality and the surface-groundwater interactions within the Cooke Underground Operations, are discussed in this Section (Table 7-1).

Table 7-1: Interactions and Impacts of Activity

Interaction number	Interaction	Impact
1	Removal and decontamination of underground infrastructure containing hydrocarbons and other contaminants from the Cooke 1, 2 and 3 underground workings	Deterioration of water quality of receiving waterbodies caused by hydrocarbon waste and other contaminants if not appropriately managed.
2	Refurbishment of plugs between Cooke 3 and Cooke 4 Shafts, as well as between Cooke 1 and Doornkop Mine	No anticipated impacts on water quality.
3	Potential capping of the shaft barrel below the dolomitic aquifer	Based on the findings of the hydrogeological assessment, the water quality in the shafts is expected to be in line with SANS 241 drinking water guidelines, hence positive impacts (water quality improvement) are envisaged on receiving waterbodies.
4	Decommissioning of surface dams and rehabilitation of dam footprints	1. Disruption of flow paths will likely occur.
5	Decommissioning of surface dams and rehabilitation of dam footprints	2. Water quality deterioration from contaminant residues during demolition of contaminated dams will remain a concern during the decommissioning of surface dams.

Interaction number	Interaction	Impact
6	Removal of settled solids from surface paddocks and mud ponds for processing through the Plant and/or disposal into the Pits	Potential of pollution of soil and adjacent waterbodies during removal due to the disturbance of the settled solids. Furthermore, there may be potential water quality impacts on the mining void where solids are deposited into if the material is of a worse quality as compared to the current material being deposited underground.
7	Decommissioning and rehabilitation of concrete channels	Disruption of flow paths during removal of concrete canals and ripping of soils. Furthermore, the ripping of soils may lead to soil erosion and consequently siltation and sedimentation of adjacent waterbodies. Soil ripping may also mobilize contaminants in contaminated soils due to increased soil permeability.
8		Water quality deterioration will likely occur during demolition of concrete channels.
9	Decommissioning of shaft headgear and surface infrastructure	Water quality deterioration will likely occur during demolition of dirty surface infrastructure and historically impacted areas.
10	Capping of shafts	The restoration of uninterrupted surface flows after covering of mine shafts may be the source of contaminated runoff if not properly managed.
11	Sale of salvageable items	No impacts on water quality.
12	Disposal of waste	Deterioration of water quality in receiving waterbodies if not appropriately managed.

Interaction number	Interaction	Impact
13	Cessation of discharge	The cessation of discharge has the potential to increase oxidation and subsequently the release of metals during rainfall events.

7.1.1 Impact Description: Interaction 1, 5, 8, 9, 10 and 12

The vehicles and machinery used for decommissioning infrastructure at the mine site are potential sources of hydrocarbon and chemical spills and leakages. When not properly managed, hydrocarbon and chemical spills and leakages will contaminate surface water resources within and in proximity to the project area.

Furthermore, the decommissioning of infrastructure may entail excavations which may result in the runoff from these areas containing high amounts of suspended solids as well as dissolved constituents which may result in siltation of receiving waterbodies. Based on the findings of the hydrogeological study, the current groundwater elevations for Cooke shaft 1, 2 and 3 are 1582.03, 1569.26 and 1513.30 mamsl, respectively. Therefore, care should be taken to excavate above the mentioned elevations to minimise contamination of the groundwater resource.

These impacts will lead to the deterioration of water quality, thereby impacting the aquatic life and the downstream water users as well, if not managed appropriately. As pointed out in the hydropedology section, the dominant flow path at the Cooke Shaft Complexes is through the interflow A/B interface, therefore spillages of hydrocarbons and/or contaminated mine residues will be conveyed dominantly through the soil/bedrock interface into the stream.

7.1.2 Impact Description: Interaction 3

A study that was undertaken by SRK Consulting (SRK) investigated the expected mine water quality that could potentially decant once the mine is completely recharged. The water quality of the groundwater samples that were obtained in 2018 showed exceedances of EC, TDS, SO4, Al, Cr, Fe, Mn, Ni, Na and U, when benchmarked against the SANS 241:2015 drinking water quality guidelines (MvB Consulting, 2020). The study then incorporated mixing of underground workings water with the aquifers as an indication of expected water quality in the future with when recharge occurs. The sources of water include Cooke 1, 2 and 3 groundwater and other shaft water, which is characterised by relatively low pH due to high SO_4 content in the host rock. The second source of water is from the dolomitic aquifers characterized by a higher pH due to the dolomitic (carbonate) interaction (MvB Consulting, 2020). The final geochemical modelling results indicate that four years into recharging, the water quality is expected to be in line with the SANS 241: 2015 drinking water quality standards. This may be attributed to the abundant dilution of any seepage entering the aquifers from surrounding non-mineralized sources (MvB Consulting, 2020).

7.1.3 Impact Description: Interaction 4 and 7

The natural surface and water flow paths were destroyed during the construction phase of the dams and concrete channels. These structures caused water to be retained on site (i.e. in the dams) and to be diverted away from downstream watercourses. During decommissioning, the potential impact may be the contamination of receiving waterbodies by residual contaminants from the decommissioning activity if contaminated runoff from these areas is not managed properly. Therefore, when decommissioning surface dams with potentially contaminated residue, the stormwater management infrastructure should remain in place until the decommissioning is completed. Furthermore, for the removal of concrete channels, temporary measures should be put in place to prevent contaminants running off into receiving waterbodies.

Thereafter (after rehabilitation), the restoration of flows into the receiving waterbodies may be achieved, even though the hydrological flow paths may now be altered. This will result in the proximal waterbodies receiving the additional water that had been diverted away by instating the infrastructure.

7.1.4 Impact Description: Interaction 6

The removal of settled solids from surface paddocks and mud ponds for processing through the plant and/or disposal into the pits may pollute soil and adjacent waterbodies as the constituents in these areas contain metal rich sludge. Therefore, there may be potential water quality impacts in the mining void where solids are deposited if appropriate waste classification and handling is not implemented.

7.1.5 Impact Description: Interaction 13

The cessation of discharge has the potential to increase oxidation and subsequently the release of metals during rainfall events. The wetland area between the Cooke 1 discharge point into Wonderfonteinspruit and the monitoring point W15 has likely become a settling area for suspended solids, which include metals. Typically dissolved metals remain in solution and become diluted, thus they are not a major concern, however the suspended solids settle in the wetland and have the potential to remobilise particularly with the change in pH and redox potential, such as may occur due to the cessation of discharge into the Wonderfonteinspruit. Therefore, samples for sediments were collected as part of the proposed Cooke closure and rehabilitation process for an assessment of quality and way forward for mitigation measures and rehabilitation.

7.1.6 Management Objectives

Management objectives during the decommissioning phase are mainly to minimize the potential contamination of receiving waterbodies as a result of hydrocarbon spillages, and hazardous chemical leaks associated with the decommissioning activities and potential historical contamination that may be exposed during the decommissioning and rehabilitation activities. Furthermore, strategic removal of surface infrastructure should be implemented so that potentially contaminated runoff is diverted away from designated clean water areas. This may be achieved by temporarily retaining stormwater infrastructure to divert dirty water from clean areas while the potentially contaminating sources are decommissioned.

7.1.7 Management Actions

The following measures are recommended:

- Restore the topography to end land use requirements as much as is practically possible by backfilling, removing stockpiles and restore the slope gradient and angle of the site;
- Clearing of vegetation should be limited to the decommissioning footprint area and immediate revegetation of cleared areas;
- Decommissioning activities should be prioritized during dry months of the year (May to October) where practical, though disturbed footprints should not be left un-rehabilitated for extended periods of time;
- All leaks and spillages should be cleaned immediately and where the materials need to dry before collection, sufficient time should be allowed for collection and handling by accredited vendors;
- Use of accredited contractors for removal or demolition of infrastructure is recommended; this will reduce the risk of waste generation and accidental spillages;
- The groundwater levels should be taken into account during excavations to minimize potential impact of groundwater quality;
- The constructed stormwater management infrastructure should remain intact until post closure to ensure dirty water is captured and contained during removal of infrastructures;
- Ensure that the infrastructure (pipelines, fuel storage areas, pumps) are first emptied of all residual material before decommissioning;
- Surface inspection should be continuously undertaken to allow runoff to drain onto the natural streams until vegetation has fully established on the site;
- The settled solids removed from surface paddocks and mud ponds for processing through the plant and/or disposal into the pits contain metal rich sludge. Therefore, there may be potential water quality impacts on the mining void where solids are deposited into if appropriate waste classification and handling is not implemented;
- An appointed Environmental Control Officer (ECO) must always be available to ensure implementation of the recommended mitigation/management measures during the planned decommissioning of the project;
- Implementation of the soil management plan is essential for controlling potential contamination of receiving waterbodies as a result of erosion and mobility of potentially contaminated soil. The soil management plan was compiled by Digby Wells (2017). In the soil management report, recommendations are made to i) preserve usable topsoil

by undertaking regular reconciliation of volumes of topsoil stripped, stockpiled and returned to the reshaped landform, ii) ensure soil replacement and amelioration is done effectively by ensuring staff members are trained in the usage of machinery that is used to replace or rip soil and knowing where the various soil types should be replaced and iii) prevention of soil compaction by handling soils when dry and restoring soil fertility. Further recommendations were made for erosion control and monitoring, including growth of indigenous grass (Vetiver) to form a vegetative barrier, drainage controls such as cut-off trenches and culverts, amongst other measures. Additional mitigation measures were proposed to address potential soil compaction, soil contamination, soil fertility and subsidence. It is recommended that the soil management report be reviewed, and recommendations applied accordingly to ensure effective rehabilitation, while minimizing potential impacts on the soil and water resources environment; and

- Rehabilitation of the areas surrounding the Cooke Shafts to ensure that contaminated sediments and or wastewater is not discharged into the Wonderfonteinspruit River, as currently proposed.

7.1.8 Impact Ratings

The following tables rate the impacts for the decommissioning phase:

Table 7-2: Potential Impacts of the Decommissioning Phase for Interaction 1, 5, 8, 9, 10 and 12

Dimension	Rating	Motivation	Significance
Impact: Deterioration of water quality of receiving waterbodies caused by hydrocarbon waste and other contaminants			
Duration	5	The impact will likely occur throughout the decommissioning phase.	84- Moderate (negative)
Intensity	4	Moderate impacts to water quality and ecosystem functionality are expected.	
Spatial scale	3	The impact may extend across the site and to nearby settlements if contaminants are washed into proximal watercourses.	
Probability	7	It is most likely that the impact will occur.	
Post Mitigation			
Duration	5	The impact will likely occur during the decommissioning phase.	18-Negligible (negative)
Intensity	2	With proper management of hydrocarbon and chemicals on site the impact intensity will be low.	

Dimension	Rating	Motivation	Significance
Spatial scale	2	With proper management, the impact will be localised to incident sites, where contaminants will quickly be cleaned up.	
Probability	2	The possibility of the impact occurring is very low if mitigation measures re adequately implemented.	

Table 7-3: Potential Impacts of the Decommissioning Phase for Interaction 3

Dimension	Rating	Motivation	Significance
Impact: Improvement of water quality in the Cooke shaft areas due to recharging the shafts			
Duration	7	Permanent benefits are anticipated once closure and recharge has been undertaken.	90- Moderate (positive)
Intensity	5	On-going and widespread benefits to local communities are anticipated over time.	
Spatial scale	3	The extent of the benefits will extend across the site and to nearby settlements.	
Probability	6	The impact is highly probable.	

Table 7-4: Potential Impacts of the Decommissioning Phase for Interaction 4 and 7

Dimension	Rating	Motivation	Significance
Impact: Alteration of flow paths and water quality deterioration from contaminant residues during demolition of contaminated dams			
Duration	3	The impact will occur during demolition of infrastructure which is not anticipated to be prolonged.	50- Minor (negative)
Intensity	4	Moderate impacts to water quality and ecosystem functionality are expected.	
Spatial scale	3	The impact may extend across the site and to receiving watercourses.	
Probability	5	It is likely that the impact will occur.	
Post Mitigation			

Dimension	Rating	Motivation	Significance
Duration	3	The impact will occur during demolition of infrastructure which is not anticipated to be prolonged.	12- Negligible (negative)
Intensity	2	Intensity is minimal with proper management of potentially contaminated runoff.	
Spatial scale	1	The extent is limited/isolated to specific parts of the site.	
Probability	2	The possibility of the impact occurring is very low if mitigation measures re adequately implemented.	

Table 7-5: Potential Impacts of the Decommissioning Phase for Interaction 6

Dimension	Rating	Motivation	Significance
Impact: The removal of settled solids from surface paddocks and mud ponds for processing through the plant and/or disposal into the pits may cause water quality impacts on the mining void where solids are deposited into			
Duration	6	The impact will most likely carry on even after the metal rich solids are deposited into the mining voids.	60- Minor (negative)
Intensity	4	Moderate impacts to water quality and ecosystem functionality are expected.	
Spatial scale	5	The disposal of metal rich sludge due to poor treatment will result in heavy metals seeping into groundwater and may potentially contaminate the Wonderfonteinspruit, which supports a number of water users.	
Probability	4	It is probable that this impact will occur.	
Post Mitigation			
Duration	1	Limited/negligible duration of impacts if proper treatment takes place before disposal into mine voids.	8- Negligible (negative)
Intensity	2	Intensity is minimal with treatment.	
Spatial scale	1	The extent is limited/isolated to specific parts of the site.	

Dimension	Rating	Motivation	Significance
Probability	2	The impacts are unlikely/improbable post mitigation	

Table 7-6: Potential Impacts of the Decommissioning Phase for Interaction 13

Dimension	Rating	Motivation	Significance
Impact: Release of metals during rainfall events due to the cessation of discharge potentially to increasing oxidation			
Duration	6	The impact will most likely carry on post closure until the natural flows into the Wonderfonteinspruit are restored.	45- Minor (negative)
Intensity	4	Serious, medium-term impacts to water quality and ecosystem functionality are expected.	
Spatial scale	5	The metals released into the stream may potentially contaminate the Wonderfonteinspruit, which supports a number of water users.	
Probability	3	Based on the findings of the sediment analyses, the risk of residual contamination from sediments is low.	
Post Mitigation			
Duration	1	Limited/negligible duration of impacts.	8- Negligible (negative)
Intensity	2	Intensity is minimal.	
Spatial scale	1	The extent is limited/isolated to specific parts of the site.	
Probability	2	The impacts are unlikely/improbable post mitigation	

7.2 Final Rehabilitation and Closure Phase

Activities during the rehabilitation and closure phase that may have potential impacts on surface water quality and the surface-groundwater interactions within the Cooke Operations are discussed in this Section (Table 7-7).

Table 7-7: Interactions and Impacts of Activity

Interaction Number	Interaction	Impact
1	Recharging of underground workings	Based on the findings of the hydrogeological assessment, the water quality in the shafts is expected to be in line with SANS 241 drinking water guidelines, hence positive impacts are envisaged on receiving waterbodies.
2		Positive impacts are envisaged due to the restoration of natural flow into the receiving waterbodies (i.e. the magazine pan wetland and the Wonderfonteinspruit).
3		Furthermore, an improvement in water quality is envisaged from ceased pumping of partially treated effluent into the pan and the Wonderfonteinspruit over the long term once the natural flows are restored in the River. However, in the interim, the discharge has resulted in an improvement in nutrient concentrations in the stream from upstream users discharging nutrients in the Wonderfonteinspruit. Therefore, the upstream contribution in excess nutrients needs to be closely monitored until natural flows are restored.
4	Rehabilitation of surface paddocks and mud ponds	A positive impact on soil and water pollution in the soil environment and nearby waterbodies due to the removal of a potential contamination source.
5	Rehabilitation of Magazine Pan, an artificial pan used for water management	A positive impact is envisaged due to restoration of hydrological processes to sustainable and practically fit-for-purpose conditions.
6	Rehabilitation of infrastructure footprints	Positive impacts are envisaged as this may cause the hydropedological functions of the site to satisfy the needs of interested and affected parties who are beneficiaries of the land and water resources in the area. Furthermore, the potential source of contaminants will be removed, and this will improve water quality.

7.2.1 Impact Description: Interaction 1

The recharging of underground workings is likely to result in improved water quality as the hydrogeological study indicated that the water quality in the Cooke shafts is expected to be uncontaminated based on the SANS 241 drinking water quality guidelines over time (MvB Consulting, 2020).

7.2.2 Impact Description: Interaction 2 and 3

The recharging of Cooke Shaft 3 will allow flow into the magazine pan pre-dominantly through the soil/bedrock interface as water flow will be restored. It is anticipated that the flow volumes into Wonderfonteinspruit will also benefit in the long term through groundwater recharge.

The effluent from Cooke 2 and Cooke 3 will no longer be discharged to the magazine pan and this is expected to improve water quality at the pan. It is envisaged that the magazine pan will be recharged through surface flows from restored landscape and through predominantly the soil/bedrock interface as a result of the observed shallow groundwater and surface water interactions within the Cooke Complexes. Although the magazine pan is likely to reduce in size, the rehabilitation will likely cause close to pre-mining conditions in the pa over time and the post mine land users will benefit from the magazine pan functionality.

7.2.3 Impact Description: Interaction 4, 5 and 6

Recharging of Cooke 1 and Cooke 2 will also cause the groundwater levels in the aquifers to recover and feed into the Wonderfonteinspruit over time. Furthermore, the rehabilitation of surface infrastructure footprints will result in surface runoff draining into the Wonderfonteinspruit, although the natural flow paths will now be altered. Care should be taken to minimize erosion during the establishment of vegetation within rehabilitated areas.

7.2.4 Management Objectives

The main objectives during the rehabilitation and closure phase is to ensure that the rehabilitated area is left in a condition best suited for the intended land use post mining and ensuring that closure is done in an environmentally sustainable manner, with minimal pollution during closure and restoring ecosystem services as much as possible. Furthermore, the aim is to prevent any contamination even after the associated mining activities have ceased.

7.2.5 Management Actions

The following measures are recommended:

- The rehabilitation plan should take into account the impact of the changes in flow paths that is anticipated for the Magazine Pan to preserve the wetland area and the associated ecological functioning of the pan;
- The post mining land use has been identified as agriculture and biofuel energy production. It is recommended that soil contamination testing be undertaken prior to any agricultural developments to ensure that the soil is free of any heavy metals or mine contaminants that may adversely impact on the crop yield; and
- Ongoing monitoring of surface and groundwater for early detection of any deviations from the RQO's of the catchment area assess the effectiveness of the rehabilitation plan.

7.2.6 Impact Ratings

The following tables rate the impacts for the rehabilitation and closure phase:

Table 7-8: Potential Impacts of the Rehabilitation and Closure Phase of Interaction 1

Dimension	Rating	Motivation	Significance
Impact: Potential for groundwater contamination and pollution plumes due to the recharging of underground workings			
Duration	6	The impacts would occur for some time post closure.	26- Negligible (negative)
Intensity	2	The intensity of decant would be minimal as the water quality is considered to be of acceptable quality as the findings of the hydrogeology report indicated that the decant is expected to be of acceptable quality in comparison to the SANS drinking standards over time.	
Spatial scale	5	Impacts would extend beyond the project boundary and impact on the local communities and receiving waterbodies.	
Probability	2	It is unlikely that decant will occur as the shaft barrels are concrete lined.	
Post Mitigation			
Duration	6	The impacts would occur for some time post closure.	13- Negligible (negative)
Intensity	2	Minimal impacts are envisaged.	
Spatial scale	5	The spatial scale remains the same post mitigation.	
Probability	1	It is unlikely that decant will occur.	

Table 7-9: Potential Impacts of the Rehabilitation and Closure Phase of Interaction 2

Dimension	Rating	Motivation	Significance
Impact: Restoration of natural flow into the receiving waterbodies due to recharging of underground workings			
Duration	7	The recharging of underground workings is expected to cause the groundwater aquifer to recover over time and eventually cause groundwater recharge into the Wonderfonteinspruit. Furthermore, the rehabilitation of the magazine pan is anticipated to restore natural flows into the pan, in addition to potential baseflow contributions from recharging the upstream Cooke 3 shaft area.	84- Moderate (positive)
Intensity	4	The impacts may take some time to be evident but will be ongoing after the initial benefits of recharging are realized.	
Spatial scale	3	Local impacts are envisaged.	
Probability	6	The natural flows into the receiving waterbodies is highly probable.	

Table 7-10: Potential Impacts of the Rehabilitation and Closure Phase of Interaction 3

Dimension	Rating	Motivation	Significance
Impact: Improved water quality from ceasing pumping effluent into environment			
Duration	7	Mine effluent will no longer be discharged into the magazine pan and Wonderfonteinspruit post closure.	78- Moderate (positive)
Intensity	3	Average, ongoing benefits are anticipated.	
Spatial scale	3	The discharge of mine effluent had minimal impact on the Wonderfonteinspruit hence the improved water quality is envisaged to be within the project area.	
Probability	6	The improvement in water quality is highly probable.	

Table 7-11: Potential Impacts of the Rehabilitation and Closure Phase of Interaction 4, 5 and 6

Dimension	Rating	Motivation	Significance
Impact: Rehabilitation of surface infrastructure, dams and surface paddocks will restore the environment to the best suitable post mining land use			
Duration	7	Permanent benefits are anticipated once rehabilitation has been undertaken.	78- Moderate (positive)
Intensity	4	Moderate benefits are anticipated over time.	
Spatial scale	2	The extent of the benefits will be limited to the rehabilitated areas.	
Probability	6	The impact is highly probable.	

7.3 Cumulative Impacts

The approach undertaken by Sibanye in developing site-specific long-term objectives represent both upstream and downstream potential impacts on the Wonderfonteinspruit catchment. Upstream water users include industrial activities, municipal sewage and Lancester dam which is a potential seepage source. Activities associated with Cooke Operations include Luipaardsvlei dam (upstream of Cooke 1 shaft), associated mining activities, seepage areas, point source discharge from Cooke 1. Downstream of the Cooke Operations includes Donaldson Dam, the 1 m pipeline, recreational activities, agricultural activities and treated and untreated sewage and untreated runoff from residential areas.

By comparing the water quality monitoring network established by Sibanye in the Wonderfonteinspruit, the influence of the identified water users is captured. W6 is the most upstream water quality monitoring point, while W18 is the most downstream point. Based on the water quality assessment, the potential impacts of Sibanye's activities were minimal based on comparing the water being discharged into the Wonderfonteinspruit and the immediate downstream point (W15). Furthermore, W15 represents the downstream of all upstream water quality uses and hence the cumulative impact at this point.

Therefore, the overall impact of the proposed rehabilitation and closure of the Cooke operations is envisaged to have an overall positive cumulative impact within the Wonderfonteinspruit catchment. The cessation of the discharge of partially treated mine effluent into the Wonderfonteinspruit is expected to further improve water quality at W15 and further downstream of the Wonderfonteinspruit. However, ongoing surface and groundwater monitoring remain indispensable to ensure that the expected results are realised.

8 Environmental Management Plan

This section provides a summary of the proposed project activities, environmental aspects and impacts on the receiving surface waterbodies. The frequency of mitigation, timing of implementation, the roles and responsibilities of persons implementing the EMP are summarized (Table 8-1).

Table 8-1: Environmental Management Plan

Activities	Potential Impacts	Aspects Affected	Phase	Mitigation Measure	Mitigation Type	Time period for implementation
Decommissioning and removal of infrastructure	Contamination of receiving waterbodies	Surface Water	Decommissioning phase	• Restore the topography to pre-mining conditions as much as is practically possible by backfilling, removing stockpiles and restore the slope gradient and angle of the site; • Immediate revegetation of cleared areas is recommended; • Decommissioning activities should be prioritized during dry months of the year (May to October) where practical; • All leaks and spillages should be cleaned as soon as possible and disposed of by accredited vendors; • Use of accredited contractors for removal or demolition of infrastructure is recommended; this will reduce the risk of waste generation and accidental spillages; • The constructed stormwater management infrastructure should remain intact until post closure to ensure dirty water is captured and contained during removal of infrastructures; • Ensure that the infrastructure (pipelines, fuel storage areas, pumps) are first emptied of all residual material before decommissioning; • Surface inspection should be continuously undertaken to allow runoff to drain onto the natural streams until vegetation has fully established on the site; • The settled solids removed from surface paddocks and mud ponds for processing through the plant and/or disposal into the pits contain metal rich sludge. Therefore, there may be potential water quality impacts on the mining void where solids are deposited into if appropriate waste classification and handling are not implemented; and • An appointed Environmental Control Officer (ECO) must always be available to ensure implementation of the recommended mitigation/management measures during the planned decommissioning of the project.	Storm water management: Control contamination of receiving waterbodies by consideration of potential contamination sources and strategic decommissioning to minimize potential environmental impacts	During the decommissioning phase
Recharging of underground workings	Drying up of parts of the magazine pan	Magazine pan	Post closure	• The rehabilitation plan should take into account the impact of the changes in flow paths that is anticipated for the Magazine pan to preserve the wetland area and the associated ecological functioning of the pan	Restoration of flow paths close to natural conditions, if possible: Monitoring of the rehabilitation efforts post closure	Post closure

9 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. Currently, Sibanye has an extensive surface and groundwater monitoring program. It is recommended that this monitoring programme continues for a period of approximately 3-5 years post closure to ascertain the effectiveness of the rehabilitation and to detect any potential unforeseen concerns for downstream water users, depending on the results the frequency can be revised, however the groundwater recharging rates must be taken into consideration.

Table 9-1: Surface Water Monitoring Plan for the Decommissioning and Closure of the Cooke Shaft Operations

Monitoring Element	Comment	Frequency	Responsibility
Water quality	The existing water quality monitoring plan at Sibanye is deemed as sufficient with regards to the parameters monitored and coverage of the monitoring network.	Monthly monitoring during decommissioning and for at least three (3) years after closure, or until rehabilitation has reached a sustainable state with no further changes.	Environmental Officer
Water quantity	The recovery of the magazine pan should be monitored to better understand the significance of the potential drying up of portions of the pan due to cessation of discharge of mine effluent into the pan	Monthly monitoring post closure	Environmental Officer
Soil Monitoring	The required soil monitoring post closure includes soil erosion, compaction and pollution. Furthermore, vegetation establishment and dust generation should also be monitored.	Monthly monitoring during decommissioning and post closure until vegetation establishment in rehabilitated areas.	Environmental Officer

10 Recommendations

The following recommendations are made for the study:

- Ongoing water quality monitoring of surface and groundwater monitoring is imperative during the decommissioning, rehabilitation and post closure phases to allow for early detection of potential contaminants that may cause unforeseen negative impacts on the receiving environment;
- It is recommended that the proposed management actions in this study be implemented during the decommissioning and closure to ensure that the identified risks are mitigated, and the anticipated positive impacts of the projects post closure are realised;
- It is further emphasized that the rehabilitation plan of the magazine pan be developed by reprofiling the terrain close to natural drainage conditions and consider the potential impacts of the reduction of wetland area due to ceased pumping of partially treated mine effluent into the pan;
- It is recommended that the recommendations made in the soil management plan (Digby Wells Environmental, 2017) be revisited and implemented during rehabilitation and post closure to ensure minimal soil contamination, preservation of land capability and to maximise on the benefits of post mining land use;
- Care should be exercised to ensure that no disruptions of flow paths occur during the decommissioning and rehabilitation processes, with guidance from the identified hydrological responses at specific sites as described in the hydropedological Section 6.4; and
- Despite the ultimate positive outcome of the discharge it should be noted that other water users impacting upon the catchment in the interim in terms of metals, salts, nutrients and pathogens will need to be carefully monitored and managed as the current dilution provided will be temporarily reduced due to the cessation of the Cooke 1 discharge.

11 Reasoned Opinion Whether Project Should Proceed

Based on the impact assessment, mitigation measures and recommendations proposed it is the opinion of the specialist that the project should proceed. It is anticipated that the potential positive impacts would outweigh negative impacts in the long term and thus the associated closure activities would ultimately be beneficial for the receiving environment in the long term.

12 Conclusions

The proposed decommissioning activities may have impacts on the water regime and flow paths within the Cooke shaft areas. Therefore, the proposed mitigation measures should be implemented to minimize negative impacts on receiving waterbodies. The potential impacts associated with decommissioning pertain to contamination of receiving waterbodies due to spillages and leaks of hydrocarbons and potentially contaminated residue in the infrastructure to be decommissioned. This impact may be controlled most effectively by keeping the storm water infrastructure in place while decommissioning potential sources of contaminants and by prioritizing decommissioning during the low rainfall or dry periods (i.e. between May to October).

The recharging of underground workings is anticipated to result in positive impacts with regards to improved water quality being released into the Wonderfonteinspruit. Furthermore, water quantity flowing into the Wonderfonteinspruit is anticipated to increase over time. Additionally, reprofiling the landscape during rehabilitation will allow close to natural flows in the pan which will benefit the pan.

The implementation of the proposed project description, along with the recommended mitigation measures will provide positive impacts within the Cooke shafts project area and receiving waterbodies over the long term. Ongoing monitoring of surface and groundwater is necessary during decommissioning and three to five years post closure in order to effectively monitor the envisaged impacts of the proposed activities.

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Appendix A: Impact Assessment Methodology

1.1 Impact Assessment Methodology

To clarify the purpose and limitations of the impact assessment methodology, it is necessary to address the issue of subjectivity in the assessment of the significance of environmental impacts. Even though Digby Wells, and the majority of environmental impact assessment practitioners, propose a numerical methodology for impact assessments, one has to accept that the process of environmental significance determination is inherently subjective.

The weight assigned to each factor of a potential impact, and also the design of the rating process itself, is based on the values and perception of risk of members of the assessment team, as well as that of the I&AP's and authorities who provide input into the process. Whereas the determination of the spatial scale and the duration of impacts are to some extent amenable to scientific enquiry, the severity value assigned to impacts is highly dependent on the perceptions and values of all involved.

It is for this reason that it is crucial that all EIAs make reference to the environmental and socio-economic context of the proposed activity to reach an acceptable rating of the significance of impacts. Similarly, the perception of the probability of an impact occurring is dependent on perceptions, aversion to risk and availability of information.

It has to be stressed that the purpose of the EIA process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. The methodology employed for the environmental impact assessment is divided into two distinct phases, namely, impact identification and impact rating.

1.1.1 Impact Rating

The impact assessment methodology utilised during the EIA Phase for the Project consists of two phases namely impact identification and impact significance rating.

Impacts and risks have been identified based on a description of the activities to be undertaken. Once impacts were identified, a numerical environmental significance rating process was undertaken that utilises the probability of an event occurring and the severity of the impact as factors to determine the significance of a particular environmental risk.

The severity of an impact is determined by taking the spatial extent, the duration and the severity of the impacts into consideration. The probability of an impact is then determined by the frequency at which the activity takes place or is likely to take place and by how often the type of impact in question has taken place in similar circumstances.

Following the identification and significance ratings of potential impacts, mitigation and management measures were incorporated into the EMP.

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 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 EIA/EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 2. The description of the significance ratings is discussed in Table 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 1: Impact Assessment Parameter Ratings

Rating	Intensity/Replaceability		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.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
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.	<u>Province/ Region</u> 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.	<u>Municipal Area</u> 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.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
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.
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.

Rating	Intensity/Replaceability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	**Positive Impacts (Nature = +1)**			
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 2: Probability/Consequence Matrix

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

Consequence

Table 3: Significance Rating Description[1]

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) (-)

[1] It is generally sufficient to only monitor impacts that are rated as negligible or minor