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ENVIRONMENTAL

Environmental Regulatory Process Required to Amend and Consolidate the Mooikraal Colliery Environmental Management Programme Report, Sasolburg, Free State

Surface Water Assessment

Project Number:

SAS5175

Prepared for:

Sasol Mining (Pty) Ltd

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EXECUTIVE SUMMARY

Sasol Mining (Pty) Ltd (hereafter Sasol Mining) owns and operates the Sigma Colliery which consists of two operational components, Sigma Colliery: Mooikraal (hereafter referred to as Mooikraal) and Sigma Colliery: 3 Shaft (hereafter referred to as 3 Shaft).

Digby Wells Environmental (Pty) Ltd (hereafter Digby Wells) was appointed by Sasol Mining Mooikraal to undertake a surface water assessment to determine the baseline hydrology, water quality description, floodlines determination and impact assessment for Sasol Mining, Sigma Colliery.

Baseline Hydrology

The Mooikraal and 3 Shaft region is characterised by moderate to high rainfall with the Mean Annual Precipitation (MAP) ranging from 619 mm to 644 mm. Annual average runoff depth is moderate ranging between 35.5 mm and 57.28 mm. On an average basis high evaporative losses of 1650 mm, are experienced annually.

Normal rainfall (90% of events) for the wettest month of January will likely not exceed 56 mm. Extreme rainfall (10% of events) for January will likely not exceed 171 mm. Normal runoff depth during the wettest month (January) will likely not exceed 1.1 mm. Runoff resulting from extreme events in January will likely not exceed 33.4 mm.

Floodlines

The 1:50-year and 1:100-year floodlines for the area which Mooikraal and 3 Shaft occupy includes the pipelines and conveyor belt. Hydraulic modelling for sections of the Kromelmboogspruit, Leeuspruit and their tributaries was undertaken.

No infrastructure is within the 1:100-year floodline at Mooikraal. The existing Primary Plant at 3 Shaft falls within the 1:100-year floodline on the Leeuspruit tributary. The proposed relocation of the primary plant infrastructure should consider the demarcated flood extent in order to avoid inundation of the proposed primary plant and crusher facilities.

The modelled floodlines are for indicative purposes only, and not meant for any engineering designs. They should be used as a general indication of infrastructure placement, if new mining infrastructure is to be constructed at both the Mooikraal and 3 Shaft sites.

Water Quality

A water quality assessment was conducted for the Kromelmboogspruit, Dirty Water Dams or PCDS and the Sewage Treatment Plant (STP) at Mooikraal, the Leeuspruit tributary and PCD at 3 Shaft and benchmarked against the Water Use License (WUL) limits (Number: 08/C22K/CIGJFAE/6981).

Kromelmboogspruit

Surface water quality upstream (KROM/S) and downstream (KROM/N) of Mooikraal on the Kromelmboogspruit is within the WUL standard limits.

Mooikraal Dirty Water Dams (Sump, South & North PCDs)

The water quality in dirty water dams (South & North PCDs) at Mooikraal reflects a strong sodium bicarbonate character typical of the underlying geology (rich in sodium). The water from the Mooikraal Adit Sump has a more calcium-magnesium bicarbonate character. A sharp increase in total alkalinity occurred in 2010 which later levelled off at values just below 400mg/l.

Sewage Treatment Plant (STP)

The quality of treated effluent from the STP is monitored at Mooikraal as required by the WUL (License No. 08/C22K/CIGJFAE/6981). EC, pH, TSS, PO_4, Faecal Coliform and E. Coli are generally within acceptable WUL limits during the monitoring period from January 2018 to February 2019. Elevated NO_3 above the WUL limit of 15 mg/L is indicated for most of the monitoring period with a marked drop in February 2019 to below the WUL limit. Ammonia levels are generally within the acceptable WUL limit (6 mg/L) except for samples collected on the 17th of April 2018 and 2nd of February 2019 where slight increases are observed. For almost the whole monitoring period from January to February 2019, Cl levels exceeded the stringent WUL standard limit of 0.25 mg/L.

3 Shaft

Trend analysis for electrical conductivity (EC), pH, SO_4 and chloride (Cl) sourced from the bi-annual IGS report (IGS, 2018) leads to the following conclusions on the Leeuspruit water quality:

- SO_4 levels both upstream and downstream of 3 Shaft are within the WUL acceptable limit of 200 mg/L. Point SIG/5 upstream of 3 Shaft has lower SO_4 concentration than the downstream point (SIG/6) indicating some contamination from activities at the existing 3 Shaft Plant and Crusher.
- Cl and EC are generally within the WUL acceptable limits for all monitoring points at least from 2007 to 2018.
- All other parameters analysed and compared against WUL limits in January 2018 are within acceptable WUL ranges excluding sodium (Na), manganese (Mn), nitrate (NO_3), phosphate (PO_4), total suspended solids (TSS), Faecal Coliform and E. Coli.
- Farming activities including use of pesticides and fertilisers in agricultural fields around the Leeuspruit drainage are possible sources of NO_3, PO_4, and TSS in addition to sediments washed-off by runoff at 3 Shaft;
- Faecal coliform, E Coli exceed WUL limits within the Leeuspruit tributary which can be explained by contamination from regular municipal sewage overflows upstream of 3 Shaft.
- Although the Leeuspruit is perennial, flow volumes and rates are generally low with high flows generally associated with high rainfall events. High runoff can cause the increase in TSS observed in the January results that represent a wet season survey; and

- Mn and Na are naturally occurring elements that are enriched in the soils and geology of the area which is the source of these contaminants (IGS, 2018);

Water Balance

The water balance shows that runoff from dirty areas is captured in the South and North PCDs (MK dirty water dams). The dust suppression volume for Mooikraal is indicated to be 964 569 m3/annum while that for 3 Shaft is indicated to be 493 339 m^3/annum constituting groundwater from the OG3 and Old 66 pits and rainfall. A treated sewage effluent volume of 25 000 m^3/annum from the Sewage Treatment Plant (STP) (Aerator and Cl2 Tank) is discharged to the natural environment.

The total dust suppression volume of 1 457 908 m^3/annum for Mooikraal and 3 Shaft falls within the WUL limit of 7 440 000 m^3/annum. The volume of treated effluent (25 000 m^3/annum) that is discharged to the natural environment complies with the 30 000 m^3/annum stipulated by the WUL requirements.

Surface Water Impact Assessment

Identified potential surface water impacts include the following:

Construction Phase

- Sedimentation and siltation of nearby watercourses that may lead to deteriorated water quality. This impact will result from the washing away of disturbed soils during relocation of the existing 3 Shaft Primary Plant and Crusher, conveyor belts, and coal bunker and during the upgrading of the storm water infrastructure at 3 Shaft.
- Deterioration of surface water quality from contamination by hydrocarbons such as oils and fuels which are washed off into the Leeuspruit tributary.
- Flood attenuation and contribution to base flow by rehabilitated wetland at 3 Shaft will lead to naturalised flow regimes and ecosystem support within the Leeuspruit. This constitutes a positive impact of the rehabilitation process to the environment.

Operational Phase

- Deterioration of surface water quality from contamination by hydrocarbon materials (oils, fuels and diesel). Contaminants emanate from the handling of the hydrocarbons during maintenance of pipelines and conveyors and during general mine operations at both Mooikraal and 3 Shaft.
- Water quality deterioration from contaminated runoff. Runoff from dirty areas at 3 Shaft (plant, crusher and stockpile areas) and at Mooikraal (Waste storage area, South & North PCDs, hydrocarbon waste storage areas such as the bulk hydraulic oil and diesel storage area, shaft and workshop areas) will be dirty with considerable levels of contaminants.
- Surface water contamination due to spillage of mine water from transfer pipelines (the 5 and 10 Ml/day pipeline within the conveyor belt servitude) and coal spillages under the MK 1 and 2 belts, as well as at the drive houses/ transfer points along the

MK 3 – 8 belt series during the operational phase. Such spillage may occur not only from damage to the pipelines but also due to lack of maintenance resulting in leaks at the flanges or connecting points.

- Surface water contamination from spillage of sewage effluent from the Sewage Treatment Plant (STP) or discharge of partially treated effluent into the natural environment. The spillages may occur due to damaged or poorly maintained infrastructure at the mine site. Discharges of contaminated effluent not treated to acceptable levels may also result in the contamination of surface water resources. Sewage polluted water promote algal growth and increase biological oxygen demand resulting in the death of aquatic life, including fish.
- The waste rock dump at Mooikraal is a potential source of contamination; once material is exposed to oxygen and rainfall, leachate generating reaction may occur and introduce contamination into the groundwater environment via seepage. Total concentration analysis identified Barium and Copper as potential elements of concern however these results are a worst case scenario. Leachable concentration analysis, which is the most representative of the expected leachate at the site, shows no concern within regards to the leachate expected to emanate from the dump.

Decommissioning/Closure Phase

- Sedimentation and siltation of watercourses that lead to deteriorated water quality. Disturbance of soils during demolition and removal of infrastructure at both Mooikraal and 3 Shaft will result in generation of sediment that will report to the Kromelmboogspruit and Leeuspruit and their tributaries.
- Surface water contamination that leads to deteriorated water quality due to hydrocarbon waste. Oils, fuels and grease spills during demolition and transportation of material from decommissioned infrastructure at both Mooikraal and 3 Shaft may be washed into the Kromelmboogspruit and Leeuspruit Rivers and their tributaries.
- Potential surface water pollution from possible decant of contaminated groundwater is envisaged from mine shaft, ventilation shaft and boreholes. The groundwater model outcome, however, predicts a very low probability of decant at the Mooikraal-3 Shaft area (IGS, 2018).

Recommendations

Construction Phase

The modelled floodlines are for indicative purposes only, and not meant for any engineering designs. They should be used as a general indication of infrastructure placement, if new mining infrastructure is to be constructed at both the Mooikraal and 3 Shaft sites.

The storm water management plan at 3 Shaft Colliery should be implemented to include the proposed relocation of the Primary Plant and Crusher facilities as per the DWS GN704 regulation. Construction should be undertaken during the dry winter period to reduce sedimentation in the Leeuspruit tributary since there will be minimal to no occurrence of rainfall. Site preparation for the proposed 3 Shaft Primary Plant and Crusher should be confined to the existing 3 Shaft footprint area to minimise disturbance of soils and the probability of sedimentation and siltation of the Leeuspruit tributary.

All storage areas for oils, fuels, paints and other chemicals should be appropriately bunded and spill kits should be in place, construction workers should be trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills during the construction.

Water quality monitoring 3 Shaft should continue fortnightly upstream (SG/5 and SG/6) and downstream of 3 Shaft on the Leeuspruit tributary during the construction of the primary plant and crusher.

Operation Phase

The clean-up and rehabilitation after spillages of coal at the overland conveyor transfer points/drive houses to 3 Shaft and the MK2 conveyor belt to the Silo at Mooikraal should be conducted immediately and appropriately managed to control the spread of the impact to the external environment.

All mine infrastructure (PCDs, Sewage Treatment Plant, Pipelines, conveyor belts) must be put onto a planned maintenance system to ensure that regular inspections and maintenance is undertaken to prevent spillages at both Mooikraal and 3 Shaft.

The storm water management infrastructure at 3 Shaft should be upgraded to include the proposed new Primary Plant and Crusher, and conveyor belt facilities so that dirty water from these areas is contained within the mine for re-use. Construction of the proposed cut-off trenches at the Stockpile area should be implemented to separate dirty runoff from the clean environment; and

Constant monitoring of PCD volumes should be undertaken in order to detect any rise in water levels that may lead to overflows. This is necessary, especially during rainfall events, to ensure that any extra water is quickly transferred through the already installed pipelines away from the PCDs for re-use before any overflows can occur.

STP infrastructure should regularly be checked and maintained to reduce chances of leakages of contaminated effluent into the natural environment.

Monitoring of treated sewage effluent quality should continue to ensure that all discharges into the Kromelmboogspruit are within acceptable WUL limits.

The waste rock dump should be maintained with slopes that reduce pooling of water, to reduce the amount of leachate generation. Stormwater management must be placed around the facility to ensure dirty water is contained.

Decommissioning/Closure Phase

Use of accredited contractors for demolition and removal of infrastructure during the decommissioning and closure phase should be considered to reduce the risk of waste generation and accidental spillages. Rehabilitated areas must be re-vegetated and stabilised to minimise sedimentation of nearby watercourses.

Landscape re-profiling must be undertaken on rehabilitated land to allow good drainage. This will ensure improvement of catchment runoff yield close to pre-mining conditions in the surrounding Kromelmboogspruit and Leeuspruit watercourses.

The storm water management plan at 3 Shaft should be implemented to include the proposed relocation of the Primary Plant and Crusher facilities as per the DWS GN704 guidelines. Site preparation for the proposed 3 Shaft Primary Plant and Crusher should be confined to the existing 3 Shaft footprint to minimise disturbance of soils and reduce the probability of sedimentation and siltation of the Leeuspruit tributary. Proposed cut-off trenches at the stockpile area should be implemented to separate dirty runoff from the stockpile from the surrounding clean environment.

The possibility of contaminated water decant can be reduced by sealing-off mine shafts and boreholes with cement and plugging them with concrete.

Monthly water quality monitoring should continue 3 years after decommissioning at both Mooikraal and 3 Shaft as per Department of Water and Sanitation (DWS) requirements.

Monitoring Programme

Surface water monitoring should continue at Mooikraal (Upstream and Downstream of Mooikraal Colliery on Kromelmboogspruit; in all dirty water dams & sumps and at the discharge point of treated sewage effluent from the STP) and at 3 Shaft (Upstream and Downstream of 3 Shaft on Leeuspruit tributary and in the 3 Shaft dirty water dam or PCD). Monitoring should be conducted fortnightly during the construction phase, monthly during the operation phase and monthly for 3 years after mine decommissioning/closure. All water quality results should be benchmarked to the Mooikraal WUL (No. 08/C22K/CIGJFAE/6981) to determine any impact on the quality of water (positive/negative). Parameters to be monitored as given in the WUL are indicated below:

Parameters	Unit	WUL RQO
pH	pH unit	5.5 - 9.5
Electrical conductivity (EC)	mS/m	150
Sulphate (SO_4)	mg/l	200
Chloride (Cl)	mg/l	150
Sodium (Na)	mg/l	100
Magnesium (Mg)	mg/l	80
Calcium (Ca)	mg/l	50
Total Suspended Solids (TSS)	mg/l	25
Nitrate (NO3)	mg/l	40

Dissolved Oxygen (DO)	mg/l	8
Chemical Oxygen Demand (COD)	mg/l	75
E Coli	CFU/100ml	0
Faecal Coliform	CFU/100ml	1000

Continued monitoring of site-specific rainfall at Mooikraal – 3 Shaft is recommended to ensure maintenance of accurate direct rainfall input for the water balance.

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1 Introduction

Sasol Mining (Pty) Ltd (hereafter Sasol Mining) owns and operates the Sigma Colliery which consists of two operational components, Sigma Colliery: Mooikraal (hereafter referred to as Mooikraal) and Sigma Colliery: 3 Shaft (hereafter referred to as 3 Shaft).

Digby Wells Environmental (Pty) Ltd (hereafter Digby Wells) was appointed by Sasol Mining Mooikraal to undertake a surface water assessment to determine the baseline hydrology, water quality description, floodlines determination and impact assessment for Sasol Mining, Sigma Colliery.

Mooikraal is an underground coal mine located near Sasolburg. It currently operates under a consolidated Mining Right (Reference No. FS 30/5/1/2/2/2/1/221) and approved amended Environmental Management Programme (EMPr) (Reference No. 30/5/1/2/3/2/1 (221) EM) granted in April 2016. The authorisation permits the undertaking of various activities associated with the underground coal mining operation. Mooikraal also holds a separate approved EA (Reference No. EMB/28/14/43 dated 09 March 2015) for a 10 and 7 Mega litre per day (Ml/day) water transfer pipelines. The 7 Ml/day pipeline authorises the transport of water from the Kleinvlei Ventilation Shaft and the 10 Ml/day pipeline is authorised to transport water from the Mooikraal pollution control dam to Sasolburg Operations.

Mooikraal is now proposing to reconfigure and relocate the conveyer belt series and existing crusher facility currently located at the 3 Shaft primary plant area. In addition Mooikraal also wishes to amend and consolidate the approved Mooikraal EMPr to include all activities and properties associated with the proposed operations, as detailed in Section 5 below. An environmental regulatory process is thus required to obtain the necessary EA.

Through this environmental authorisation process, it is intended that the following will be undertaken:

- Listed Activities now triggered in terms of the Environmental Impact Assessment (EIA) Regulations 2014 (as amended) (Government Notice No. R. 982 of 4 December 2014 as amended by Government Notice No. R.326 of 7 April 2017) referred to hereinafter as the EIA regulations, 2014 (as amended) promulgated under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) be applied for; and
- Incorporate all activities at Mooikraal and 3 Shaft operations into amended EMPr so as to ensure that all activities are lawfully executed.

The triggering of listing activities, amendment and consolidation of the EMPr constitutes a Basic Assessment and Regulation 31 Amendment Process in terms of the EIA Regulations, 2014 (as amended). This will be undertaken as a consolidated process.

Further details pertaining to the new proposed activities and those to be incorporated, through this application is discussed below:

Table 1-1: Summary of Activities under Application

Basic Assessment Process Activities	Regulation 31 Amendment Activities
▪ Demolition activities at 3 Shaft which includes the demolition of the existing conveyor belt, crushing facility and coal bunker which is currently situated within a wetland; ▪ Relocation/reconstruction of the primary crusher on the coal stockpile area outside of the wetland at 3 Shaft (to remain within the 3 Shaft footprint); ▪ Installation of a new conveyor belt; this belt will join the existing conveyor belt to the relocated crusher on the stockpile. This new conveyor belt will traverse a delineated wetland (to remain within the 3 Shaft footprint); and ▪ Drilling of exploration, monitoring and rescue boreholes within the approved Mooikraal Mining Right Area (MRA) and 3 Shaft Complex situated within 500 m of a watercourse.	▪ In addition Mooikraal wishes to amend and consolidate the approved Mooikraal EMPr to incorporate all activities at Mooikraal, Kleinvlei ventilation shaft, 3 Shaft and along both servitudes as well as all their associated properties. The intention is to ensure one EMPr is utilised for the entire Mooikraal and 3 Shaft operation to ensure effective implementation of the mitigation measures.

2 Project Background

Sasol Mining commenced with its mining operations in Sasolburg at Sigma Colliery in 1952 with the aim of supplying coal to SSO from both its underground and opencast mining operations. The Sigma Colliery ceased operations in 2006 (now known as the Sigma Defunct Colliery) thereafter Mooikraal Shaft took over the supply of coal to the SSO. Sigma Colliery is therefore subidivided into the operational and the defunct Colliery. The operational colliery consist of the Mooikraal Mine and the 3 Shaft Complex operations. The 3 Shaft Complex is where the coal handling takes place and consist of conveyors transporting the coal from Mooikraal to primary crusher and stockpiles and conveyor to the SSO.

Mooikraal is located approximately 18 kilometres (km) from the Sigma Defunct Colliery and 18 km southwest of Sasolburg in the Fezile Dabi District Municipality, Free State Province. The mine began operation in 2005 and has a Life of Mine (LoM) of 34 years until 2039.

Mooikraal is an underground coal mine that is currently mining five underground sections at a depth of 200m and deeper. Mooikraal accesses the underground workings via an incline shaft which was constructed utilising the box cut method. The incline shaft is utilised to allow vehicles, machinery and personnel to both enter and exit the underground workings.

Mooikraal extracts coal utilising the underground bord and pillar mining method, however in some areas high extraction mining is taking place to optimally mine the reserves. The coal mined at Mooikraal is referred to as run of mine coal (ROM).

The Run of Mine (ROM) coal is transported via a conveyor belt underground and brought to surface via the same incline shaft which is used to enter the mine (MK1). The coal is then stored in a silo. Subsequently the ROM coal is conveyed via an 18 km overland conveyor belt (MK3 – MK7 from Mooikraal to 3 Shaft, where the coal is crushed and stockpiled, before it is transferred to SSO for further industrial use.

2.1 Infrastructure

The following infrastructure is currently present at Mooikraal:

- Incline shaft;
- Ventilation Shaft (Kleinvlei Shaft) - Downcast;
- PCDs (North and South Dams);
- Access roads (including access routes to the rescue boreholes);
- Pump station;
- Sumps located at the wash bay, fuel storage, shaft complex and various areas around the mine for stormwater management;
- Explosives magazine;
- Transformers and bunds;
- Clean water channels;
- Soil stockpiles;
- Waste Rock Dump (WRD);
- Borrow pits;
- Sewage Treatment Plant (STP);
- Waste storage area;
- Workshops (cable, boiler and diesel);
- Lamp room;
- Bulk fuel and oil storage area and bunds;
- Dust suppression storage area and bund;
- Stone dust silo;
- Capital yard;
- Warehouse;
- Material storage yards;
- Conveyor belting, associated drive houses, transformers and substations;
- Coal scanners located on belts;

- 5Ml/day pipeline from Mooikraal to SSO
- 10Ml/day pipeline from Mooikraal to SSO;
- 7Ml/day pipeline from Kleinvlei Shaft to PCDs;
- Electricity pylons located with the existing servitudes;
- Various pipelines (potable and sewerage);
- Office blocks (including kitchen, security and proto room);
- Various walkways;
- Tuck-shop (where light meals are prepared);
- Change houses;
- Smokers facilities;
- Laundry washing facility;
- Security fencing; and
- Rescue boreholes.

The following infrastructure is present at 3 Shaft Complex:

- Primary plant area – including crusher facility;
- Stockpile area including stacker reclaimer for ROM and imported coal;
- Unpaved haul roads;
- Access roads;
- Security fencing;
- Transformers and substations;
- Conveyor belt and transfer points;
- Coal scanners located on the belts
- Bulk fuel storage area;
- Wash bay;
- ABET training centre;
- Warehouse;
- Parking area;
- Hazardous chemical storage area;
- Offices (including security and mine closure offices);
- Material handling stores;

- Workshops (diesel and boiler);
- Various pipelines (potable and sewerage);
- Paint spraying booth;
- Waste storage area;
- A cement dam for dust suppression (this dam is fed by the 5Ml/day pipeline from Mooikraal);
- Contractors storage yard; and
- Dirty water storage dams.

2.2 Water Management

A description of water management at both Mooikraal and 3 Shaft is provided below. A schematic is provided which gives an indication of the water reticulation at both Mooikraal and 3 Shaft provided in Figure 2-1.

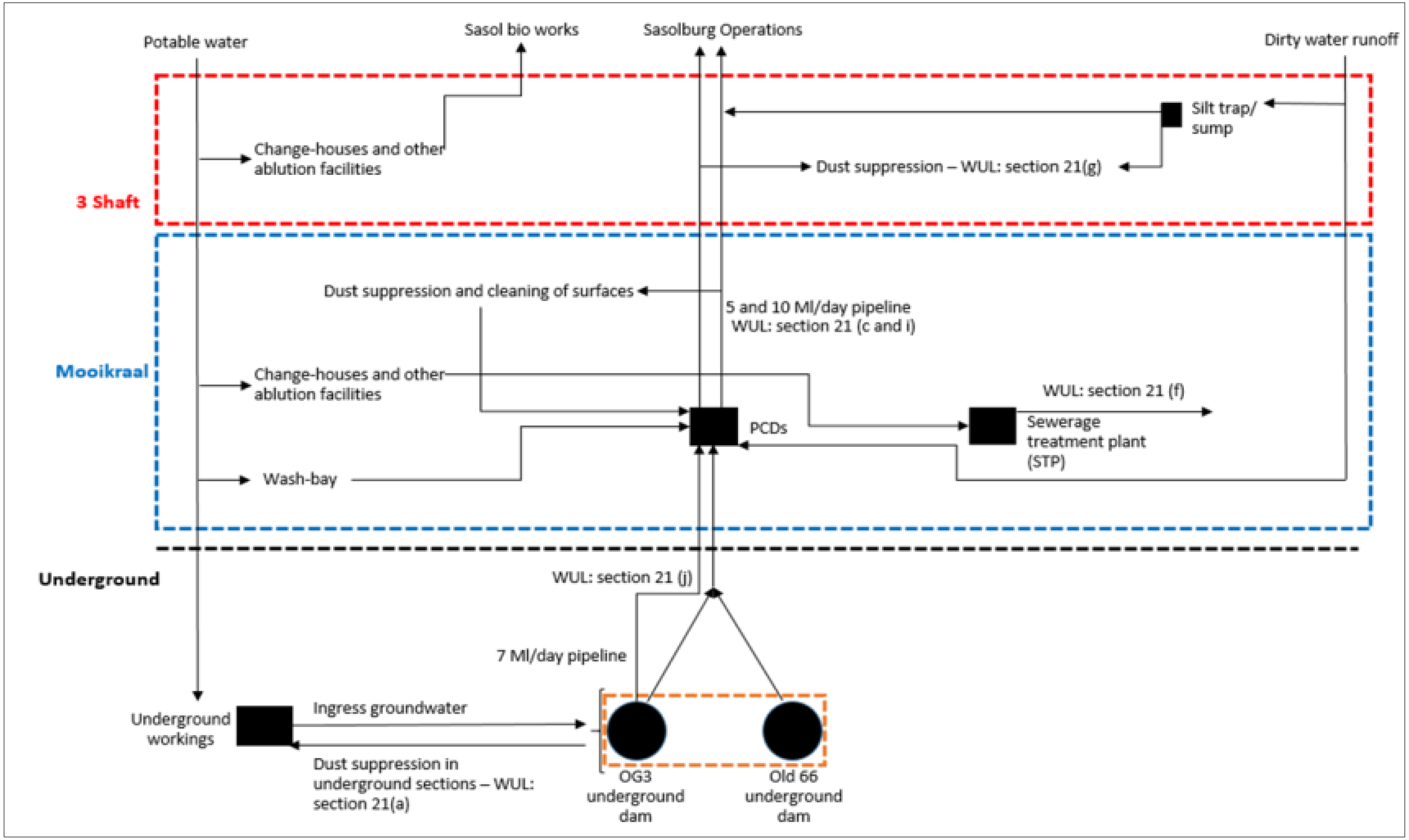


Figure 2-1: Water management schematic representation at Mooikraal and 3 Shaft

2.3 Potable Water

Mooikraal and 3 Shaft both receive potable water from Rand Water via a potable water line.

At Mooikraal the line runs within the Mooikraal servitude and is located below ground. The potable water line enters Mooikraal and is split to provide potable water to various sources, namely offices (kitchen and ablution facilities), laundry washing facility, the wash bay and change houses (showers and ablution facilities). Potable water utilised at the wash bay is for the cleaning of underground machinery and vehicles. Potable water is delivered to the underground workings in water canisters, no pipelines distribute potable water to the underground workings.

Potable water at 3 Shaft is utilised at the change houses (showers and ablution facilities) and offices (kitchen and ablution facilities).

2.4 Sewage Water (Effluent)

2.4.1 Mooikraal

All sewage generated at the change houses, surface ablution facilities and kitchen is pumped to the sewerage treatment plant (STP) at Mooikraal, via a sewerage network.

The sewage enters the STP through a grid screen at the entrance of the raw sump, the STP operator cleans the grid screen on a daily basis, the screenings that is generated is removed and disposed of to skips. The screenigs is considered to be hazardsous. The raw sump is equipped with a pump and high level and low level float switches, when the effluent level in the raw sump reaches the high level float switch, the pump activates to empty the contents of the raw sump to the aerator tank (Photograph 2-1), and the pump is de-activated when the low level float switch is reached.

The aerator tank circulates and aerates the incoming sewage from the raw sump. The aerator tank contains bio sludge which breaks down the sewerage. As part of the process, the operator determines the volume and age of the bio-sludge on a daily basis.

Similarly to the raw sump operating mechanism, the aerator tank has a high and low level float switches. When the level reaches the high float switch, the aerator tank stops circulating and aerating, and allows for a settling period of approximately 1 hour, this is to prevent decant of sludge with the treated water.

After the settling period has been completed, the aerator pump begins to discharge the treated water to the chlorine tank (Photograph 2-2), discharge continues until the low float switch level is reached. The chlorine dosing pump is simultaneously activated upon receipt of the treated water. 2 ppm of chlorine is dosed into the first chamber of the chlorine tank to treat the water.

The chlorine tank consists of 4 settling chambers, the overflow weir is situated in the last chamber of the chlorine tank, the treated water leaves the chlorine tank through the overflow weir and is discharged to the receiving environment, and is authorised by section 21 (f) of the Mooikraal Integrated Water Use Licence (IWUL) (license number: 08/C22K/CIGJFAE/6981; file number: 27/2/2/C1022/12/1, dated 16 January 2018).

Photograph 2-1: Aeration tank

Photograph 2-2: Chlorine tank

2.4.2 3 Shaft

All effluent from the change houses, surface ablution facilities and kitchen is transferred to the municipal sewer system where it is treated.

2.5 Underground Water Management

Underground water management refers to the ingress water into underground workings, underground dirty water storage compartments, underground water received into the PCDs and dirty water pipelines. This section is only applicable to Mooikraal as no underground mining is taking place at 3 Shaft.

2.5.1 Mooikraal

Underground water that ingresses into the underground workings is managed via an underground water reticulation system which involves a complex system of pipelines and storage dams. The underground water storage dams are sealed off by means of seal walls. The water level and water pressure behind the seal walls are monitored on a daily basis. The underground seals are designed to contain water to a level of 5 meters.

To give effect to the design specifications of the underground seals, volumes of underground water are pumped from the underground water storage compartments to the surface PCDs, namely North and South dams, as is authorised by section 21 (j) of the Mooikraal IWUL (license number: 08/C22K/CIGJFAE/6981; file number: 27/2/2/C1022/12/1, dated 16 January 2018).

The North and South PCDs are clay lined to prevent the potential for dirty water seepage. The South Dam is utilised as a settlement dam. The water, once settled, is then allowed to flow naturally to North Dam.

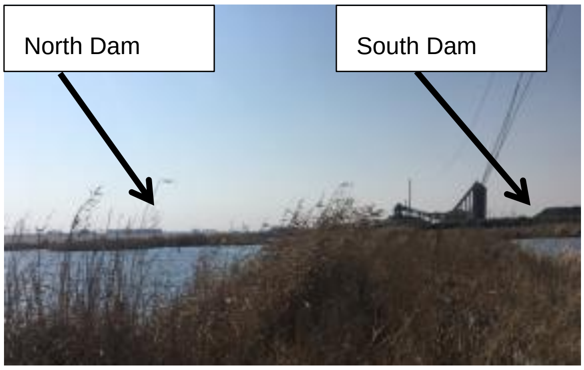
The capacity of the North and South PCDs is 50, 985 m^3 and 46,920 m^3 respectively (Photograph 2-3). A 5Ml/day pipeline was installed during the construction of Mooikraal to transport water from the PCDs to SSO. The 5Ml/day pipeline is installed along the conveyor belt servitude. The purpose of this pipeline was to ensure zero overflow from the PCDs, based on the assumption that approximately 5Ml/day of underground water would be removed from the underground workings and 5Ml/day of water would be transported from the PCDs to SSO.

In 2013, ingress of underground water into the underground workings far exceeded the assumption of 5Ml/day, and there existed an imbalance between the volume of water removed from underground and the volume of water transported by the hydraulically constrained 5Ml/day pipeline, resulting in unauthorised overflows of water from the PCDs.

As part of the management plan to address the PCD overflows, an environmental authorisation and water use licence process was undertaken to construct two additional pipelines (7Ml/day and 10Ml/day). The 7Ml/day pipeline will transport underground water from the Kleinvlei ventilation shaft to the South PCD. The 10Ml/day pipeline will transport water from the North PCD to SSO. The environmental authorisation was issued on the 09

March 2015 and the Water Use Licence (WUL) was issued on 16 January 2018. Construction of the pipeline began in 2015/2016 except in the areas where the pipeline will cross watercourses.

The 7Ml/day pipeline is approximately 3 km in length and the 10Ml/day pipeline is approximately 18.5 km in length. Both pipelines run within existing Sasol Mining servitudes. The 7Ml/day pipeline is within an existing servitude utilised for power lines and the 10Ml/day pipeline has been constructed within the existing fenced off overland coal conveyor servitude. The 7Ml/day pipeline has been buried below the surface, with the exception of the watercourse crossing where it is constructed on surface for 100m either side of the Kromelmboogspruit. The 10Ml/day pipeline has been constructed above ground and placed on plinths. The 10Ml/day pipeline will cross the Leeuspruit, as well as several other watercourses and wetlands. It is proposed with the receipt of the WUL that the pipeline crossings will be constructed and are anticipated to be completed by the end of 2018. (See Photograph 2-4 and Photograph 2-5).



Photograph 2-3: PCDs at Mooikraal

Photograph 2-4: Existing pump station

Photograph 2-5: Constructed Pipelines

2.6 Dust Suppression

Dust suppression is undertaken at both Mooikraal underground and 3 Shaft at the stockpile areas to manage the level of dust generated from the operations.

2.6.1 Mooikraal

Underground water is used for dust suppression in the underground workings which is authorised by section 21 (a) of the Mooikraal IWUL (license number: 08/C22K/CIGJFAE/6981; file number: 27/2/2/C1022/12/1, dated 16 January 2018). The water is abstracted from the underground water compartments and distributed underground. It is also noted that stone dust is also utilised to contain the dust that is generated underground.

Water that is pumped from underground to the PCDs is also utilised for dust suppression along the conveyor belt trajectory to ensure excessive coal dust is not generated while being transported from Mooikraal to 3 Shaft. Additionally the water is also utilised to clean areas around the conveyer belt. Sumps are located along the conveyer belt to contain any excess water generated. The water is also utilised to clean surfaces at the Mooikraal operation.

2.6.2 3 Shaft

Underground water is re-used at 3 Shaft for dust suppression. The current 5Ml/day pipeline, which transports underground water from the Mooikraal PCDs to SSO, splits at 3 Shaft. One of the pipeline transfers the underground water to SSO, and the other pipeline delivers underground water to 3 Shaft. The water is contained in concrete-lined PCD. Refer to Photograph 2-6.

The underground water is used to clean surfaces at 3 Shaft as well as utilised to suppress dust emanating from the activities at 3 Shaft (crushing and screening processes), as authorised by section 21 (g) of the Mooikraal IWUL (license number: 08/C22K/CIGJFAE/6981; file number: 27/2/2/C1022/12/1, dated 16 January 2018).

Photograph 2-6: PCD at 3 Shaft

2.7 Clean and Dirty Water Management

In accordance with GN704 of the National Water Act, 1998 (Act No. 36 of 1998), dirty water generated at Mooikraal and 3 Shaft will be contained within designated dirty water areas and will not be permitted to discharge to the environment. Clean water will be directed away from the dirty water areas and discharged back to the environment.

2.7.1 Mooikraal

Clean and dirty water areas are separated at Mooikraal, the dirty water footprint is kept as small as possible, and the clean water footprint is maximised. Water entering dirty water areas (rainfall, cleaning or dust suppression) will be considered dirty water, and must be separated from clean water areas through a dirty water management system.

The dirty water management system involves a system of channels and sumps/ silt traps which ultimately divert dirty water to the Mooikraal PCDs. A series of sumps are located at Mooikraal to manage dirty water generated around the shaft complex.

Dirty water management along the incline/decline and conveyor belts, MK 1 and MK2, is managed through a series of sumps, which ultimately pump to the Mooikraal PCDs.

Two sumps are located near the wash bay and at the fuel and oil storage area. The sumps separate hydrocarbons from the runoff water prior to entering the PCDs. Dirty water runoff from the diesel workshop is also contained in a sump prior to it entering the PCDs.

Various sumps and channels are used to divert dirty water runoff from the office area and parking lot areas. Photograph 2-7 to Photograph 2-10 provides an indication of the sumps located at Mooikraal.

Photograph 2-7: Sump located at wash bay

Photograph 2-8: Oil skimmers at wash bay

Photograph 2-9: Sump located at workshop

Photograph 2-10: Sump located at incline

2.7.2 3 Shaft

The 3 Shaft area has been used for coal operations since 1952, the primary plant as well as coal stockpile is situated at 3 Shaft. In 2016 Mooikraal delimitated all the wetlands located within the Mooikraal Mining right and 3 Shaft area.

The results of this study indicated that the primary plant area is located within the delineated wetland and stormwater runoff from the coal handling activities was not being adequately managed. In order to implement stormwater management principles in accordance with GN704, Mooikraal is proposing to relocate the primary plant which contains the crusher from within the delineated wetland area at 3 Shaft. It is proposed that Mooikraal will install a new primary plant with latest technology north east of the old primary plant located within the existing stockpile area. It is also proposed that the bunker that is currently located at the existing primary plant will be decommissioned.

This re-location of the crusher plant and its associated conveyor belt system (existing MK 9 and CP2 belts) implies that a new conveyor will be constructed over the shortest distance from the MK 8 transfer point to the relocated primary plant at the CO2 transfer point located at the stockpile area, this conveyor will be the new MK 9 belt. The new conveyor belt will cross the delineated wetland at one section. This crossing is essential to maintaining current operational conditions and the uninterrupted coal supply to the SSO without impacting on production feedstock which would result in down times to the SSO.

3 Details of the Specialist

The following specialists compiled this surface water study report:

Responsibility	**Report Writer**
Full Name of Specialist	Daniel Fundisi
Highest Qualification	MSc Hydrology
Years of experience in specialist field	7
Registration(s):	Pr.Sci.Nat. (SACNASP); Reg. Number: 400034/17
Responsibility	**Technical Review**
Full Name of Specialist	Mashudu Rafundisani
Highest Qualification	MSc Hydrology
Years of experience in specialist field	7
Responsibility	**Final Review**
Full Name of Specialist	Andre van Coller
Highest Qualification	MSc Geohydrology
Years of experience in specialist field	10

3.1 Declaration of Specialist

I, Daniel Fundisi, as the appointed specialist, hereby declare/affirm the correctness of the information provided or to be provided as part of the application, and that I:

- in terms of the general requirement to be independent, other than fair remuneration for work performed/to be performed in terms of this application, have no business, financial, personal or other interest in the activity or application and that there are no circumstances that may compromise my objectivity;
- in terms of the remainder of the general requirements for a specialist, am fully aware of and meet all of the requirements and that failure to comply with any the requirements may result in disqualification;
- have disclosed/will disclose, to the applicant, the Department and interested and affected parties, all material information that have or may have the potential to influence the decision of the Department or the objectivity of any report, plan or document prepared or to be prepared as part of the application; and
- am aware that a false declaration is an offence in terms of regulation 48 of the 2014 NEMA EIA Regulations.

Signature of the specialist

Daniel Fundisi (Pr.Sci.Nat)

Full Name and Surname of the specialist

Digby Wells Environmental

Name of company

January 2019

Date

4 Methodology

The study was undertaken following relevant methodologies, guidelines and legislative frameworks governing national, regional and local settings. As such, the hydrology of the Vaal Water Management Area 5 (WMA 5), Quaternary Catchments C23B and C22K, and the local project site, was assessed as described in the following sections:

4.1 Baseline Hydrology

Rainfall, evaporation and runoff data obtained from the results database of the Water Resources of South Africa 2012 study (WRC, 2015) was analysed to determine the Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and the Mean Annual Runoff (MAR) for the Mooikraal and 3 Shaft Collieries project sites. Time series rainfall-runoff and Symons Pan evaporation historical data for 1920 to 2009 were adequate to determine mean hydro-meteorological parameters for the project site. These analyses were useful to provide insight into the general rainfall-runoff and evaporation dynamics for the site, which informed the surface water impact assessment for the Mooikraal and 3 Shaft Collieries.

4.2 Peak Flows

Catchment delineation was undertaken in Global Mapper using Advanced Land Observing Satellite (ALOS) World 3D – 30m (AW3D30) global digital surface model (DSM) data (JAXA, 2015). This dataset is stored in a raster GeoTIFF format referenced to the Hartebeesthoek 94 Datum (WGS84 ellipsoid). The ALOS data showed a higher resolution than a Digital Elevation Model (DEM) generated from 5 m contours (National Geospatial Institute, 2013) of the area.

Design rainfall depths were calculated using the Design Rainfall Programme for South Africa and the modified Hershfield equation for use in determining flood peaks. Widely used and recommended methods including the Rational Method Alternative 3 (RM3), Standard Design Flood (SDF) and the Midgley & Pitman (MIPI) were used to calculate the 1:50-year and 1:100-year peak flows for the delineated catchment at the project site (SANRAL, 2013).

4.3 Land Cover and Soils

Land cover and soil data are necessary for peak flow calculations since they determine potential for infiltration and overland flow. The South African Atlas of Climatology and Agro-hydrology (Schulze, 2008) was used to classify general land cover. Soil information was obtained from databases of the Agricultural Research Council Institute for Soil, Climate and Water (ARC-ISCW).

4.4 Floodlines

Hydraulic modelling was conducted in HEC-RAS 5.05 which allows pre-processing within the in-built RAS Mapper module. A digital terrain model (DTM) was generated from the ALOS DSM for the area to make the topographic data compatible with RAS Mapper. The pre-processing involved generation of the channel geometry, including the river network, banks, flow paths and cross sections. The new geometry was opened in HEC-RAS where hydraulic analysis occurred.

The HEC-RAS model simulates total energy of water by applying basic principles of mass, continuity and momentum as well as roughness factors between all cross sections (US Army Corps of Engineers, 1995). A height is calculated at each cross-section, which represents the level to which water will rise at that section, given the potential peak flows. This was calculated for the 1:50-year and 1:100-year flows on all river sections.

Analyses are performed by modelling flows at the sub-catchment outlet of particular stream or channel sections first, moving upstream. . Manning's Roughness Coefficients (n) for the channels were set at 0.02, and those for river banks were determined to be 0.03 representing natural channels with weeds, reeds and brush on the banks (Chow, 1959).

The approach used in the determination of floodlines is summarised in Figure 4-1.

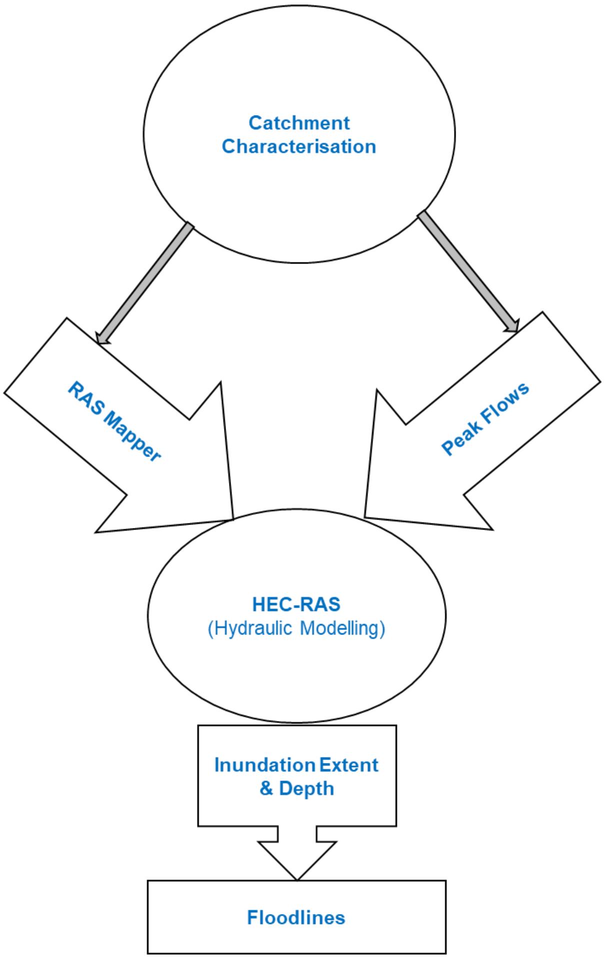


Figure 4-1: Summary of the floodline determination approach

4.5 Water Quality

Water quality monitoring is being conducted by the Institute of Groundwater Studies (IGS) of the University of The Free State (UFS). The criteria used for inorganic surface water sampling is the Water Quality Objectives prescribed in the Mooikraal WUL (License NO.: 08/C22K/CIGJFAE/6981 dated 16 January 2018) by the Department of Water Affairs and Sanitation (DWS).

The water quality data was analysed by a South African National Standards (SANAS) accredited laboratory and then verified by the IGS. Time series records were presented using the WISH programme. The water quality objectives stipulated within the Mooikraal Water Use License (WUL), license number: 08/C22K/CIGJFAE/6981 were used to benchmark the sample chemistry results.

4.6 Surface Water Impact Assessment

Potential and existing surface water (quality and quantity) impacts that may result from the proposed project activities, based on the established baseline conditions, were identified. A numerical environmental significance rating methodology that utilises the impact's probability of occurrence and its severity as factors to determine the significance of a particular environmental risk was utilised. Mitigation measures were then determined for implementation to prevent and/or reduce the identified potential and existing surface water impacts.

The surface water impact assessment was completed in the manner described in the following subsections.

4.6.1 Impact Rating

The methodology utilised to assess the significance of impacts is discussed in detail below. The significance rating formula is as follows:

Significance = Consequence x Probability

Where

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

Type of Impact *=* ***+1*** *(Positive Impact) or* ***-1*** *(Negative Impact)*

The weighting assigned to the various parameters for positive and negative impacts is provided for in the formula and is presented in Table 4-1. The probability consequence matrix for impacts is displayed in Table 4-2, with the impact significance rating described in Table 4-3.

Table 4-1: Surface Water Impact Assessment Parameter Ratings

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
7	High significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	Noticeable, on-going social and environmental benefits which have improved the livelihoods and living standards of the local community in general and the environmental features.	International The effect will occur across international borders.	Permanent: No Mitigation The impact will remain long after the life of the Project.	Certain/ Definite. There are sound scientific reasons to expect that the impact will definitely occur.
6	Significant impact on highly valued species, habitat or ecosystem. Irreparable damage to highly valued items of cultural significance or breakdown of social order.	Great improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the receiving environment.	National Will affect the entire country.	Beyond Project Life The impact will remain for some time after the life of a Project.	Almost certain/Highly probable It is most likely that the impact will occur.
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	Municipal Area Will affect the whole municipal area.	Long term 6-15 years.	Probable Has occurred here or elsewhere and could therefore occur.
3	Moderate, short-term effects but not affecting ecosystem functions. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements.	Medium term 1-5 years.	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.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by very few of population.	Limited Limited to the site and its immediate surroundings.	Short term Less than 1 year.	Rare/ improbable Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.
1	Limited damage to minimal area of low significance that will have no impact on the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month.	Highly unlikely/None Expected never to happen.

Table 4-2: Probability Consequence Matrix for Impacts

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 4-3: Significance Threshold Limits

Score	Description	Rating
109 to 147	A very beneficial impact which 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	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effect on the social and/or natural environment.	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. 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 social and/or natural environment.	Negligible (negative)
-36 to -72	An important negative impact which 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 social and/or natural environment.	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects.	Moderate (negative)
-109 to -147	A very serious negative impact which 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.	Major (negative)

4.7 Assumptions and Limitations

The following assumptions and limitations are applicable to this study and report:

- The existing stormwater management plan (SWMP) and water quality reports for Mooikraal and 3 Shaft adequately cover proposed developments for the two mine operations. As such the surface water impact assessment will be based on findings in these reports and on site visit investigations.
- No water quality sampling was undertaken for this study by Digby Wells for the purpose of this specialist study. Water quality data and reports obtained from Mooikraal were, therefore, considered as representative of current conditions at the Mooikraal and 3 Shaft project site. The Water Quality Report for Mooikraal was used to describe the general surface water quality at Mooikraal-3 Shaft (IGS, 2018).
- Baseline hydrological assessment, floodlines, water balance and surface water impact assessment were undertaken as components of the scope of the current study.

5 Baseline Hydrology

5.1 Catchment Description

South Africa is divided into nine Water Management Areas (WMA) as part of the Revised National Water Resource Strategy (DWS, 2012), and are managed by separate water boards. Each of the WMAs is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A to X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment; A2 for example will represent the secondary catchment; A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources of South Africa, 2012 manual. Each of the quaternary catchments has associated hydrological parameters.

The project is located in the Vaal Water Management Area 5 (WMA 5), with Mooikraal and 3 Shaft sites falling within quaternary catchments C23B and C22K, respectively. These quaternary catchments lie in the Vaal River catchment with the Mooikraal and 3 Shaft sites located within the Kromelmboogspruit and Leeuspruit sub-catchments respectively. The Kromelmboogspruit and Leeuspruit are perennial tributaries of the Vaal River.

The regional and local settings showing quaternary catchments including the C23B and the geographical surroundings are shown in Figure 5-1 and Figure 5-2.

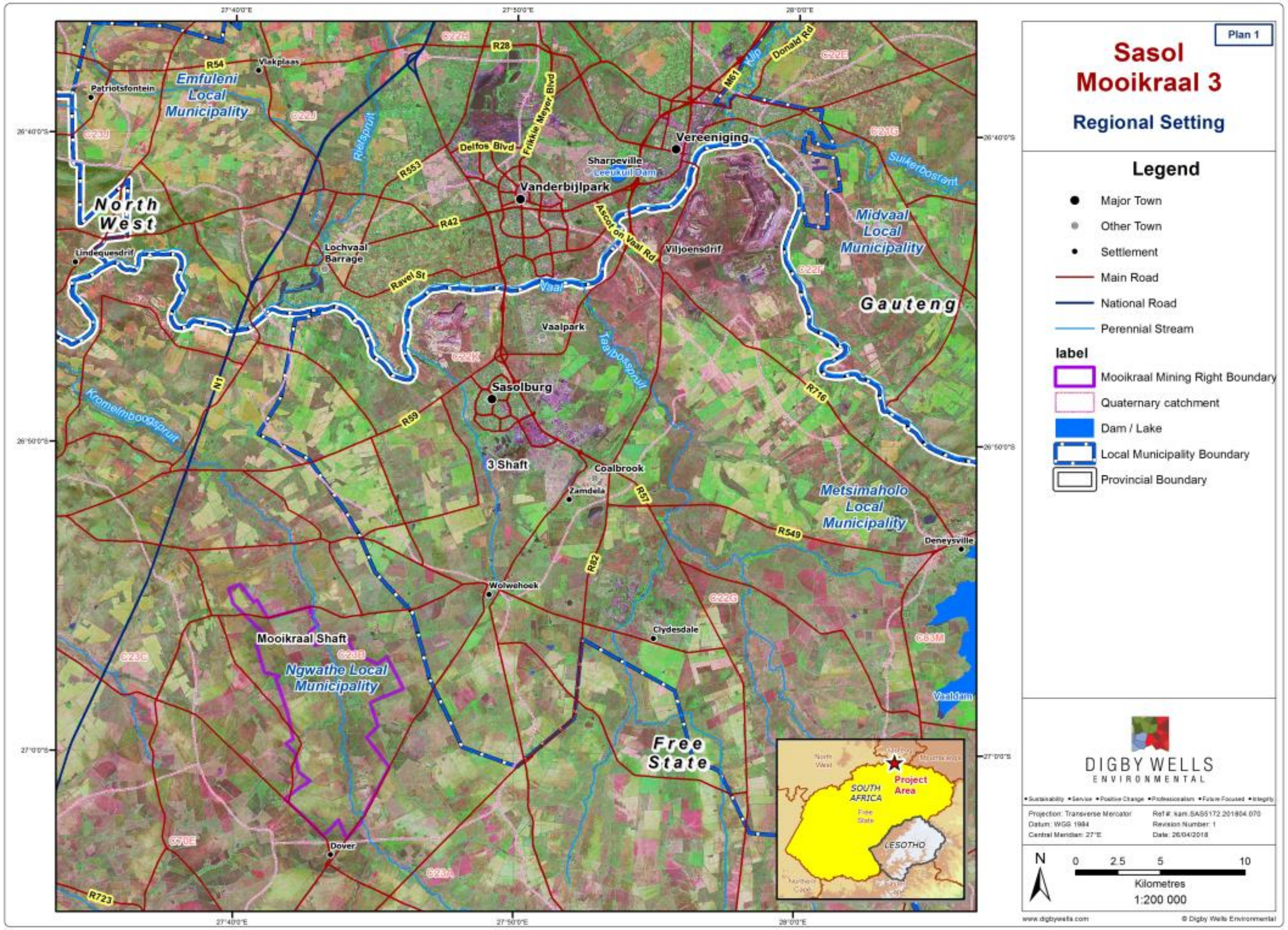


Figure 5-1: Regional setting of Mooikraal-3 Shaft project site

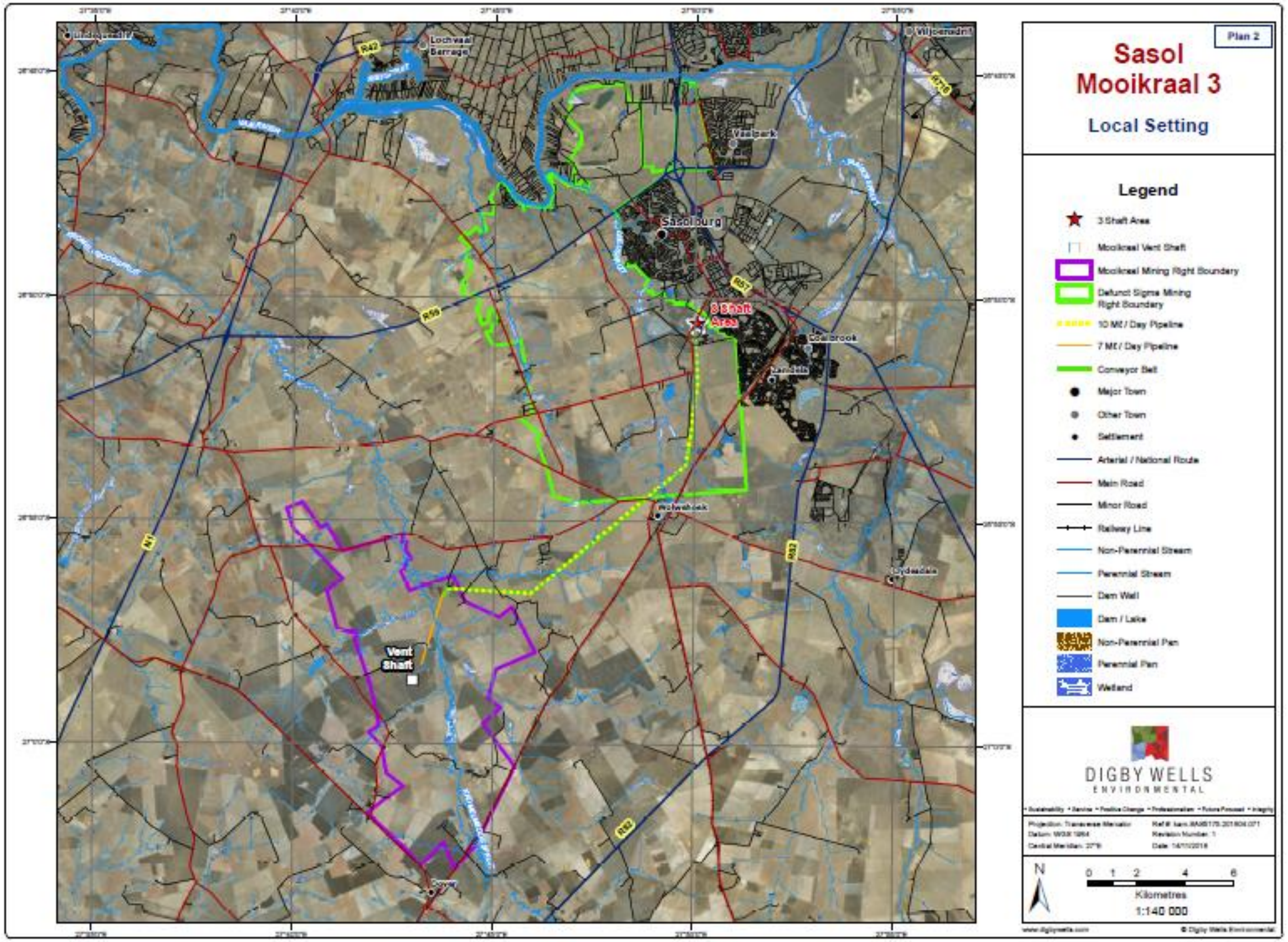
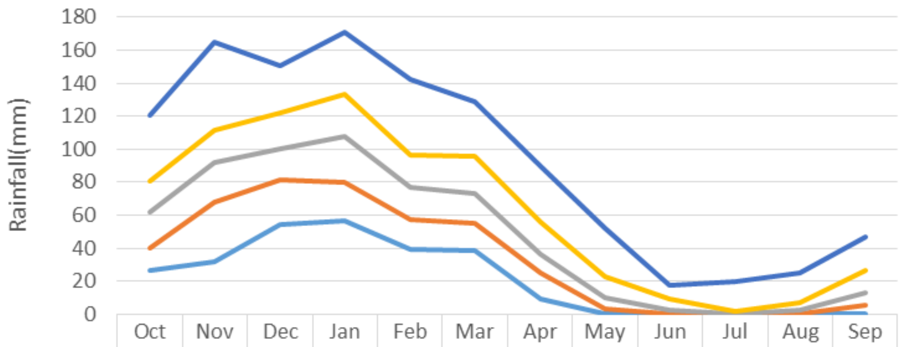


Figure 5-2: Locality of Mooikraal- 3 Shaft project site

5.2 Hydrometeorology

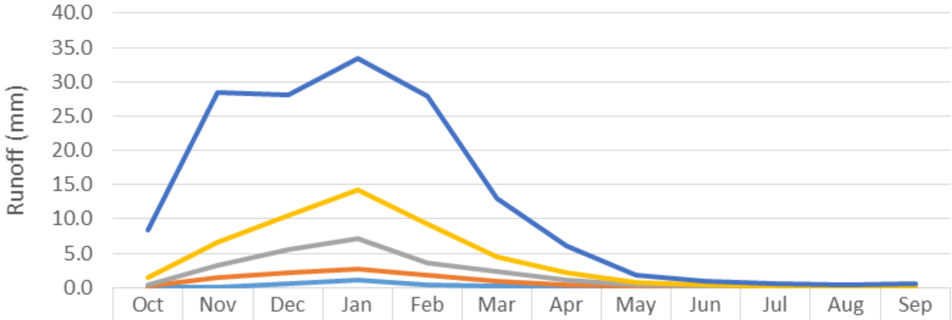
Similar rainfall, runoff and evaporation trends are prevalent within both the C23B and C22K quaternary catchments. Both fall within the C2C rainfall zone and are within the same 11A evaporation zone. The Mean Annual Precipitation (MAP) for C23B and C22K are 619 mm and 644 mm, while the Mean Annual Runoff (MAR) are 35.5 mm and 57.28 mm, respectively. Measured rainfall data at Mooikraal-3 Shaft for the period 1954 to 2018 indicates an MAP of 671 mm, which is comparable to the one obtained from the WRC database. Differences in catchment areas and runoff adjustment factors for C23B and C22K explain the notable differences in the MAP and MAR for the sites. The Mean Annual Evaporation (MAE) for the region (C23B and C22K) is 1,650 mm. Moderate to high rainfall is experienced within this region of which approximately 6% and 9% translate into surface runoff within C23B and C22K quaternary catchments, respectively. The MAP and MAR within the two quaternaries are likely to be distributed as indicated in Figure 5-3 and Figure 5-4, respectively. Normal rainfall (90% of events) for the wettest month of January will likely not exceed 56 mm, while extreme rainfall (10% of events) for the same month will likely not exceed 171 mm. The normal runoff depth during the wettest month (January) will likely be equivalent to 1.1 mm while runoff resulting from extreme events in the same month will be in the order of 33.4 mm.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
E90	26	32	54	56	40	39	9	0	0	0	0	0
E70	40	68	82	80	58	55	25	3	0	0	0	6
E50	62	92	100	108	77	73	37	10	3	0	2	13
E30	81	111	122	133	97	96	56	23	9	2	7	27
E10	120	165	151	171	142	129	90	52	17	20	25	47

E10 represents a value that cannot be exceeded in 10% of events, etc.

Figure 5-3: Rainfall distribution for the Sasolburg region

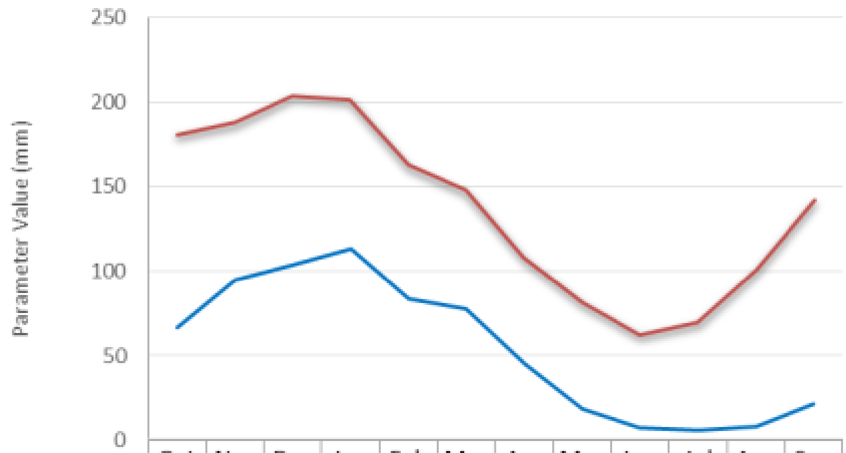


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
E90	0.1	0.1	0.6	1.1	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
E70	0.2	1.5	2.3	2.8	1.8	0.9	0.4	0.2	0.2	0.2	0.2	0.1
E50	0.5	3.3	5.6	7.1	3.7	2.4	1.2	0.4	0.3	0.3	0.2	0.2
E30	1.4	6.6	10.6	14.2	9.2	4.5	2.1	0.7	0.4	0.3	0.3	0.2
E10	8.4	28.4	28.1	33.4	28.0	12.9	6.1	1.8	0.8	0.5	0.4	0.5

E90 represents a value that cannot be exceeded in 90% of events, etc.

Figure 5-4: Runoff distribution for the Sasolburg region

Regional annual evaporation is approximately 2.5 times higher than the MAP confirmed by monthly distribution trends indicated in Figure 5-5



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation(mm)	181	188	204	202	163	148	108	82	62	70	101	142
Rainfall (mm)	67	95	104	113	84	78	45	19	7	6	8	22

Figure 5-5: Evaporation and rainfall trends for Sasolburg region

5.3 Peak Flows

5.3.1 Design rainfall depths

Design Rainfall Depths for the 1:2-year to 1:100-year return periods were calculated using the Design Rainfall Software for South Africa (Smithers and Schulze, 2000). The rainfall depths are presented in Table 5-1. The rainfall depths with durations equal to the time of concentration (Tc) of assessed catchments were used to calculate peak flows using the RM3 method. The recalibrated modified Hershfield equation was used to determine precipitation depths used in the SDF method (Alexander, 2002).

Table 5-1: 24-Hour Design rainfall depths for Sasolburg region

Duration	Return Period (Years)					
	2	5	10	20	50	100
5 m	8.5	11.5	13.5	15.6	18.5	20.9
10 m	12.4	16.7	19.7	22.7	27	30.3
15 m	15.5	20.7	24.5	28.3	33.6	37.7
30 m	19.7	26.4	31.2	36	42.7	48.1
45 m	22.7	30.4	35.9	41.5	49.2	55.4
1 h	25.1	33.6	39.7	45.9	54.4	61.2
1.5 h	28.9	38.7	45.8	52.9	62.7	70.5
2 h	31.9	42.8	50.6	58.5	69.3	77.9
4 h	37.7	50.5	59.7	69	81.8	92
6 h	41.5	55.7	65.8	76	90.1	101.3
8 h	44.5	59.6	70.4	81.4	96.5	108.5
10 h	46.9	62.9	74.3	85.8	101.8	114.4
12 h	49	65.7	77.6	89.6	106.3	119.5
16 h	52.5	70.4	83.1	96	113.9	128
20 h	55.3	74.2	87.7	101.3	120.1	135
24 h	57.8	77.5	91.5	105.8	125.4	141

5.3.2 Delineated subcatchments and peak flows

A total of 9 subcatchments (SC1 to SC9) were delineated for the Kromelmboogspruit and selected relevant tributaries (Figure 5-6). Peak flows calculated using the RM3 and MIPI methods are of the same order of magnitude, hence the SDF flood peaks were considered an over-estimate for the site. RM3 flood peaks which were more conservative than those for the MIPI method were used in HEC-RAS for hydraulic modelling. Catchment characteristics and calculated peak flows are presented in Table 5-2 and Table 5-3, respectively.

Table 5-2: Characteristics of delineated catchments at Mooikraal-3Shaft Collieries

Catchment	AREA	Longest Watercourse (L)	Distance to Centroid (Lc)	Elevation (mamsl)		Slope
	km^2	km	km	10%L	84%L	(m/m)
SC1	509.1	54.25	40.01	1454	1554	0.0024
SC2	34.8	8.381	6.077	1461	1483	0.0035
SC3	33.9	8.499	5.703	1456	1480	0.0038
SC4	77.3	10.361	6.059	1460	1485	0.0032
SC5	51.8	11.323	6.94	1455	1497	0.0049
SC6	6.4	3.741	2.99	1459	1482	0.0079
SC7	7.1	3.459	2.89	1462	1494	0.0123
SC8	11.2	6.298	5.44	1459	1483	0.0051
SC9	9.9	3.627	1.72	1450	1485	0.0129

Table 5-3: Peak flows in the Kromelmboogspruit and selected tributary catchments

Catchment	Method					
	RM3		SDF		MIPI	
	1:50yr	1:100yr	1:50yr	1:100yr	1:50yr	1:100yr
	(m^3/s)					
SC1	<u>420.88</u>	<u>569.86</u>	650.62	823.93	382.44	483.08
SC2	<u>96.82</u>	<u>131.17</u>	176.31	223.28	98.11	123.93
SC3	<u>96.50</u>	<u>130.73</u>	174.91	221.50	97.88	123.64
SC4	<u>185.38</u>	<u>251.19</u>	324.18	410.54	176.79	223.31
SC5	<u>135.17</u>	<u>183.16</u>	238.47	302.00	127.94	161.60
SC6	<u>40.20</u>	<u>54.46</u>	68.28	86.47	37.42	47.27
SC7	<u>45.15</u>	<u>61.19</u>	88.74	112.38	43.09	54.42
SC8	<u>42.07</u>	<u>56.97</u>	77.11	97.65	44.61	56.35
SC9	<u>63.99</u>	<u>86.73</u>	122.96	155.72	62.42	78.85

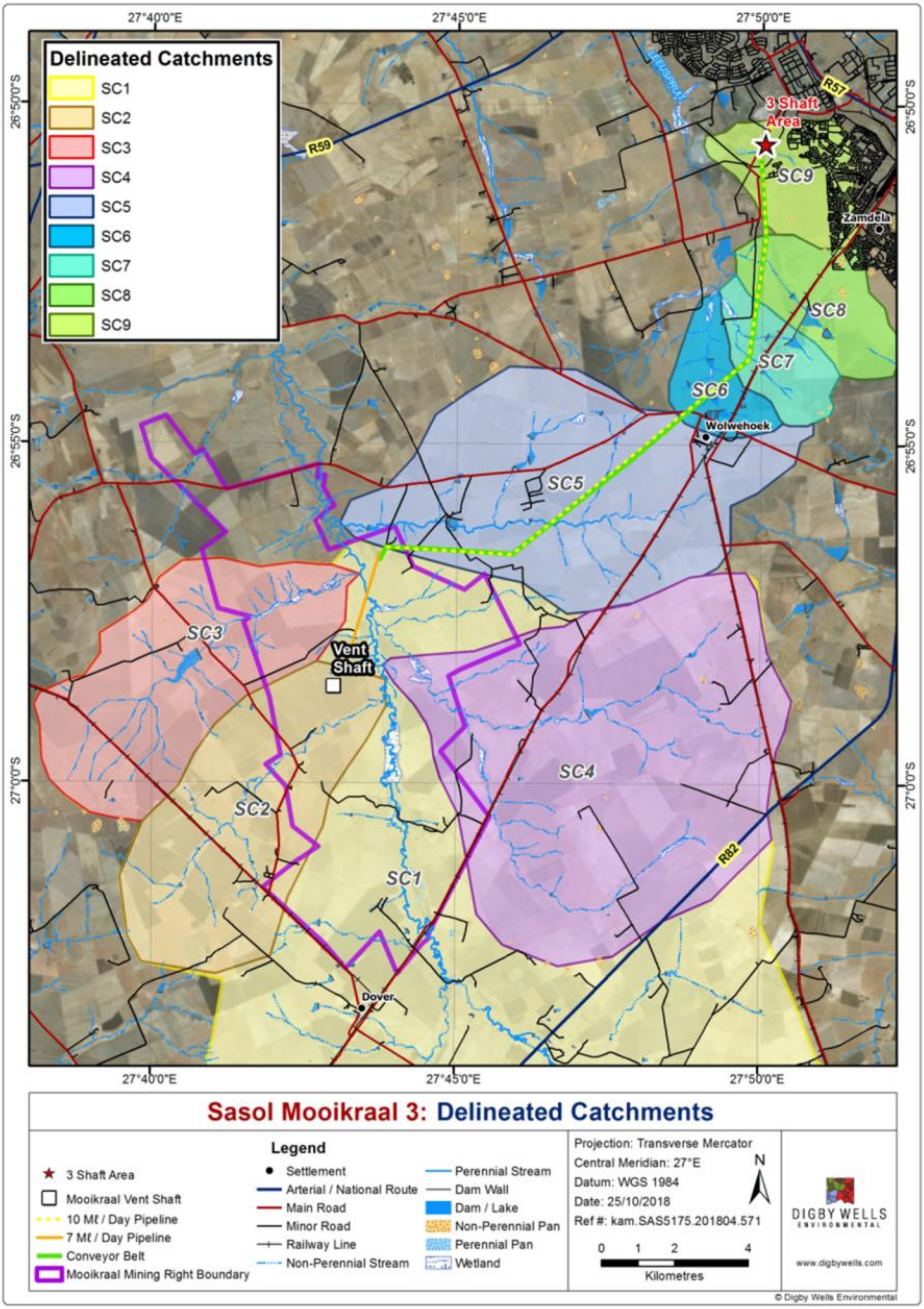


Figure 5-6: Delineated subcatchments at Mooikraal and 3Shaft

6 Floodlines

The 1:50-year and 1:100-year floodlines for the Kromelmboogspruit and its tributaries at Mooikraal and the Leeuspruit and its tributaries at all river crossings along the conveyor belt/pipeline route and at 3 Shaft were modelled and mapped. The general overview of the floodlines can be seen in Figure 6-1.

The 7Ml/day pipeline traverses the Kromelmboogspruit at one point, while the 10Ml/day pipeline crosses a tributary of the Kromelmboogspruit once and Leeuspruit tributaries at three points along its length (Figure 6-1). Floodlines of the Kromelmboogspruit at Mooikraal are presented in Figure 6-2 while those at the Leeuspruit river crossings with the 10Ml/day pipeline are indicated in Figure 6-3. Pre-development 1:50-year and 1:100-year floodlines on the Leeuspruit tributary at 3 Shaft are presented in Figure 6-4.

No infrastructure is within the 1:100-year floodline at Mooikraal. The existing Crusher at 3 Shaft falls within the 1:100-year floodline on the Leeuspruit tributary (Figure 6-2). The proposed site to which the 3 Shaft Plant and Crusher will be relocated is outside the 1:100-year floodline.

The modelled floodlines are for indicative purposes only, and not meant for any engineering designs. They should be used as a general indication of infrastructure placement, if new mining infrastructure is to be constructed at both the Mooikraal and 3 Shaft sites.

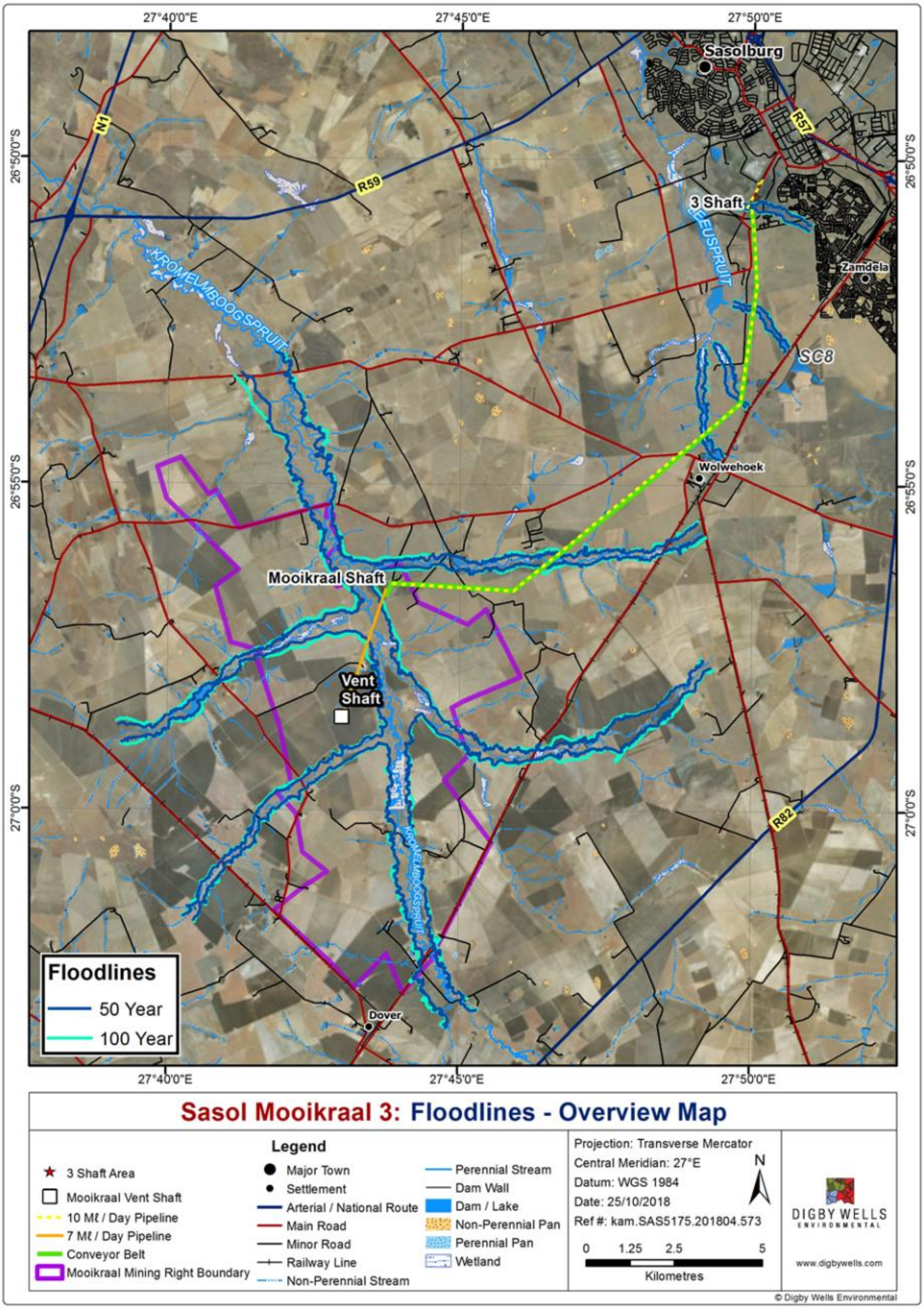


Figure 6-1: 1:50-year and 1:100-year floodlines at Mooikraal and 3 Shaft

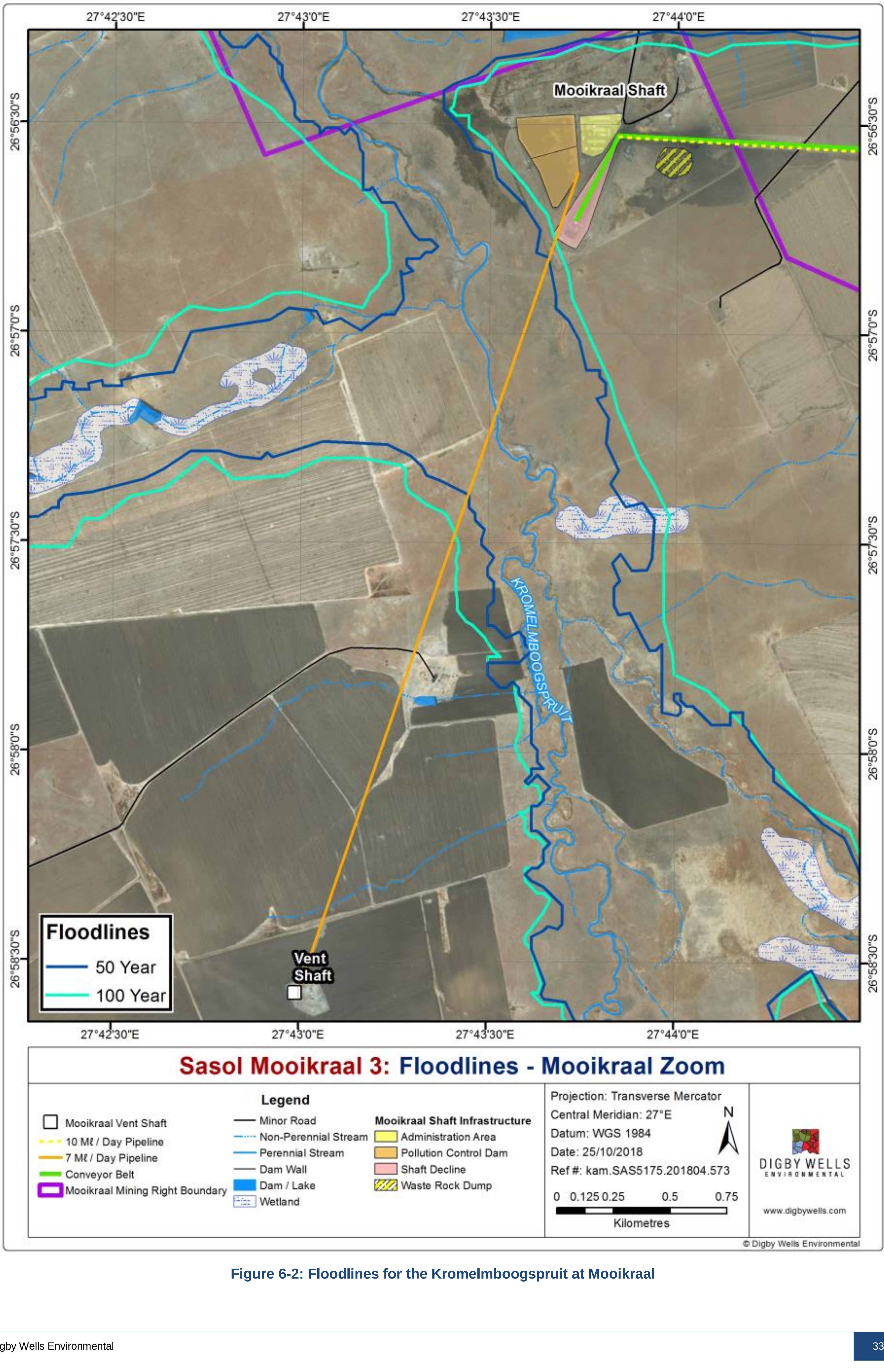


Figure 6-2: Floodlines for the Kromelmboogspruit at Mooikraal

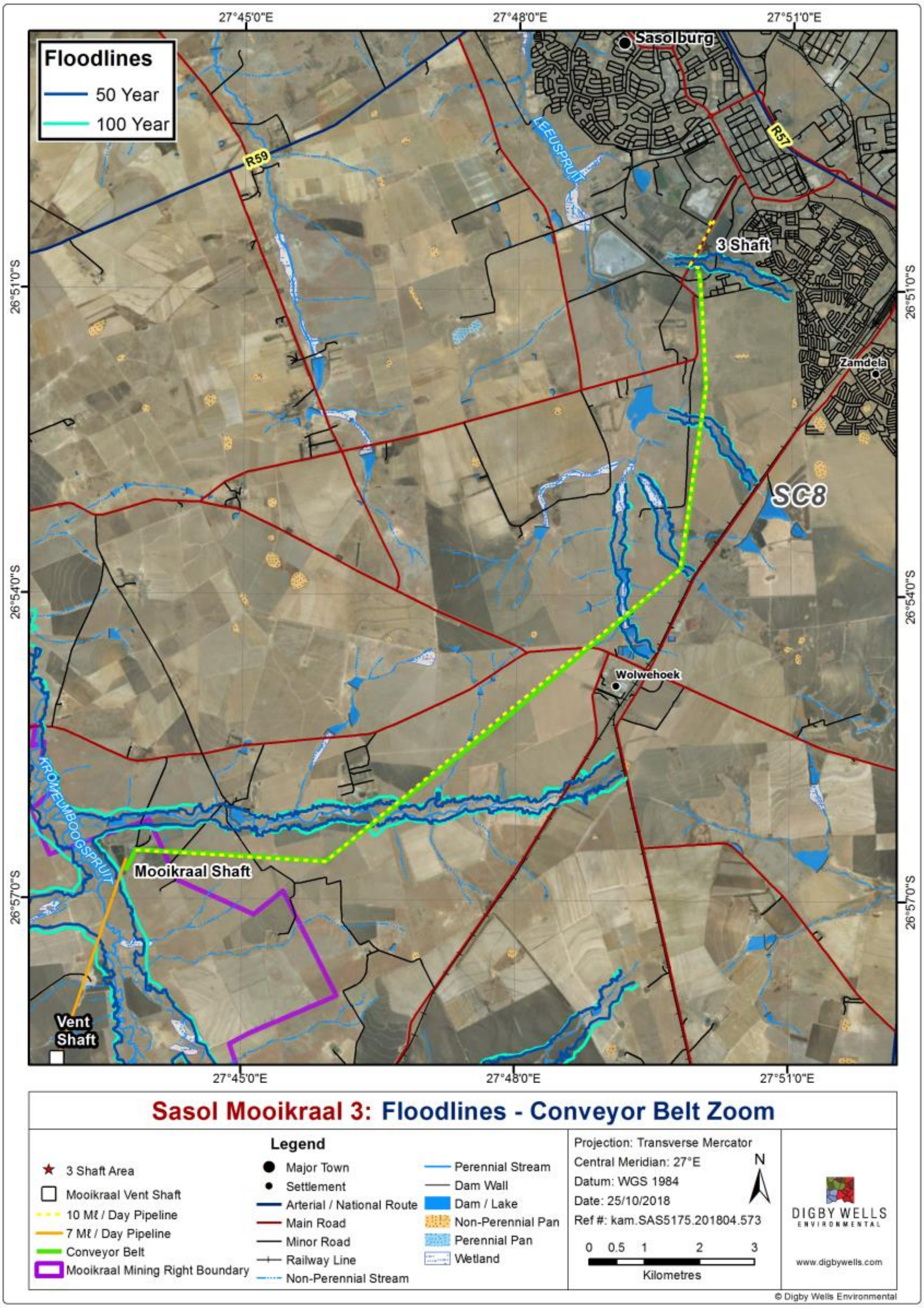


Figure 6-3: Floodlines across the 10Ml/day pipeline from Mooikraal to 3 Shaft

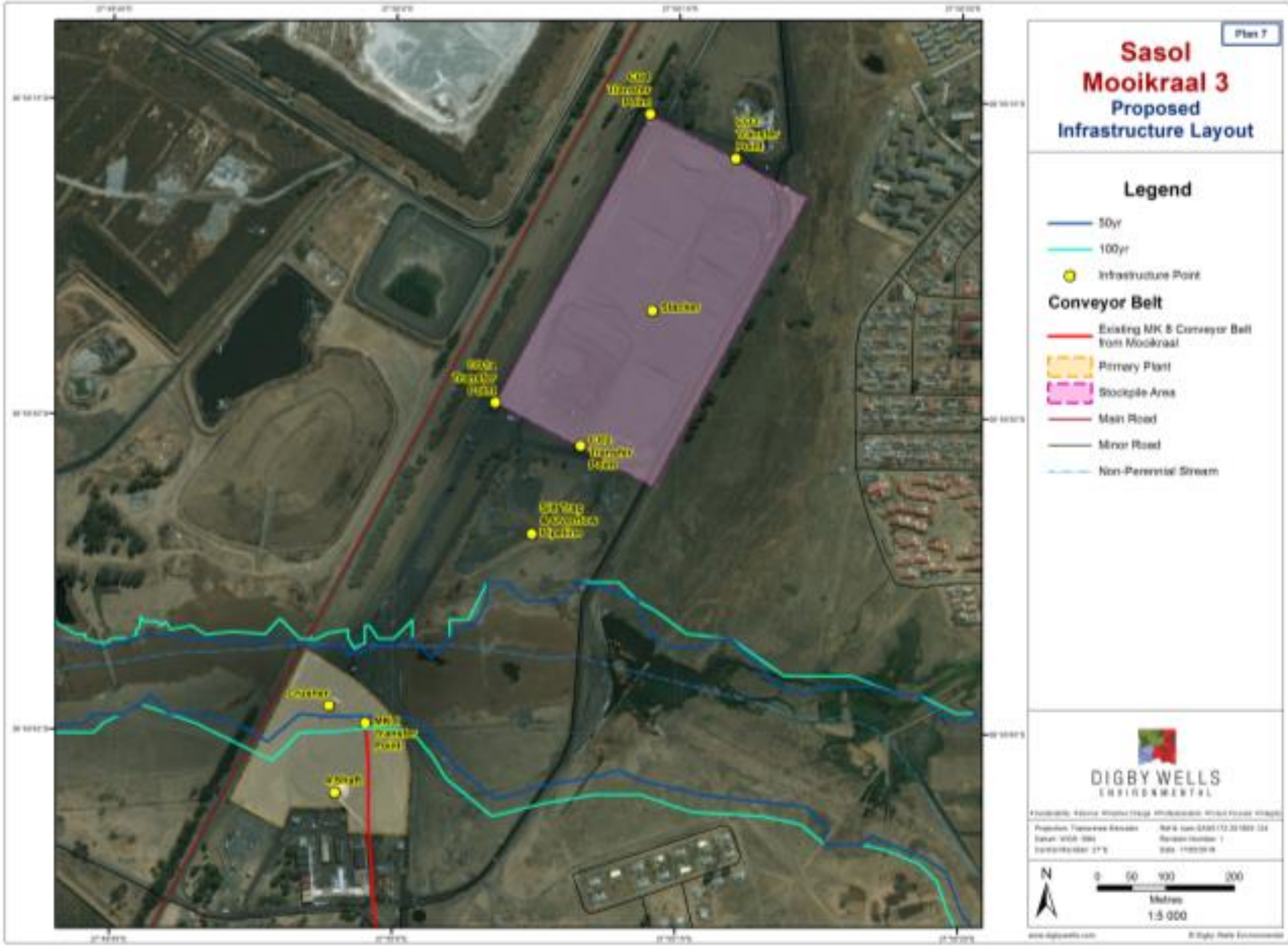


Figure 6-4: Pre-development 1:50-year and 1:100-year floodlines at 3 Shaft

7 Water Quality

IGS was appointed by Sasol Mining (Pty) Ltd to conduct the water monitoring of the Mooikraal and 3 Shaft. This section summarises the water quality information based on the latest water quality analysis conducted by IGS (April 2018) which outlines the results of an on-going bi-annual monitoring programme. The monitoring programme focuses on an integrated approach where all water resources are holistically monitored for potential impacts of mining. The parameters analysed for are displayed in Table 7-1.

Table 7-1: Summary of the parameters/variables analysed for

Water Quality Parameters						
pH	EC	TDS	Ca	Mg	Na	K
P-Alk	M-Alk	Cl	SO_4	NO_3 as N	F	Cd
Al	Fe	Mn	NH_4 as N	Si	Cr	B
Co	Cu	Pb	PO_4	COD	DOC	TOC
Phenols	Turbidity	Suspended Solids				

Nine surface water monitoring sites form part of the monitoring program at Mooikraal - 3 Shaft. The monitoring locations are listed in Table 7-2 and shown in Figure 7-1.

Table 7-2: Summary of surface water monitoring points

Area	Site ID	Status	Comments
Mooikraal	MK-DAM	Monitored	Mooikraal dirty water dam
Mooikraal	MK-PIT	Monitored	Decline Shaft Pit
Mooikraal	MK-SUMP	Monitored	Dirty water entering MK- Dam/Inaccessible- excessive weeding
Mooikraal	KROM/N	Monitored	Kromelmboogspruit downstream of the Mooikraal Shaft
Mooikraal	KROM/S	Monitored	Kromelmboogspruit upstream of the Mooikraal Shaft
3 Shaft	SG/5	Monitored	Downstream of Zamdela and upstream of 3 Shaft on Leeuspruit
3 Shaft	SG/6	Monitored	Downstream of 3 Shaft Primary Plant and Crusher on Leeuspruit

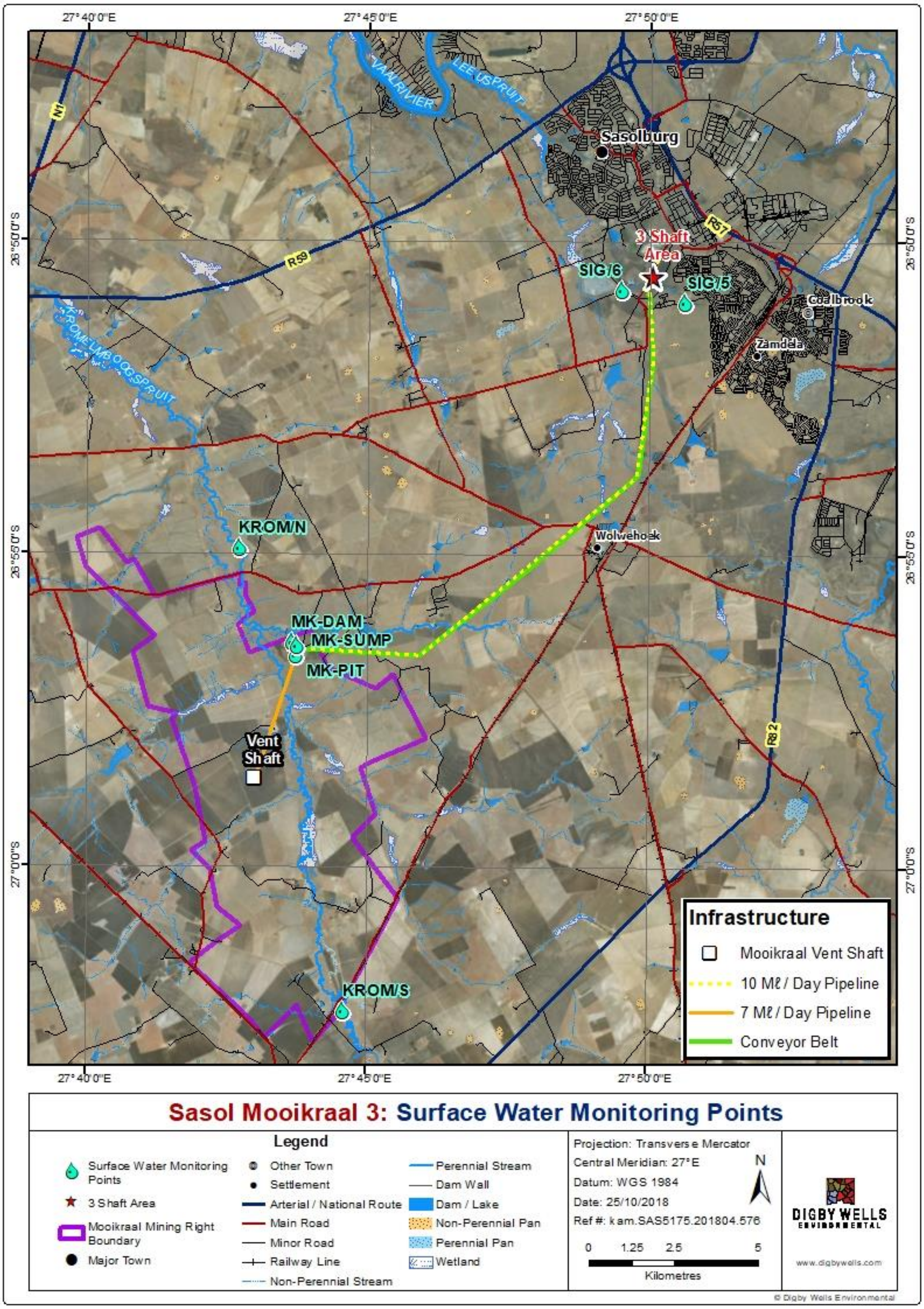


Figure 7-1: Mooikraal-3 Shaft surface water monitoring points

7.1 Kromelmboogspruit

Surface water quality results upstream (KROM/S) and downstream (KROM/N) of the Kromelmboogspruit indicate that all tested parameters are within the WUL (License Number 08/C22K/CIGJFAE/6981) prescribed limits (Table 7-3).

Table 7-3: Chemical analysis of the Kromelmboogspruit for February 2018 (IGS, 2018)

SiteName	EC	pH	Ca	Mg	Na	K	PAlk	MAlk	F	Cl	NO2(N)
	mS/m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WRQO	<150	5.5 - 9.5	<50	<80	<100	N/S	N/S	N/S	N/S	<150	N/S
KROM/N	11	7.4	7	3	8	5.9	0	39	0.29	5	0.011
KROM/S	8	6.8	4	2	6	6.4	0	23	0.24	5	<0.01
SiteName	NO3(N)	PO4	SO4	Al	Fe	Mn	NH4(N)	TDS	B	Si	Cd
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WRQO	<40	N/S	<200	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
KROM/N	0.767	<0.1	7	0.326	0.252	<0.020	0.23	79	<0.040	5.64	<0.003
KROM/S	0.509	<0.1	8	0.521	0.438	<0.020	0.09	57	<0.040	6.18	<0.003
SiteName	Co	Cr	Cu	Pb	Turb	COD	Susp. Solids	Phenol	DOC	TOC	
	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/lO2	mg/L	
WRQO	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	
KROM/N	<0.020	<0.020	0.026	<0.020	661	54	446	<0.010	13	14	
KROM/S	<0.020	<0.020	0.028	<0.020	218	60	110	<0.010	18	19	

WRQO - Water quality limits specified in the Mooikraal WUL Number 08/C22K/CIGJFAE/6981
N/S - Not specified

The latest 2018 water quality for the Kromelmboogspruit as indicated in Figure 7-2 reveals a calcium bicarbonate signature. At times water quality at Kom/N and Krom/S is observably variable and this can probably be attributed to occasional overflows from PCDs into Kromelmboogspruit which variably occurred since 2010 (Figure 7-3). The May and November 2016 samples were collected just after heavy rains received in the area and the flow rate in the Kromelmboogspruit was higher than usual, therefore, the similarity in water quality signature of the downstream and upstream sampling points during these periods.

The historic data (Figure 7-3) show that elevated chloride and sodium trends have been observed in the past. Higher levels of sodium and chloride were indicated at the downstream Krom/N site than at the upstream Krom/S site.

The latest 2018 EC trends for Krom/N have indicated to be directly influenced by the sodium content. Essentially, the decrease in sodium (latest record) revealed a direct decrease in EC.

As mentioned, the water quality of the Kromelmboogspruit indicates that all parameters are well within the prescribed Mooikraal WUL (License Number 08/C22K/CIGJFAE/6981) limits.

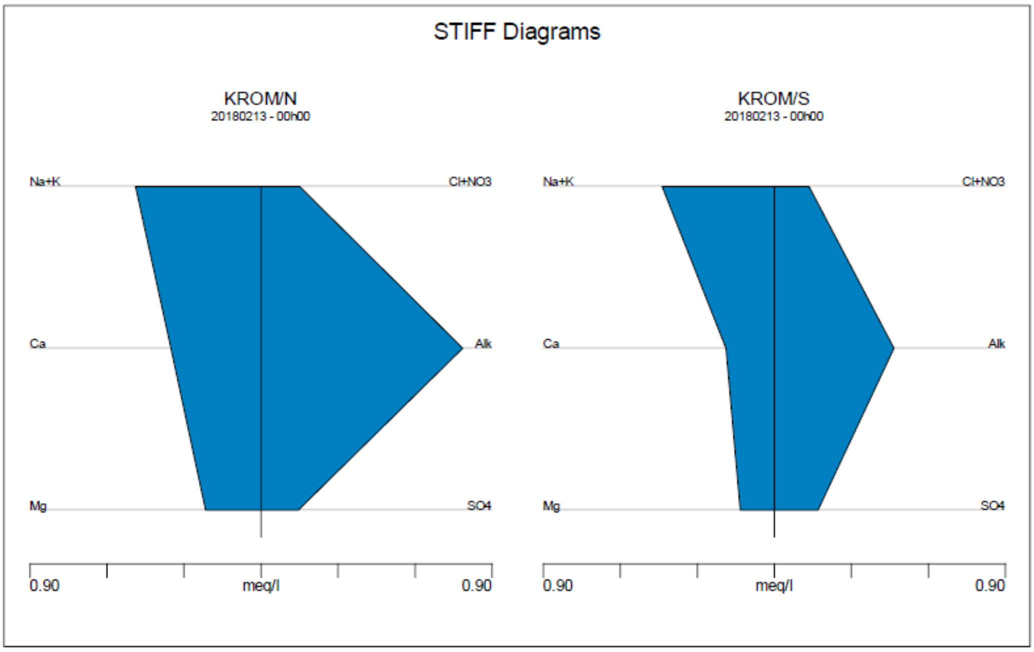


Figure 7-2: Stiff diagrams showing the latest water quality trends in the KromeImboogspruit

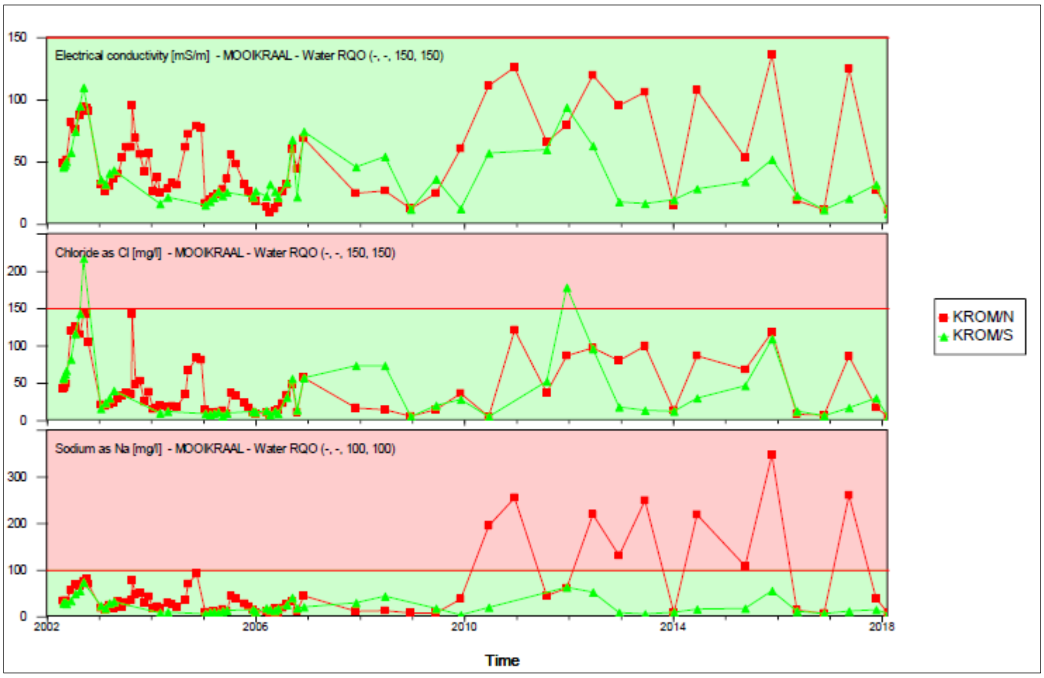


Figure 7-3: Sodium, chloride and electrical conductivity trends for the KromeImboogspruit

7.2 Mooikraal Dirty Surface Water System

The dirty water dam monitoring system consists of three different samples (Table 7-2 and Figure 7-1). The sample at the Adit Sump is referred to as MK-Pit (Photograph 7-1), the blended water from the sump and from underground as MK-Sump (Photograph 7-2), and the sample at the dirty water South/ North PCDs as MK-Dams (Photograph 7-3). MK-Sump was inaccessible for the last 2018 sampling run due to excessive weeding.

Photograph 7-1: Adit Sump (MK-Pit)

Photograph 7-2: Pipe discharging the sump and underground water (MK-Sump)

Photograph 7-3: Mooikraal South & North PCDs or Dirty Water Dams (MK-Dams)

The latest water quality for the Mooikraal dirty water sites including South and North PCDs is presented in Table 7-4 and Figure 7-4. The water quality in all the samples reflects a strong sodium bicarbonate character. These qualities resemble the underlying geology (rich in sodium) and are expected as the water is pumped directly from underground before its quality deteriorates. The sump (MK-Pit) has a more calcium-magnesium bicarbonate character. The historic time series trends (Figure 7-5) similarly correspond to the latest qualities, with the exception of a short period in 2012 that showed different chemical signature.

The total alkalinity observed over time from this dam is indicated in Figure 7-6. Since 2010, a sharp increase in total alkalinity has been observed and it levelled off at values just below 400mg/l. The eventual constant alkalinity, together with an improvement in chloride, has had a huge influence on the electrical conductivity of the dam which also improved slightly.

Table 7-4: Chemical analysis of dirty surface water dams at the Mooikraal (IGS, 2018)

SiteName	EC	pH	Ca	Mg	Na	K	PAlk	MAlk	F	Cl	NO2(N)
	mS/m		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WRQO	<150	5.5 - 9.5	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	<15
MK DAM	117	8.6	26	14	248	3.7	35	391	0.78	90	<0.1
MK PIT	102	8.3	64	50	109	5.3	2	324	0.31	122	<0.1

SiteName	NO3(N)	PO4	SO4	Al	Fe	Mn	NH4(N)	TDS	B	Si	Cd
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WRQO	<15	<10	N/S	N/S	N/S	N/S	<6	N/S	N/S	N/S	N/S
MK DAM	<0.5	<1	113	0.020	<0.020	<0.020	0.24	884	0.808	6.37	<0.003
MK PIT	<0.5	<1	66	0.030	0.024	<0.020	0.16	739	0.369	15.82	<0.003

SiteName	Co	Cr	Cu	Pb	Turb	COD	Susp. Solids	Phenol	DOC	TOC	
	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/lO2	mg/L	
WRQO	N/S	N/S	N/S	N/S	N/S	<75	<25	N/S	N/S	N/S	
MK DAM	<0.020	<0.020	0.017	<0.020	0.68	49	1	<0.010	4	5	
MK PIT	<0.020	<0.020	0.013	<0.020	2.69	11	7	<0.010	5	6	

WRQO - Water quality limits specified in the Mooikraal WUL Number 08/C22K/CIGJFAE/6981
N/S - Not specified

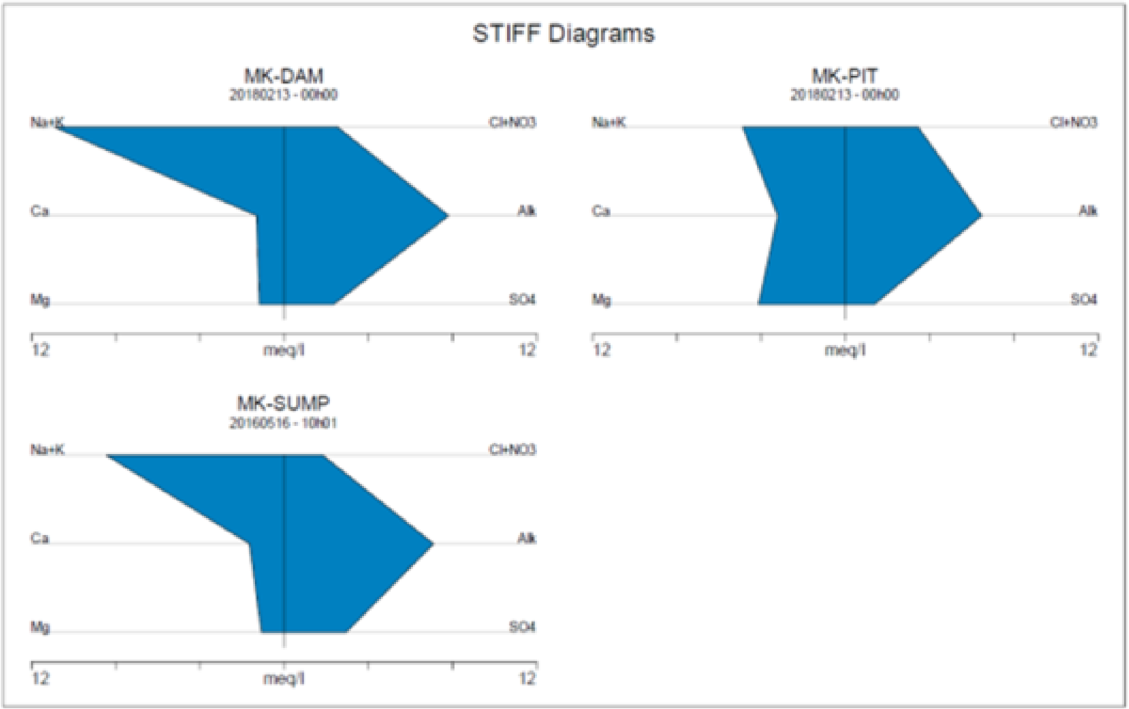


Figure 7-4: Stiff diagrams of the Mooikraal North/South dams, pit and sump

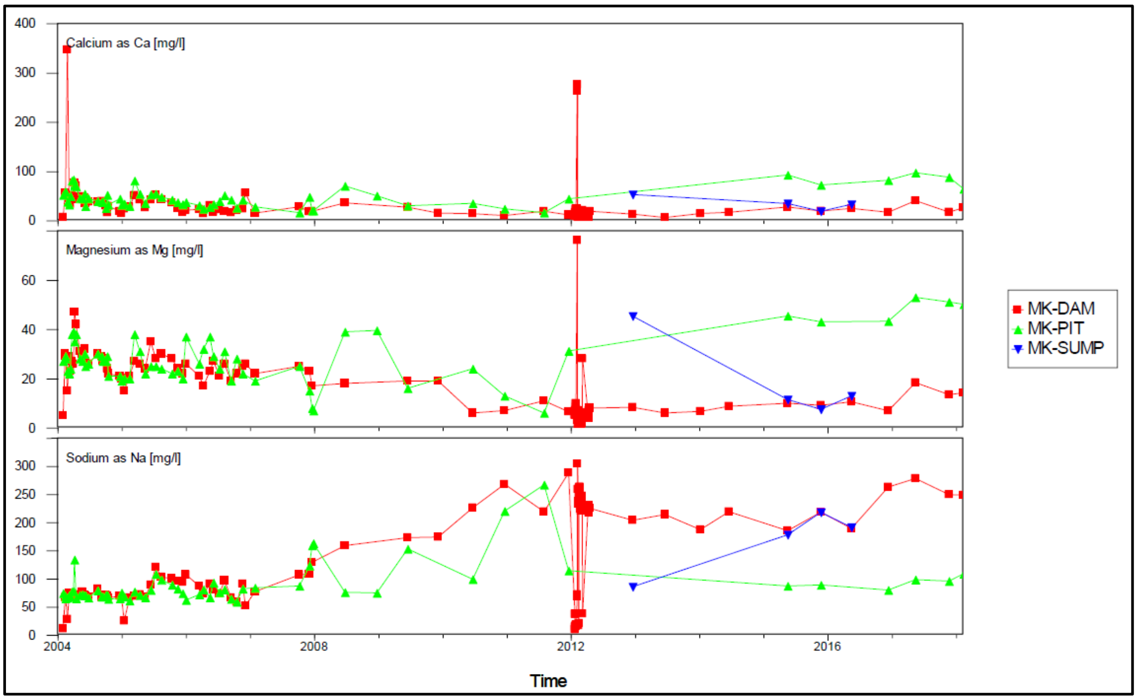


Figure 7-5: Historical time series for calcium, magnesium and sodium in dirty water areas

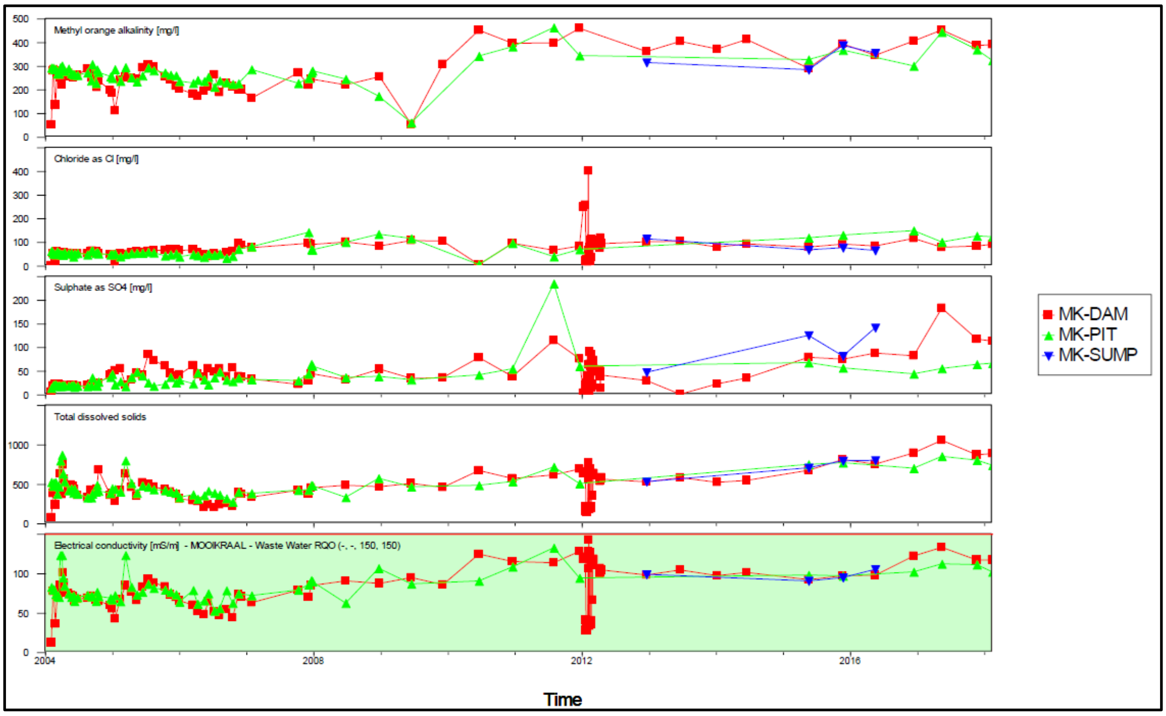


Figure 7-6: Historical time series for alkalinity, chloride, EC, sulphate and TDS in PCDs

Bacteriological analysis indicates E. Coli levels that exceed the WUL (Number 08/C22K/CIGJFAE/6981) RQO limit in the MK-Dam and MK-Pit (Table 7-5).

Table 7-5: *Dirty Water Dams bacteriological analysis results (February 2018).*

Site Name	Faecal Coliform	E. Coli
	CFU/100ml	CFU/100ml
WUL (08/C22K/CIGJFAE/6981) RQO 08/C22K/CIGJFAE/6981) RQO	<1000	0
MK DAM	201	93
MK PIT	23	4

7.3 Sewage Treatment Plant (STP)

The quality of the treated effluent from the Sewage Treatment Plant (STP) is monitored at Mooikraal as required by the WUL (License No. 08/C22K/CIGJFAE/6981). The water quality was benchmarked against the WUL standard limits as indicated in Table 7-6.

EC, pH, TSS, PO_4, Faecal Coliform and E. Coli are generally within acceptable WUL limits during the monitoring period from January 2018 to February 2019. Elevated NO_3 above the WUL limit of 15 mg/L is indicated for most of the monitoring period with a marked drop in February 2019 to below the WUL limit. Ammonia levels are generally within the acceptable WUL limit (6 mg/L) except for samples collected on the 17th of April 2018 and 2nd of February

2019 where slight increases are observed. For almost the whole monitoring period from January to February 2019, Cl levels exceeded the stringent WUL standard limit of 0.25 mg/L. (See Table 7-6).

Table 7-6: Treated effluent quality from Mooikraal Sewage Treatment Plant

Date	Free Chlorine (as Cl_2, mg/l)	COD (mg/l)	pH	EC (mS/m)	TSS (mg/l)	Ammonium (as NH_3, mg/l)	Nitrate (as N, mg/l)	Orthophosate (as P, mg/l)	Faecal Coliform (cfu/100 ml)	Ecoli (cfu/100 ml)
WUL limits	0.25	75	5.5-9.5	70	25	6	15	10	1000.00	0
2018-01-19	0.40	58.00	6.00	54.50	6.00	4.40	25.50	4.67	0.00	0.00
2018-02-20	0.50	30.00	7.47	31.00	2.00	1.90	0.00	0.00	1.00	0.00
2018-03-20	0.30	14.60	6.20	51.80	2.00	0.57	29.00	5.80	0.00	0.00
2018-04-17	0.20	47.00	7.02	60.40	2.00	9.80	23.40	3.90	25.00	0.00
2018-05-15	5.10	22.00	6.78	51.20	2.00	0.16	18.60	2.96	0.00	0.00
2018-06-13	5.00	14.60	6.67	62.30	2.00	0.16	18.90	12.70	0.00	0.00
2018-07-24	2.50	47.00	6.77	45.00	2.80	0.79	18.00	4.20	0.00	0.00
2018-08-21	0.30	14.60	6.45	42.10	2.00	0.16	12.70	4.10	2.00	1.00
2018-09-21	1.10	18.00	5.96	50.00	10.00	0.16	20.50	5.10	0.00	0.00
2018-10-15	5.00	14.60	9.76	249.00	2.00	0.16	12.10	3.40	0.00	0.00
2018-11-20	1.50	75.00	6.01	48.10	2.00	0.22	31.00	5.60	0.00	0.00
2018-12-11	1.20	31.00	6.18	48.00	2.00	0.66	27.00	6.80	0.00	0.00
2019-01-21	1.50	48.00	6.13	52.00	2.00	0.90	37.00	5.02	0.00	0.00
2019-02-18	1.50	76.00	7.09	38.20	2.00	9.40	1.10	3.48	0.00	0.00

7.4 Leeuspruit Water Quality

Monitoring points SIG/5 and SIG/6 represent water quality upstream and downstream of 3 Shaft on a tributary of the Leeuspruit. The water quality was compared against the WUL (License No. 08/C22K/CIGJFAE/6981) standard limits.

From the Stiff diagrams shown in Figure 7-7 the water type of both SIG/5 and SIG/6 can be described as sodium-bicarbonate water with SIG/6 (downstream) more enriched with sulphate (SO_4) than that of the upstream point SIG/5. The change in sulphate concentrations within the Leeuspruit tributary is illustrated in its characters that change from a calcium-bicarbonate water at the upstream point to a sodium-bicarbonate water at the downstream point.

Trend graphs (chemistry against time) for electrical conductivity (EC), pH, SO_4 and chloride (Cl) sourced from the bi-annual IGS report (IGS, 2018) are shown in Figure 7-8.

Bacteriological analysis results are presented in Table 7-7.

Trend analysis for electrical conductivity (EC), pH, SO_4 and chloride (Cl) sourced from the bi-annual IGS report (IGS, 2018) leads to the following conclusions on the Leeuspruit water quality:

- SO_4 levels both upstream and downstream of 3 Shaft are within the WUL acceptable limit of 200 mg/L. Point SIG/5 upstream of 3 Shaft has lower SO_4 concentration than the downstream point (SIG/6) indicating some influence of activities at the existing 3 Shaft Plant and Crusher. The upgrade of the stormwater management plan for 3 Shaft will help to separate clean and dirty areas after the relocation of the 3 Shaft infrastructure.

- Cl and EC are generally within the WUL acceptable limits for all monitoring points at least from 2007 to 2018.
- All other parameters analysed and compared against WUL limits in January 2018 are within acceptable WUL ranges excluding sodium (Na), manganese (Mn), nitrate (NO_3), phosphate (PO_4), total suspended solids (TSS), Faecal Coliform and E. Coli.
- Farming activities including use of pesticides and fertilisers in agricultural fields around the Leeuspruit drainage are possible sources of NO_3, PO_4, and TSS in addition to sediments washed-off by runoff at 3 Shaft;
- Faecal coliform, E Coli exceed WUL limits within the Leeuspruit tributary which can be explained by contamination from regular municipal sewage overflows upstream of 3 Shaft.
- Although the Leeuspruit is perennial, flow volumes and rates are generally low with high flows generally associated with high rainfall events. High runoff can cause the increase in TSS observed in the January results that represent a wet season survey; and
- Mn and Na are naturally occurring elements that are enriched in the soils and geology of the area which is the source of these contaminants (IGS, 2018);

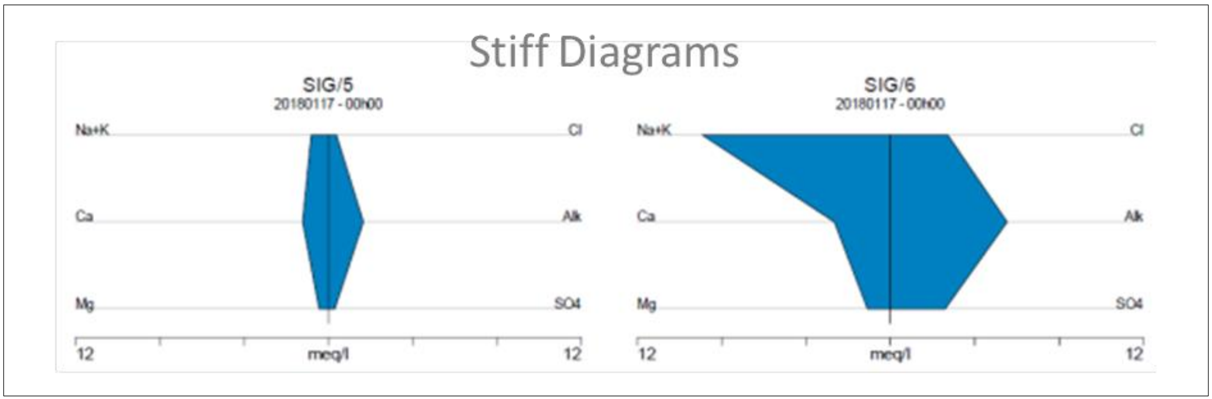


Figure 7-7: Stiff diagrams illustrating the water quality of the Leeuspruit tributary (SIG/5 & SIG/6) (IGS, 2018)

Figure 7-8: Electrical conductivity, pH, chloride and sulphate time graphs for the Leeuspruit tributary (SIG/5 & SIG/6) (IGS, 2018)

Table 7-7: Leeuspruit bacteriological analysis results (IGS, 2018)

Site Name	Faecal Coliform	E. Coli
	CFU/100 ml	
WUL Limit	<1000	0
SG5	65	45
SG6	1825	1380
WUL (No. 08/C22K/CIGJFAE/6981) Standards Limits		

8 Water Balance

The water balance with process flow for Mooikraal-3 Shaft is indicated in Figure 8-1 while the DWS format of the water balance is presented in Table 8-1.

The water balance shows that runoff from dirty areas is captured in the South and North PCDs (MK dirty water dams). The dust suppression volume for Mooikraal is indicated to be 964 569 m^3/annum while that for 3 Shaft is indicated to be 493 339 m^3/annum constituting groundwater from the OG3 and Old 66 pits and rainfall. A treated sewage effluent volume of 25 000 m^3/annum from the Sewage Treatment Plant (STP) (Aerator and Cl2 Tank) is discharged to the natural environment.

The total dust suppression volume of 1 457 908 m^3/annum for Mooikraal and 3 Shaft falls within the WUL limit of 7 440 000 m^3/annum. The volume of treated effluent (25 000 m^3/annum) that is discharged to the natural environment complies with the 30 000 m^3/annum stipulated by the WUL requirements.

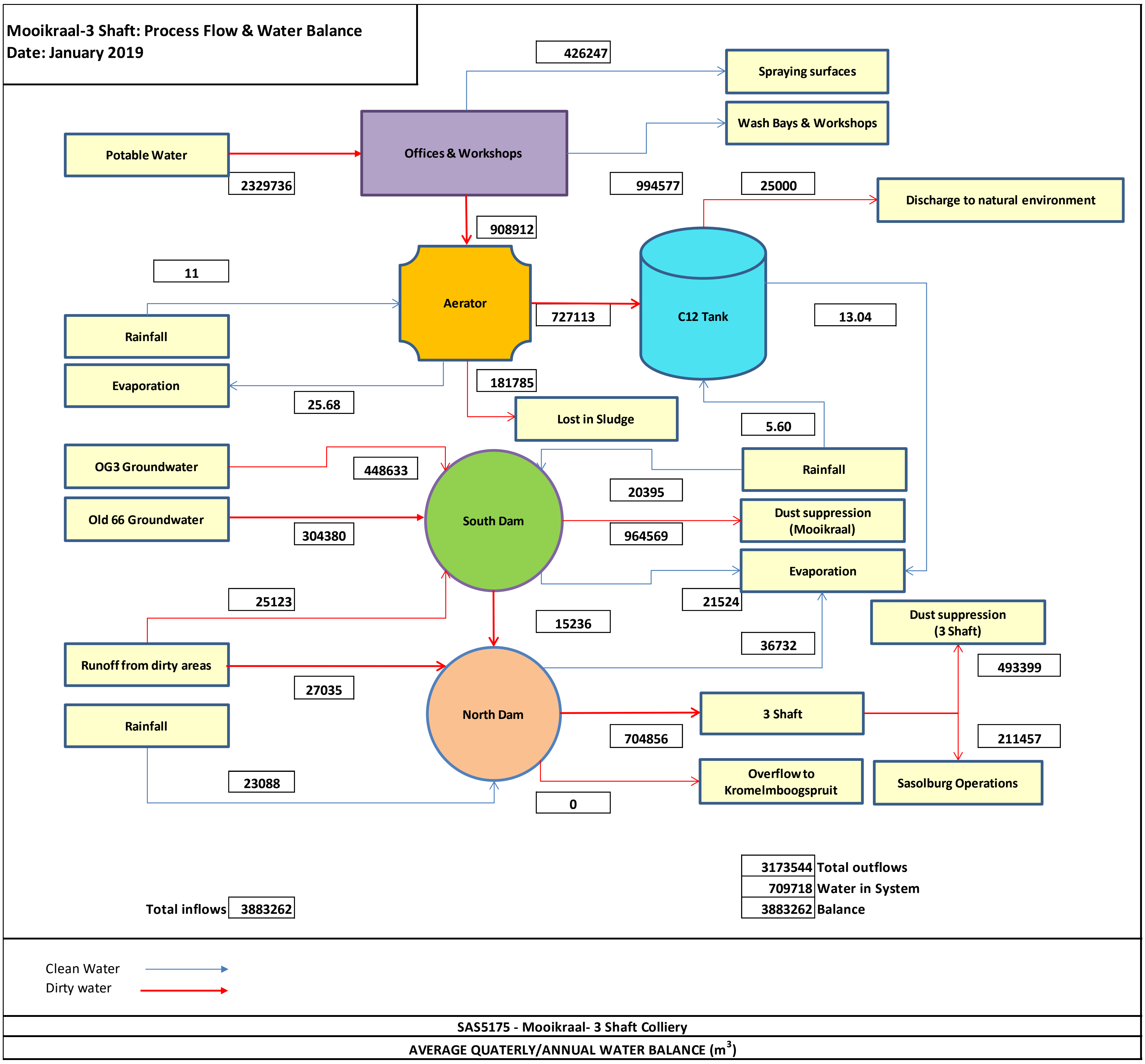


Figure 8-1: Water balance with PFD for the Mooikraal-3 Shaft

Table 8-1: DWS format water balance for the Mooikraal-3 Shaft

Mooikraal - 3 Shaft Water Balance (m^3)					
Facility Name	**Water In**		**Water Out**		**Balance**
	Water Circuit/stream	**Quantity**	**Water Circuit/stream**	**Quantity**	
Offices & Workshops			Spraying Surfaces	426,247	
	Potable Water	2,329,736	Wash Bays & Workshops	994,577	
			Aerator	908,912	
	Total	**2,329,736**		**2,329,736**	**0.00**
Aerator	Rainfall	11	C12 Tank	727,113	
	Offices & Workshop	908,912	Lost in Sludge	181,785	
			Evaporation	25.68	
			Water in storage	0.00	
	Total	**908,923**		**908,923**	**0.00**
C12 Tank	Rainfall	5.6	Discharge to Natural Environment	25,000.0	
	Aerator	727,112.8	Evaporation	13.0	
			Water in storage	702,105	
	Total	**727,118**		**727,118**	**0.00**
South Dam	Rainfall	20,395	North Dam	15,236	
	Runoff from Dirty Water Areas	25,123	Dust suppression at Mooikraal	964,569	
	OG3	448,633	Evaporation & Other losses	160,142	
	Old 66	304,380	Water in storage	46,920	
	Make-up	388,337			
	Total	**1,186,867**		**1,186,867**	**0.00**
North Dam			Evaporation	36,732	
	Rainfall	23,088	Overflow to Kromelmboogspruit	0.00	
	South Dam	15,236	Infrachem at 3 Shaft	704,856	
	Runoff from Dirty Water Areas	27,035	Water in Storage	836	
	Make-up	677,066			
	Total	**742,425**		**742,425**	**0.00**
3 Shaft					
			Sasolburg	211,457	
	North Dam (Mooikraal)	704,856	Dust suppression at 3 Shaft	493,399	
	Total	**704,856**		**704,856**	**0.00**

9 Surface Water Impact Assessment

The surface water impact assessment was completed in the manner described in Section 4.6.

9.1 Identified Potential Surface Water Impacts and Mitigations

The potential surface water impacts were assessed considering the project lifetime including Construction, Operation and Decommissioning/Closure phases. Similar projects were researched on to identify additional impacts and risks and were compared to the context of the proposed development.

9.1.1 Construction Phase (relocation of the 3 Shaft primary plant, crusher & conveyor and associated infrastructure)

Activities during the construction phase that may have potential impacts (Table 9-1) on the surface water resources are described and the appropriate management/mitigation measures are provided below.

Table 9-1: Interaction and Impacts of Activity

Interaction	Impact
Disturbance of soils during relocation of the Primary Plant and Crusher, conveyor belts, coal bunker, and construction of cut-off trenches at the 3 Shaft	Sedimentation and siltation of nearby watercourses most likely leading to deteriorated water quality.
Wetland rehabilitation at the 3 Shaft	Flood attenuation and contribution to base flow leading to naturalised flow regimes and ecosystem support within the Leeuspruit
Washing off of oils, fuels and other hydrocarbon spills during the relocation of conveyor belt, Primary Plant, Crusher, and coal bunker	Surface water contamination and deterioration of water quality

9.1.1.1 *Impact Description: Sedimentation and possible siltation of nearby watercourses due to infrastructure removal at 3 Shaft*

Disturbance of soils during removal of the Primary Plant and Crusher, conveyor belts, and bunker decommissioning at the 3 Shaft will result in soil erosion leading to sedimentation and possible siltation of nearby watercourses.

9.1.1.2 *Impact Description: Flood attenuation and contribution to base flow leading to naturalised flow regimes within the Leeuspruit*

The rehabilitation of the 3 Shaft wetland will have positive effects to the environment and will be beneficial to downstream water users. The rehabilitated wetland will resume its natural functions which include flood attenuation, base flow contribution and subsequent supporting of ecological systems. This will have a positive impact on downstream water users and ecological systems due to sustained water supply and improved water quality within the Leeuspruit.

9.1.1.3 Impact Description: Surface water contamination from hydrocarbon materials

Oils, fuels and other hydrocarbons from earthmoving equipment used during the relocation of conveyor belt, Primary Plant and Crusher, coal bunker and the construction of cut-off trenches can wash off into the nearby Leeuspruit. This impact will lead to the deterioration of water quality, affecting aquatic life and downstream water users.

9.1.1.4 Management/ Mitigation Measures

The following mitigation measures are recommended during the construction activities at 3 Shaft:

- Site preparation for the proposed 3 Shaft Primary Plant and Crusher should be confined to the existing 3 Shaft footprint area to minimise disturbance of soils and the probability of sedimentation and siltation of the Leeuspruit tributary.
- Rehabilitation and revegetation of the disturbed 3 Shaft site after removal of the Primary Plant and Crusher, and the decommissioning of the coal bunker should be undertaken to reduce chances of soil erosion and subsequent sedimentation in nearby streams.
- The storm water management upgrade including construction of cut-off trenches at 3 Shaft should be implemented to include the proposed relocation of the Primary Plant and Crusher facilities as per the DWS GN704 regulation.
- Construction should be undertaken during the dry winter period to reduce sedimentation in the Leeuspruit tributary since there will be minimal to no occurrence of rainfall.
- All storage areas (fuels, paints, oils) used at the construction camp should be appropriately bunded and spill kits should be in place, and construction workers trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills.

Table 9-2: Impact significance rating for the construction phase

Impact: Sedimentation and possible siltation of nearby watercourses due to infrastructure removal at 3 Shaft			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	5	The impact will likely occur for the duration of the project	40-Minor (negative)

Impact: Sedimentation and possible siltation of nearby watercourses due to infrastructure removal at 3 Shaft			
Dimension	**Rating**	**Motivation**	**Significance**
Intensity	2	This will have minor to medium-term impacts resulting in a reduction in water quality for immediate downstream users and the aquatic life	
Spatial scale	3	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the construction phase	14-Negligible (negative)
Intensity	2	Should the impact occur, it will have minor medium-term impacts resulting in a reduction in water quality for downstream users and the aquatic life	
Spatial scale	3	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	2	If mitigation measures are correctly implemented, it will be rare/improbable for this impact to occur.	

Impact: Flood attenuation and toxins filtration leading into improved water quality within the stream			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	7	A very beneficial impact which may be sufficient by itself to justify implementation of the Project. The impact may result in permanent positive change.	119-Major (positive)
Intensity	5	Average to intense environmental enhancements which will benefit ecosystems and downstream water users	
Spatial scale	5	The positive impact will extend across the site and to nearby environments	

Impact: Flood attenuation and toxins filtration leading into improved water quality within the stream			
Dimension	**Rating**	**Motivation**	**Significance**
Probability	7	It is certain/ definite that this impact will occur (there is no mitigation for this impact)	

Impact: Sedimentation and siltation of nearby watercourses due to reconstruction of infrastructure			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	3	The impact will likely occur for the duration of the project	36-Minor (negative)
Intensity	2	This will have minor to medium-term impacts resulting in a reduction in water quality for immediate downstream users and the aquatic life	
Spatial scale	4	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the construction phase	14-Negligible (negative)
Intensity	2	Should the impact occur, it will have minor medium-term impacts resulting in a reduction in water quality for downstream users and the aquatic life	
Spatial scale	3	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	2	If mitigation measures are correctly implemented, it will be rare/improbable for this impact to occur.	

Impact: Surface water contamination from hydrocarbon materials			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	2	The impact will mainly occur during the construction phase	32-Negligible (negative)
Intensity	4	This will moderately impact the water quality and the ecosystem functionality for downstream users	
Spatial scale	2	Limited to the site and its immediate surroundings	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the construction phase	12-Negligible (negative)
Intensity	2	Minor effects on biological or physical environment	
Spatial scale	2	Limited to the site and its immediate surroundings	
Probability	2	With the existing measures already in place. It will be rare/improbable for this impact to occur.	

9.1.2 Operational Phase

Activities during the operational phase that may have potential impacts (Table 9-3) on the surface water resources are described and the appropriate management/mitigation measures are provided below.

Table 9-3: Interactions and Impacts of Activity

Handling of hydrocarbons (oils, fuels and diesel) during maintenance of pipelines and conveyor belt servitudes and general mine operations at Mooikraal and 3 Shaft.	Deterioration of surface water quality from contamination by hydrocarbon materials (oils, fuels and diesel)
Runoff from the new 3 Shaft Plant and Crusher area and at Mooikraal will be polluted possibly with considerable levels of contaminants from mined coal	Water quality deterioration from contaminated runoff

Operation and maintenance of North and South PCDs at Mooikraal, conveyors and surface pipelines transporting mine water during the operational phase	Surface water contamination due to wash-off of spilt coal residues, and unauthorised water use due to spillage/overflow of mine water to the environment
Operation of the Sewage Treatment Plant (STP) and discharge of treated effluent into the natural environment	Surface water contamination from spillage of sewage effluent or discharge of partially treated effluent into the natural environment
Leachate from Waster Rock Dump (WRD) at Mooikraal	Contamination of surface water resources by leachate from Waste Rock Dump

9.1.2.1 Impact Description: Surface water quality deterioration from contamination by hydrocarbons (oils, fuels and diesel)

Handling of hydrocarbons (oils, fuels and diesel) during maintenance of pipelines and conveyors and during general mine operations at Mooikraal and 3 Shaft may lead to contamination of surface water resources when runoff from contaminated areas reports to the nearby streams.

9.1.2.2 Impact Description: Surface water quality deterioration from contaminated runoff

The 3 Shaft Plant and Crusher area, conveyor belt transfer points/drive houses, Stockpile area will be dirty due to contamination by coal residues. Sulphates and other pollutants are expected and these will be carried away in runoff after rainfall events on the area. If not well managed, this dirty runoff will end up contaminating surface water resources in watercourses which are in proximity to the sites.

9.1.2.3 Impact Description: Surface water contamination due to wash-off of spilt coal residues, and unauthorised water use due to spillage/overflow of mine water to the environment

In the event of improper maintenance of PCDs, pipelines and conveyor belts, spillages of mine water and fine coal residues may occur. The spilt coal residues can wash off into nearby watercourses during rainfall events thereby decreasing the in-stream water quality. Incidental PCD overflows and mine water spillages from pipelines may occur resulting in unauthorised water use (spillage/overflow of mine water to the environment) possibly polluting surface water resources. The probability of PCD overflows is, however, very low due to installed pipelines which transfer surplus PCD water to other functional areas for re-use before PCD freeboard is exceeded.

9.1.2.4 Impact Description: Surface water contamination from spillage of sewage effluent or discharge of partially treated effluent into the natural environment

Spillages of sewage effluent from the sewage treatment plant infrastructure or discharges of contaminated effluent not treated to acceptable levels may result in the pollution of surface water resources.

9.1.2.5 Impact Description: Contamination of surface water resources by leachate from Waste Rock Dump

The waste rock dump at Mooikraal is a potential source of contamination; once material is exposed to oxygen and rainfall, leachate generating reaction may occur and introduce contamination into the groundwater environment via seepage. Total concentration analysis identified Ba and Cu as potential elements of concern however these results are a worst case scenario. Leachable concentration analysis, which is the most representative of the expected leachate at the site, shows no concern within regards to the leachate expected to emanate from the dump.

9.1.2.6 Management/ Mitigation Measures

The following mitigation measures are recommended:

- The clean-up and rehabilitation after spillages of coal at the overland conveyor transfer points/drive houses to 3 Shaft and the MK2 conveyor belt to the Silo at Mooikraal should be conducted immediately and appropriately managed to control the spread of the impact to the external environment;
- All mine infrastructure (PCDs, Sewage Treatment Plant, Pipelines, conveyor belts) must be put onto a planned maintenance system to ensure that regular inspections and maintenance is undertaken to prevent spillages at both Mooikraal and 3 Shaft.
- The storm water management must be implemented so that dirty water from these areas is contained within the mine for re-use.
- Constant monitoring of PCD volumes should be undertaken in order to detect any rise in water levels that may lead to PCD overflows. This is necessary, especially during rainfall events, to ensure that any extra water is quickly transferred through the already installed pipelines away from the PCDs for re-use before any overflows can occur.
- Sewage Treatment infrastructure should regularly be checked and maintained to reduce chances of leakages of contaminated effluent into the natural environment.
- Monitoring of treated sewage effluent quality should continue to ensure that all discharges into the Kromelmboogspruit are within acceptable WUL limits.
- The waste rock dump should be maintained with slopes that reduce pooling of water, to reduce the amount of leachate generation. Stormwater management must be placed around the facility to ensure dirty water is contained.

Table 9-4: Impact significance rating for the operation phase

Impact: Surface water quality deterioration from contamination by hydrocarbons (oils, fuels and diesel)			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	5	The impact will cease after the operational life span of the project	44-Minor (negative)
Intensity	4	Extending across the site and to nearby environment affecting downstream water users.	
Spatial scale	2	The impact will be localised, extending only across the site and to nearby environment.	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post- Mitigation			
Duration	3	The impact will occur for the duration of the project and should be mitigated as recommended	14-Negligible (negative)
Intensity	2	The impact will have negligible effect with mitigation measures in place.	
Spatial scale	2	The impact spatial extent will be limited to the incident site.	
Probability	2	With mitigation measures in place, it will be rare/improbable for this impact to occur	

Table 9-5: Impact significance rating for the operation phase

Impact: Surface water quality deterioration from contaminated runoff			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	4	The impact will cease after the operational life span of the mines	36-Minor (negative)
Intensity	3	Moderate, short-term effects which might affect ecosystem functions.	
Spatial scale	2	The impact will be localised, extending only across the site and to nearby environment.	
Probability	4	Without appropriate mitigation, it is probable that this impact will occur	
Post- Mitigation			

Duration	3	The impact will occur for the duration of the project and should be mitigated as recommended	14-Negligible (negative)
Intensity	2	The impact will have negligible effect with mitigation measures in place.	
Spatial scale	2	The impact spatial extent will be limited to the incident site.	
Probability	2	With mitigation measures in place, it will be rare/improbable for this impact to occur	

Impact: Surface water contamination due to leakage of dirty water and fine coal residues			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	5	The impact will cease after the operational life span of the pipelines and conveyors	27-Negligible (negative)
Intensity	2	Moderate, short-term effects which might affect ecosystem functions.	
Spatial scale	2	Limited to the site and its immediate surroundings.	
Probability	3	There is a possibility that the impact will occur.	
Post- Mitigation			
Duration	3	The impact will occur for the duration of the project and should be mitigated as recommended	14-Negligible (negative)
Intensity	2	The impact will have negligible effect with mitigation measures in place.	
Spatial scale	2	The impact spatial extent will be limited to the incident site.	
Probability	2	With mitigation measures in place, it will be rare/improbable for this impact to occur	

Impact: Contamination of surface water resources by leachate from Waste Rock Dump			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	4	The impact will cease after the operational phase when the WRD is backfilled into the Mooikraal Shaft at closure.	16-Negligible (negative)

Intensity	2	Leachable concentration analysis indicates no concern of the representative leachate to the environment, but worst case potential concern of Barium and Copper	
Spatial scale	2	Limited to the site and its immediate surroundings.	
Probability	2	Though conceivable, but only in extreme circumstances, it is improbable that this impact will occur	
Post- Mitigation			
Duration	2	Leachate intensity is already low so with recommended mitigation the duration will be very short	10-Negligible (negative)
Intensity	1	With mitigation measures in place impact intensity will be negligible.	
Spatial scale	2	The impact spatial extent will be limited to the incident site.	
Probability	2	With mitigation measures in place, it will be rare/improbable for this impact to occur	

9.1.3 Decommissioning and Closure Phase

Activities during the closure phase include dismantling and removal of infrastructure and surface rehabilitation. Potential impacts on the surface water resources are described (Table 9-6) and appropriate management/mitigation measures are provided below. The waste rock dump is proposed to be backfilled into the shaft, therefore, it will not exist as a potential contamination source at the surface at mine closure.

Table 9-6: Interactions and Impacts of Activity

Interaction	Impact
Disturbance of soils during removal of infrastructure at both Mooikraal and 3 Shaft	Sedimentation and siltation of watercourses leading to deteriorated water quality.
Spillages of hydrocarbons (oils, fuels and grease) by vehicles and machinery used during demolition and transportation of material from decommissioned infrastructure	Surface water contamination due to hydrocarbon waste spillages
Reaction of sulphide compounds in extracted coal residues with water and oxygen	Potential surface water pollution from possible decant of contaminated groundwater from mine shaft, ventilation shaft and boreholes

9.1.3.1 Impact Description: Sedimentation and siltation of watercourses leading to deteriorated water quality

Removal of infrastructure will expose and disturb the soil and leave it prone to erosion which leads to increased sedimentation and possible siltation of nearby watercourses (Kromelmboogspruit at Mooikraal and Leeuspruit at 3 Shaft).

9.1.3.2 Impact Description: Surface water contamination leading to deteriorated quality due to hydrocarbon waste spillages

Water contamination may occur from spillages of hydrocarbons (oils, fuels and grease) by vehicles and machinery used during infrastructure demolition activities.

9.1.3.3 Impact Description: Possible decant from mine shaft, ventilation shaft and boreholes leading to contamination of the natural streams

- Potential surface water pollution from possible decant of contaminated groundwater is envisaged from mine shaft, ventilation shaft and boreholes. The groundwater model outcome, however, predicts a very low probability of decant at the Mooikraal-3 Shaft area (IGS, 2018).

9.1.3.4 Management/ Mitigation Measures

The following mitigation measures are recommended:

- Use of accredited contractors for removal or demolition of infrastructure must be adhered to, in order to reduce the risk of waste generation and accidental spillages;
- Landscape re-profiling must be undertaken on rehabilitated land to allow good drainage. This will ensure improvement of catchment yield close to pre-mining conditions in the surrounding Kromelmboogspruit and Leeuspruit watercourses.
- The possibility of contaminated decant can be reduced by sealing-off mine shafts and boreholes with cement and plugging them with concrete.

Table 9-7: Impact significance rating for the closure and rehabilitation phase

Impact: Sedimentation and siltation of watercourses leading to deteriorated water quality			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	2	The impact will likely occur during the closure phase only	40-Minor (negative)
Intensity	3	This will have medium-term impacts resulting in a reduction in water quality for immediate downstream users and the aquatic life	
Spatial scale	3	The impacts will be localised, only extending across the site and to nearby settlements	
Probability	5	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the closure phase	14-Negligible (negative)
Intensity	2	With the recommended mitigation measures in place, the impact intensity will be low.	
Spatial scale	3	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	2	If the recommended mitigation measures are correctly implemented, it will be rare/improbable for this impact to occur.	

Impact: Surface water contamination due to hydrocarbon waste spillages			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	2	The impact will likely occur during the closure phase only	45-Minor (negative)
Intensity	3	This will have medium-term impacts resulting in a reduction in water quality for immediate downstream users and the aquatic life	
Spatial scale	4	The impact extends across the site and to nearby settlements	

Impact: Surface water contamination due to hydrocarbon waste spillages			
Dimension	**Rating**	**Motivation**	**Significance**
Probability	5	Without appropriate mitigation, it is probable that this impact will occur	
Post-mitigation			
Duration	2	The impact will likely only occur during the closure phase	12-Negligible (negative)
Intensity	2	With the recommended mitigation measures in place, the impact intensity will be low.	
Spatial scale	2	The impacts will be localised to the nearby water resources from where the silt is being generated to the immediate downstream	
Probability	2	If the recommended mitigation measures are correctly implemented, it will be rare/improbable for this impact to occur.	

Impact: Surface water pollution from decant of contaminated groundwater from mine shaft, ventilation shaft and boreholes			
Dimension	**Rating**	**Motivation**	**Significance**
Duration	5	The impact will remain beyond project life	39-Minor (negative)
Intensity	4	High significant impact on the environment. Irreparable damage to highly valued species, habitat or ecosystem.	
Spatial scale	4	Decant contamination may affect surface water in the Kromelmboogspruit	
Probability	3	Unlikely to happen, but the possibility of it happening cannot be ruled out	
Post-mitigation			
Duration	3	The impact may remain only for the duration of the life of the project.	24-Negligible (negative)
Intensity	1	With effective prevention of the oxidation of iron sulphides the AMD impact will have low to moderate intensity	
Spatial scale	2	Limited to the site and its immediate surroundings.	
Probability	4	It is probable the impact will occur.	

9.1 Residual Impacts

No further residual impacts are envisaged post closure apart from the low-probability decant as described under the decommissioning phase.

9.2 Cumulative Impacts

Cumulative impacts on surface water resources were viewed in the light of similar mining or related operations within the Vaal River Catchment in general, the Kromelmboogspruit and Leeuspruit catchments in particular. Impacts which result from past, present and future activities at the Sasolburg Operations and the Defunct Sigma Colliery are likely to have cumulative impacts on surface water resources adding onto those from operations at 3 Shaft. Carbonaceous materials, sulphate compounds and sewage effluent emanating from the aforementioned facilities (Defunct Sigma Colliery & Sasolburg Operations) are expected to incrementally impact on the Leeuspruit and the Vaal River downstream of 3 Shaft. Based on the above discussion it is clear that cumulative impacts may be significant in this area.

9.3 Unplanned Events and Low Risks

The potential risks or unplanned events involve accidental spillages of hazardous substances (e.g. hydrocarbons, dirty process water) from pipeline and waste storage facilities during construction, operation and closure phases (Table 9-8). This may lead to impacts on water quality in the surrounding streams, should runoff from these contaminated areas enter the system.

Table 9-8: Unplanned events, associated risks and mitigation measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Hazardous material spillage	Surface water contamination	An emergency spillage response plan and spill kits should be in place and accessible to the responsible monitoring team. The Material Safety Data Sheets (MSDS) should be kept on site for reference purposes regarding handling, storage and disposal of materials.
Pipeline Bursts	Contamination from dirty water that gushes into the environment	All infrastructures should be put onto planned maintenance to ensure that regular maintenance and inspections are done on the pipeline to minimise chances of bursts and leakages or that this is picked up as soon as possible should it occur.

10 Surface Water Monitoring Plan

10.1 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.

Monitoring is currently being conducted at Mooikraal and 3 Shaft. However, the monitoring plan provides a surface water monitoring programme which includes the proposed relocation of the 3 Shaft Primary Plant, Crusher, bunker and the upgrading of the storm water management system. Surface water monitoring should continue at Mooikraal (Upstream and Downstream of Mooikraal on Kromelmboogspruit; in all dirty water dams & sumps; at the discharge point of treated sewage effluent from the STP) and at 3 Shaft (Upstream and Downstream of 3 Shaft on Leeuspruit tributary and in the dirty water PCD). Monitoring frequencies specific to different phases of the project are described in this monitoring plan. All water quality results should be benchmarked to the Mooikraal WUL (No. 08/C22K/CIGJFAE/6981) to determine any impact on the quality of water (positive/negative).

The surface water monitoring plan is summarised in Table 10-1.

Table 10-1: Surface Water Monitoring Plan

WUL condition number		Monitoring Point	Parameters	Sampling method	Monitoring points	Method of analysis	Frequency of Sampling	Reporting to DWS	Responsible Person
Mooikraal Monitoring (Kromelmboogspruit)									
no condition		Surface Water Upstream and Downstream of Mooikraal - Kromelmboogspruit	EC	grab sample	refer to monitoring plan	Electrode	Monthly during Operation & Monthly for 3 years after Closure of mine	Annual report	Environmental Practitioner
			pH			Electrode			
			TDS			Gravimetric			
			NH_3			Spectrophotometric			
			Na			Spectrophotometric			
			COD			Spectrophotometric			
			SO_4			chromatography			
			Ca			Spectrophotometric			
			Mg			Spectrophotometric			
			Cl			chromatography			
			NO_2/NO_3			chromatography			
			PO4			chromatography			
			F			chromatography			
Sewage treatment plant - effluent (only Mooikraal)									
Appendix V Section 21 (f)	2.1	Quality of sewage effluent discharged to Kromelmboogspruit	pH	grab sample	refer to monitoring plan	Electrode	Weekly	6 monthly - bi-annual water report	Environmental Practitioner
			EC			Electrode			
			Suspended solids			Gravimetric			
			NO_2/ NO_3			chromatography			
			NH3			Spectrophotometric			
			COD			Spectrophotometric			
			E. coli			membrane filtration			
			Faecal coliforms			membrane filtration			
			free Cl_2			Electrode			
			PO4			chromatography			
3 Shaft Monitoring (Leeuspruit tributary)									
no condition		Surface Water Upstream and Downstream of 3 Shaft - tributary of Leeuspruit)	EC	grab sample	refer to monitoring plan	Electrode	Fortnightly during construction of Primary Plant, Crusher; Monthly during Operation; Monthly for 3 years after mine Closure	Annual report	Environmental Practitioner
			pH			Electrode			
			TDS			Gravimetric			
			NH_3			Spectrophotometric			
			Na			Spectrophotometric			
			COD			Spectrophotometric			
			SO_4			chromatography			
			Ca			Spectrophotometric			
			Mg			Spectrophotometric			
			Cl			chromatography			
			NO_2/NO_3			chromatography			
			PO4			chromatography			
			F			chromatography			
Dirty Water Dams at Mooikraal and 3 Shaft									
no condition		South & North Dams; Sumps (Mooikraal); PCD at 3 Shaft	EC	grab sample	refer to monitoring plan	Electrode	Monthly	no requirement to report currently	Environmental Practitioner
			pH			Electrode			
			TDS			Gravimetric			
			NH_3			Spectrophotometric			
			Na			Spectrophotometric			
			COD			Spectrophotometric			
			SO_4			chromatography			
			Ca			Spectrophotometric			
			Mg			Spectrophotometric			
			Cl			chromatography			
			NO_2/NO_3			chromatography			
			PO4			chromatography			
			F			chromatography			
Water Volumes (Mooikraal and 3 shaft)									
Appendix II section 21 (a)	2 & 7.1	volume	Volume of water used underground for dust suppression	flowmeter readings	refer to monitoring plan	125 652 m^3/ annum	daily, recorded on the last day of the month	6 monthly - bi-annual water report	Environmental Practitioner
Appendix V Section 21 (f)	3.1.1	volume	volume of water containing waste discharged to the Kromelmboogspruit	flowmeter readings		30 000 m^3/annum	metered on a daily basis at the discharge point	6 monthly - bi-annual water report	
Appendix VI section 21 (g)	2.1	volume	volume of water for dust suppression at 3 shaft	flowmeter readings		7 444 000 m^3/annum	daily, recorded on the last day of the month	6 monthly - bi-annual water report	
Appendix VI section 21 (g)	2.1	volume	volume of water entering the North and South dam	flowmeter readings		9 524 000 m^3/annum	volume of water as per section 21 (j) will confer to the dam volumes	6 monthly - bi-annual water report	
Appendix VII section 21 (j)	1	volume	Volume of water removed from underground at Mooikraal Mine (property portion 2 of)Mooikraal 356	flowmeter readings		9 524 000 m^3/annum	metered and recorded on a daily basis	6 monthly - bi-annual water report	
Appendix VII section 21 (j)	1	volume	volume of water removed from underground at vent shaft (property Kleinvlei 66)	flowmeter readings		2 604 000 m^3/annum	metered and recorded on a daily basis	6 monthly - bi-annual water report	
		volume	potable water received from Randwater	flowmeter readings			monthly	annually as WCWD plan	

10.2 Proposed Surface Water Monitoring Points

Surface water monitoring should continue within the Kromelmboogspruit (Upstream & Downstream), Sewage Treatment Plant treated effluent and in the North and South PCDs (MK-Dams) and MK- Sump at Mooikraal and within the Leeuspruit tributary (Upstream & Downstream) at 3 Shaft and in PCD. Coordinates of the surface water monitoring points are presented in Table 10-2.

Table 10-2: Surface water monitoring points at Mooikraal – 3 Shaft

Area	Site ID	Comments	Coordinates	
			Latitude	Longitude
Mooikraal	MK-DAMS	South PCD	-25.0341333	29.57283333
		North PCD	-25.918097	29.5855778
Mooikraal	MK-PIT	Decline Shaft Pit	-26.946196°	27.728363°
Mooikraal	MK-SUMP	Dirty runoff enters MK- Dam at the South PCD end	-26.943833°	27.728728°
Mooikraal	KROM/N	Kromelmboogspruit downstream of the Mooikraal Shaft	-26.922308°	27.712806°
Mooikraal	KROM/S	Kromelmboogspruit upstream of the Mooikraal Shaft	-27.034387°	27.743567°
Mooikraal	STP	Sewage Treatment Plant treated effluent	-	-
3 Shaft	SG/5	Downstream of Zamdela and upstream of 3 Shaft on Leeuspruit tributary	-26.849165°	27.844471°
3 Shaft	SG/6	Downstream of 3 Shaft on Leeuspruit tributary	-26.845097°	27.829692°
3 Shaft	PCD	3 Shaft PCD	-	-

11 Conclusions

11.1 Baseline hydrology

The Mooikraal-3 Shaft region is characterised by moderate to high rainfall with the MAP ranging from 619 mm to 644 mm. Annual average runoff depth is moderate ranging between 35.5 mm and 57.28 mm. High evaporative losses of the order of 1650 mm, are experienced annually, on average.

Normal rainfall (90% of events) for the wettest month of January will likely not exceed 56 mm. Extreme rainfall (10% of events) for January will likely not exceed 171 mm. Normal runoff depth during the wettest month (January) will likely not exceed 1.1 mm. Runoff resulting from extreme events in January will likely not exceed 33.4 mm.

11.2 Floodlines

The 1:50-year and 1:100-year floodlines for parts of the Kromelmboogspruit (at Mooikraal) and the Leeuspruit (along the conveyor belt/pipeline river crossings and at 3 Shaft) were determined. The 7Ml/day pipeline traverses the Kromelmboogspruit at one point, while the 10Ml/day pipeline crosses a tributary of the Kromelmboogspruit once and Leeuspruit tributaries at three points along its length. Flood extents for all the pipeline/river crossings were determined and mapped and these will provide guidance on the placement of various infrastructures so as to avoid flooding of infrastructure and subsequent water contamination.

No infrastructure at Mooikraal is within the 1:100-year floodline. The existing Primary Plant at 3 Shaft falls within the 1:100-year floodline on the Leeuspruit tributary. The proposed relocation should consider the demarcated flood extent in order to avoid inundation of the proposed new plant and crusher infrastructure.

The modelled floodlines are for indicative purposes only, and not meant for any engineering designs. They should be used as a general indication of infrastructure placement, if new mining infrastructure is to be constructed at both the Mooikraal and 3 Shaft sites.

11.3 Water Quality

A water quality assessment was conducted for the Kromelmboogspruit, Dirty Water Dams or PCDS and the Sewage Treatment Plant (STP) at Mooikraal and the Leeuspruit at 3 Shaft and benchmarked against the Water Use License (WUL) limits (Number: 08/C22K/CIGJFAE/6981).

11.3.1 Kromelmboogspruit

Surface water quality upstream (KROM/S) and downstream (KROM/N) of Mooikraal on the Kromelmboogspruit is within the WUL standard limits.

11.3.2 Mooikraal Dirty Water Dams (Sump, South & North PCDs)

The water quality in dirty water dams (South & North PCDs) at Mooikraal reflects a strong sodium bicarbonate character typical of the underlying geology (rich in sodium). The water from the Mooikraal Adit Sump has a more calcium-magnesium bicarbonate character. A sharp increase in total alkalinity occurred in 2010 which later levelled off at values just below 400mg/l.

11.3.3 Sewage Treatment Plant (STP)

The quality of treated effluent from the Sewage Treatment Plant (STP) is monitored at Mooikraal as required by the WUL (License No. 08/C22K/CIGJFAE/6981). EC, pH, TSS, PO_4, Faecal Coliform and E. Coli are generally within acceptable WUL limits during the monitoring period from January 2018 to February 2019. Elevated NO_3 above the WUL limit of 15 mg/L is indicated for most of the monitoring period with a marked drop in February 2019 to below the WUL limit. Ammonia levels are generally within the acceptable WUL limit

(6 mg/L) except for samples collected on the 17th of April 2018 and 2nd of February 2019 where slight increases are observed. For almost the whole monitoring period from January to February 2019, Cl levels exceeded the stringent WUL standard limit of 0.25 mg/L. (See Table 7-6).

11.3.4 3 Shaft

Trend analysis for electrical conductivity (EC), pH, SO_4 and chloride (Cl) sourced from the bi-annual IGS report (IGS, 2018) leads to the following conclusions on the Leeuspruit water quality:

- SO_4 levels both upstream and downstream of 3 Shaft are within the WUL acceptable limit of 200 mg/L. Point SIG/5 upstream of 3 Shaft has lower SO_4 concentration than the downstream point (SIG/6) indicating some contamination from activities at the existing 3 Shaft Plant and Crusher.
- Cl and EC are generally within the WUL acceptable limits for all monitoring points at least from 2007 to 2018.
- All other parameters analysed and compared against WUL limits in January 2018 are within acceptable WUL ranges excluding sodium (Na), manganese (Mn), nitrate (NO_3), phosphate (PO_4), total suspended solids (TSS), Faecal Coliform and E. Coli.
- Farming activities including use of pesticides and fertilisers in agricultural fields around the Leeuspruit drainage are possible sources of NO_3, PO_4, and TSS in addition to sediments washed-off by runoff at 3 Shaft;
- Faecal coliform, E Coli exceed WUL limits within the Leeuspruit tributary which can be explained by contamination from regular municipal sewage overflows upstream of 3 Shaft.
- Although the Leeuspruit is perennial, flow volumes and rates are generally low with high flows generally associated with high rainfall events. High runoff can cause the increase in TSS observed in the January results that represent a wet season survey; and
- Mn and Na are naturally occurring elements that are enriched in the soils and geology of the area which is the source of these contaminants (IGS, 2018);

11.4 Water Balance

The water balance shows that runoff from dirty areas is captured in the South and North PCDs (MK-Dam) at Mooikraal. The dust suppression volume for Mooikraal is indicated to be 964 569 m3/annum while that for 3 Shaft is 493 339 m^3/annum constituting groundwater from the OG3 and Old 66 pits and rainfall. A treated sewage effluent volume of 25 000 m^3/annum from the STP (Aerator and Cl2 Tank) is discharged to the natural environment.

The total dust suppression volume of 1 457 908 m^3/annum for Mooikraal and 3 Shaft falls within the WUL limit of 7 440 000 m^3/annum. The volume of treated effluent (25 000 m^3/annum) that is discharged to the natural environment complies with the 30 000 m^3/annum stipulated by the WUL requirements.

11.5 Surface Water Impact Assessment

Identified potential surface water impacts include the following:

11.5.1 Construction Phase

- Sedimentation and siltation of nearby watercourses that may lead to deteriorated water quality. This impact will result from the washing away of disturbed soils during removal of the existing 3 Shaft Primary Plant and Crusher, conveyor belts, and coal bunker. Disturbance of soils will also occur during site preparation for the reconstruction of the proposed Primary Plant and Crusher, and conveyor belts and the upgrading of the storm water infrastructure at 3 Shaft.
- Deterioration of surface water quality from contamination by carbonaceous materials such as oils and fuels which are washed off into the Leeuspruit tributary. The hydrocarbons will come from heavy machinery used during demolition of the existing mine plant, crusher and bunker as well as during site preparation for reconstruction of the aforementioned facilities at 3 Shaft.
- Flood attenuation and contribution to base flow by rehabilitated wetland at 3 Shaft will lead to naturalised flow regimes and ecosystem support within the Leeuspruit. This impact will positively benefit the aquatic environment and downstream water users. The rehabilitation process will take place during the construction of the relocated primary plant and crusher at 3 Shaft.

11.5.2 Operational Phase

- Deterioration of surface water quality from contamination by hydrocarbon materials (oils, fuels and diesel). Handling of the hydrocarbons during maintenance of pipelines and conveyors and during general mine operations at both Mooikraal and 3 Shaft may lead to contamination of surface water resources when runoff from contaminated areas reports to nearby streams.
- Water quality deterioration from contaminated runoff. Runoff from dirty areas at 3 Shaft (plant, crusher and stockpile areas) and at Mooikraal (Waste storage area, South & North PCDs, hydrocarbon waste storage areas such as the bulk hydraulic oil and diesel storage area, shaft and workshop areas) will be dirty with possible high levels of contaminants.
- Surface water contamination due to spillage of mine water from transfer pipelines (the 5 and 10 Ml/day pipeline within the conveyor belt servitude) and coal spillages under the MK 1 and 2 belts, as well as at the drive houses/ transfer points along the

MK 3 – 8 belt series during the operational phase. Such spillage may occur not only from damage to the pipelines but also due to lack of maintenance resulting in leaks at the flanges or connecting points.

- Surface water contamination from spillage of sewage effluent or discharge of partially treated effluent into the natural environment. The spillages may occur due to damaged or poorly maintained infrastructure at the mine site. Discharges of contaminated effluent not treated to acceptable levels may also result in the contamination of surface water resources. Sewage polluted water promote algal growth and increase biological oxygen demand resulting in the death of aquatic life, including fish.

- The waste rock dump at Mooikraal is a potential source of contamination; once material is exposed to oxygen and rainfall, leachate generating reaction may occur and introduce contamination into the groundwater environment via seepage. Total concentration analysis identified Ba and Cu as potential elements of concern however these results are a worst case scenario. Leachable concentration analysis, which is the most representative of the expected leachate at the site, shows no concern within regards to the leachate expected to emanate from the dump.

11.5.3 Decommissioning/Closure Phase

- Sedimentation and siltation of watercourses that leads to deteriorated water quality. Disturbance of soils during demolition and removal of infrastructure at both Mooikraal and 3 Shaft will result in generation of more sediment which will reach the Kromelmboogspruit and Leeuspruit Rivers and their tributaries.
- Surface water contamination that leads to deteriorated water quality due to hydrocarbon waste. Oils, fuels and grease spills during demolition and transportation of material from decommissioned infrastructure at both Mooikraal and 3 Shaft may be washed into the Kromelmboogspruit and Leeuspruit Rivers and their tributaries.
- Potential surface water pollution from possible decant of contaminated groundwater is envisaged from mine shaft, ventilation shaft and boreholes. The groundwater model outcome, however, predicts a very low probability of decant at the Mooikraal-3 Shaft area (IGS, 2018).

12 Recommendations

12.1 Construction Phase

The modelled floodlines are for indicative purposes only, and not meant for any engineering designs. They should be used as a general indication of infrastructure placement, if new mining infrastructure is to be constructed at both the Mooikraal and 3 Shaft sites.

The storm water management plan at 3 Shaft should be implemented to include the proposed relocation of the Primary Plant and Crusher facilities as per the DWS GN704 regulation. Construction should be undertaken during the dry winter period to reduce sedimentation in the Leeuspruit tributary since there will be minimal to no occurrence of rainfall. Site preparation for the proposed 3 Shaft Primary Plant and Crusher should be confined to the existing 3 Shaft footprint area to minimise disturbance of soils and the probability of sedimentation and siltation of the Leeuspruit tributary.

All storage areas for oils, fuels, paints and other chemicals should be appropriately bunded and spill kits should be in place, construction workers should be trained in the use of spill kits, to contain and immediately clean up any potential leakages or spills during the construction.

Water quality monitoring 3 Shaft should continue fortnightly upstream (SG/5 and SG/6) and downstream of 3 Shaft on the Leeuspruit tributary during the construction of the primary plant and crusher.

12.2 Operation Phase

The clean-up and rehabilitation after spillages of coal at the overland conveyor transfer points/drive houses to 3 Shaft and the MK2 conveyor belt to the Silo at Mooikraal should be conducted immediately and appropriately managed to control the spread of the impact to the external environment.

All mine infrastructure (PCDs, Sewage Treatment Plant, Pipelines, conveyor belts) must be put onto a planned maintenance system to ensure that regular inspections and maintenance is undertaken to prevent spillages at both Mooikraal and 3 Shaft.

The storm water management infrastructure at 3 Shaft should be upgraded to include the proposed new Primary Plant and Crusher, and conveyor belt facilities so that dirty water from these areas is contained within the mine for re-use. Construction of the proposed cut-off trenches at the Stockpile area should be implemented to separate dirty runoff from the clean environment; and

Constant monitoring of PCD volumes should be undertaken in order to detect any rise in water levels that may lead to overflows. This is necessary, especially during rainfall events, to ensure that any extra water is quickly transferred through the already installed pipelines away from the PCDs for re-use before any overflows can occur.

Sewage Treatment infrastructure should regularly be checked and maintained to reduce chances of leakages of contaminated effluent into the natural environment.

Monitoring of treated sewage effluent quality should continue to ensure that all discharges into the Kromelmboogspruit are within acceptable WUL limits.

The waste rock dump should be maintained with slopes that reduce pooling of water, to reduce the amount of leachate generation. Stormwater management must be placed around the facility to ensure dirty water is contained.

12.3 Decommissioning/Closure Phase

Use of accredited contractors for demolition and removal of infrastructure during the decommissioning and closure phase should be considered to reduce the risk of waste generation and accidental spillages. Rehabilitated areas must be re-vegetated and stabilised to minimise sedimentation of nearby watercourses.

Landscape re-profiling must be undertaken on rehabilitated land to allow good drainage. This will ensure improvement of catchment runoff yield close to pre-mining conditions in the surrounding Kromelmboogspruit and Leeuspruit watercourses.

The storm water management plan at 3 Shaft should be implemented to include the proposed relocation of the Primary Plant and Crusher facilities as per the DWS GN704 guidelines. Site preparation for the proposed 3 Shaft Primary Plant and Crusher should be confined to the existing 3 Shaft footprint to minimise disturbance of soils and reduce the probability of sedimentation and siltation of the Leeuspruit tributary. Proposed cut-off trenches at the stockpile area should be implemented to separate dirty runoff from the stockpile from the surrounding clean environment.

The possibility of contaminated water decant can be reduced by sealing-off mine shafts and boreholes with cement and plugging them with concrete.

Monthly water quality monitoring should continue 3 years after decommissioning at both Mooikraal and 3 Shaft as per Department of Water and Sanitation (DWS) requirements.

12.4 Monitoring Programme

Surface water monitoring should continue at Mooikraal (Upstream and Downstream of Mooikraal on Kromelmboogspruit; in all dirty water dams & sumps & Sewage Treatment Plant effluent) and at 3 Shaft (Upstream and Downstream of 3 Shaft on Leeuspruit tributary and in the 3 Shaft dirty water dam or PCD). Monitoring should be conducted fortnightly during the construction phase, monthly during the operation phase and monthly for 3 years after mine decommissioning/closure. All water quality results should be benchmarked to the Mooikraal WUL (No. 08/C22K/CIGJFAE/6981) to determine any impact on the quality of water (positive/negative). Parameters to be monitored as given in the WUL are indicated below:

Parameters	Unit	WUL RQO
pH	pH unit	5.5 - 9.5
Electrical conductivity (EC)	mS/m	150
Sulphate (SO_4)	mg/l	200
Chloride (Cl)	mg/l	150
Sodium (Na)	mg/l	100
Magnesium (Mg)	mg/l	80
Calcium (Ca)	mg/l	50

Parameters	Unit	WUL RQO
Total Suspended Solids (TSS)	mg/l	25
Nitrate (NO3)	mg/l	40
Dissolved Oxygen (DO)	mg/l	8
Chemical Oxygen Demand (COD)	mg/l	75
E Coli	CFU/100ml	0
Faecal Coliform	CFU/100ml	1000

Monitoring of site-specific rainfall at Mooikraal – 3 Shaft should continue to ensure maintenance of accurate direct rainfall input for the water balance.

13 References

Alexander. (2002). The Standard Design Flood. *Journal of the South African Institution of Civil Engineering*, 26 - 30.

Chow. (1959). *Open Channels Hyadraulics.* USA: McGraw-Hill.

DWS. (2012). *Revised National Water Resource Strategy, 2012.* Pretoria: Department of Water Sanitation.

IGS. (2018). *Mooikraal Groundwater Model.* Bloemfontein: Unpublished specialist report.

IGS. (2018). *Sigma Colliery: Water Quality Monitoring Report for Mooikraal Colliery: Report No. 11.* Bloemfontein: Unpublished specialist report.

JAXA. (2015). *ALOS World 3D – 30m (AW3D30) the global digital surface model (DSM) dataset.* Tokyo: Japan Aerospace Exploration Agency (JAXA).

National Geospational Institute. (2013). *Maps and Geospatial Information.* Department of Rural Development and Land Reform.

SANRAL. (2013). *Drainage Manual.* Pretoria: South African National Roads Agency SOC Limited.

Schulze. (2008). *The South African Atlas of Climatology and Agro-hydrology.* Pretoria: Water Research Commission.

Smithers and Schulze. (2000). *DEsign rainfall software for South Africa.* Pietermaritzburg: University of KwaZulu-Natal.

US Army Corps of Engineers. (1995). HEC RAS Hydraulic Modelling Software. Version 4.1. California.

WRC. (2015). *Water Resources of South Africa 2012 Study (WR2012).* Pretoria: Water Research Commission .