Environmental Impact Assessment for the West Rand Tailings Retreatment Project

Surface Water Report

Project Number:

GOL2376

Prepared for:

Sibanye Gold Limited

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I, Sivan Dhaver as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Sibanye Gold Limited, other than fair remuneration for work performed, specifically in connection with the proposed West Rand Tailings Retreatment Project, Gauteng Province.

This is undertaken under oath with respect to:

- the correctness of the information provided in the report;
- the inclusion of comments and inputs from stakeholders and I&APs;
- the inclusion of inputs and recommendations from other specialist reports, where relevant; and
- any information provided by the EAP to interested and affected parties and any responses by the EAP to comments or inputs made by interested or affected parties.

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EXECUTIVE SUMMARY

The proposed West Rand Tailings Retreatment Project (WRTRP) involves the construction of a large-scale Central Processing Plant (CPP) for the recovery of gold, uranium and sulfur from old Tailings Storage Facilities (TSFs) in the West Rand. The CPP, centrally located to the West Rand resources, will be developed in phases to eventually treat up to four million tonnes (Mt) per month of tailings and current arisings. A Regional Tailing Storage Facility (RTSF) has been proposed to store the tailings from the reclamation process.

The four primary rivers draining the project area are the Leeuspruit, Klein Wes Rietspruit, Wonderfonteinspruit and the Loopspruit.

To better understand the effects on flow volumes pertaining to the changes in water quantity within these rivers, due to the proposed project, flow diagrams were developed to illustrate the changes in quantity during the re-mining of the various TSF's. The flow diagrams depicting these changes are given in section 4 of the report (Figure 4-1, Figure 4-2 and Figure 4-3).

Currently discharges (approximately 20 Ml/day) from Cooke 1 Shaft occur in the Upper Wonderfonteinspruit, with the discharge point located between the upstream Leopards Vlei Dam and the Donaldson Dam. During re-mining of the TSF's approximately 12 Ml/day will be abstracted from the current 20 Ml/day Cooke 1 Shaft discharge, thereby decreasing the volume discharged from 20 Ml/day to 8 Ml/day in the Upper Wonderfonteinspruit.

The Wonderfonteinspruit flows in a purposely designed 1 metre diameter pipe from Donaldson Dam and diverts the stream for approximately 30 kilometres before it discharges near Oberhozer (Carltonville). The pipeline is designed to reduce recharge and possible contamination of the dolomitic area underlying this section of the stream.

Discharges from Kloof 10 Shaft currently occur in the Lower Wonderfonteinspruit. Discharged water (approximately 33 Ml/day) flows into a Bio Dam before entering a pipeline that joins the 1 m Wonderfonteinspruit pipeline. During re-mining of the historical TSFs approximately 20 Ml/day will be abstracted from the Kloof 10 Shaft water source, thereby decreasing the flows into the 1 m pipeline from 33 Ml/day to 13 Ml/day. It is important to note that currently the pipeline is running at full capacity, and removal of the mentioned flow will reduce the pressure on the pipeline.

Total flows reporting to the final downstream outlet of the 1 m pipeline, once re-mining has commenced, will subsequently reduce by 32 Ml/day. Therefore, there will be a decrease in flow measured at the outlet of the 1 m pipeline and on the Wonderfonteinspruit due to this project.

Driefontein discharges approximately 50 Ml/day into the Wonderfonteinspruit at the end of the 30 kilometre pipeline.

Ezulwini Mine currently abstracts approximately 70 Ml/day from the Gemsbokfontein West dolomitic compartments, from underground workings and activities. Of the 70 Ml/day abstracted the mine discharges approximately 10 Ml/day to the Leeuspruit (East) and the remaining 60 Ml/day is discharged to the Klein Wes Rietspruit. During re-mining of the TSFs, 20 Ml/day of this water will be used to mine 1 Mt/mth from Cooke 4 South (C4S), resulting in a decrease of discharges from 60 Ml/day to 40 Ml/day. Therefore there will be a decrease in current flows measured at the Klein Wes Rietspruit.

No discharges currently occur into the Leeuspruit West. However during the re-mining of the various TSFs, there will be discharges of 15 Ml/day from the Advance Water Treatment Facility (AWTF) which receives water from the RTSF. Therefore this additional water will result in an increase in flow to the Leeuspruit (South). Water released from the RTSF after treatment will comply with the discharge water quality specifications of the AWTF.

It must be noted that over and above the 53 Ml/day entering the 1 m pipeline at Donaldson Dam, on the Upper Wonderfonteinspruit there are discharges into the Wonderfonteinspruit of approximately 15 to 20 Ml/d from the Flip Human Waste Water Treatment Works (WWTW), and at the Lower Wonderfonteinspruit approximately 10 Ml/d is discharged directly into the 1 m pipeline from the Hannes van Niekerk WWTW.

The treatment facility located at the RTSF will treat and discharge on average 15 Ml /day into the Leeuspruit. Once operations for this project cease it is planned that this facility will continue to treat excess mine water and discharge it to the Leeuspruit.

This report covers the surface water assessment for the project and the findings obtained from the relevant investigations. The following is a breakdown of the major sections of the report:

- Baseline hydrology;
- Surface water quality;
- Surface water quantity;
- Salt loading;
- Floodline delineation; and
- Surface water impact assessment.

From the baseline hydrology the following is noted: The monthly mean evaporation rates are 178 mm (MAE based on Symons Pan evaporation, approximately 2137 mm) whilst the mean annual precipitation (MAP) is 591 mm (Air Quality Study, Digby Wells, 2015).

Water quality samples were taken downstream of the proposed RTSF and associated infrastructure, and at upstream and downstream locations associated with the proposed pipeline river crossings. Samples were taken during the end of the wet season in March 2015 and in the dry season in July 2015.

The water quality parameters measured were compared against the following standards:

- In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment, in the Upper Vaal Water Management;

- South African National Standards (SANS) 241: 2015 drinking water standards (from DWS Website); and
- South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996).

The most stringent of the guidelines is the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment, in the Upper Vaal Water Management, and the water quality results are summarised as follow:

- The In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment are more stringent than the SANS 241:2015 drinking water quality standards. The surface water quality assessment thus represents a worst case scenario (use of strict Barrage WQO) as in-stream guidelines for smaller more impacted streams could potentially be less stringent for example, the new proposed RQOs for the Mooirivier allow for an EC of 110 mS/m (compared to Barrage value of 70 mS/m and sulfate values of 500 mg/L compared to the 200 mg/L for the Barrage. The in-stream guidelines for the Rietspruit in fact allows for an EC of 120 mS/m and sulfate of 500 mg/L;
- The majority of the sampled sites exceeded the WQO for the Vaal Barrage sub-catchment due to elevated concentrations are Sulfate, Nitrate, Electrical Conductivity, Ammonia and Fluoride. Sulfate concentrations are above Guideline Limits (200 mg/L);
- Surface water draining from the Ezulwini, Cooke and the Kloof mining complexes drain to sampling points SW03, L2, L3 and SW05. Monitoring point SW03 located on the Leeuspruit, downstream of the proposed RTSF and associated infrastructure, showed high Sulfate (SO_4) concentrations (417 mg/L), with mine sampling points L2 and L3 located on the upstream tributary of the Leeuspruit measuring Sulfate concentrations of 387 mg/L and 415 mg/L respectively. SW05 located on a tributary of the Leeuspruit within the Kloof mining complex, showed Sulfate concentrations of 494 mg/L;
- At the Driefontein mining complex, most of the water quality monitoring points were dry during the time of the site visit in July which is representative of the dry season, however two samples (SW08 and SW09) taken in the upstream and downstream tributary of the Wonderfonteinspruit showed Sulfate concentrations of 362 mg/L and 372 mg/L respectively (Figure 7-4); and
- Water quality monitoring points LP004, LP005, LP006, LU014 and W12 display high concentrations of Nitrate (as N) in relation to the In-Stream Guideline Limit (0.3 mg/L), with the latter four monitoring points exceeding 230 mg/L. LP004, LP005 and LP006 drain a portion of the Kloof and Driefontein mining area, whilst LU014 and W12 drain a portion of the Kloof and Cooke mining area respectively.

Downstream flow gauging station C2H080 is used to represent the current flows exiting the 1 m pipeline. The mentioned gauging station has a record length of over a year (January 2014 – February 2015). Current flows are measured to be 72 123 m^3/day (72 Ml/day) on average. Decrease in flows is expected to range between 37 to 55 % at the outlet of the 1 m pipeline.

Flow estimations for the Leeuspruit were estimated based on the catchment size contributing to the runoff on the downstream section of the mentioned river, together with changes in runoff response due to seasonality (represented by runoff factors). The catchment area reporting to the downstream section amounts to 107 km^2, with the runoff factors adopted to best represent conditions during the wet and dry seasons (0.05 for the wet season and 0.03 for the dry season). Flows in the Leeuspruit due to natural runoff can range from no flows during the dry season to a max of 24 593 m^3/day (24 Ml/day) during the wet season. Flows on the Leeuspruit will increase from no flows observed during the dry season to a constant 15 000 m^3/day (15 Ml/day) increase flowing down the section of the Leeuspruit when re-mining commences. During the wet season peak flows can be as much as 39 593 m^3/day (39 Ml/day).

The flow for the Klein Wes Rietspruit was obtained from a flow measuring point located downstream of the Peter Wright Dam. The flow data record length ranges from January 2014 to September 2015.

To estimate the flows on the Loopspruit two nearby gauging stations were investigated, which include C2H051 located on the Kraalkopspruit and C2H169 located on the Loopspruit. No data is available for station C2H169, therefore to better estimate the flows at C2H169 area weighting of the available flows for C2H051 was undertaken. Area weighting involves adjusting the flows obtained from station C2H051 based on the ratio of its catchment area with the catchment area of flow gauging station C2H169. The catchment area of C2H051 is 5.4 km^2, whilst the catchment area of gauging station C2H169 is 54.9 km^2. This indicates that the flow on the Loopspruit should be close to ten times the flow measured at C2H051. This method is considered applicable in this particular case as the catchment characteristics which dictate the runoff reporting to the watercourses are fairly similar.

When pollution loads and discharge compliance requirements are under consideration, it is appropriate to use Sulfate and TDS or EC for determining salt loads (BPG: Water and Salt Balances, 2006). Sulfate has shown elevated concentrations that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment, in the Upper Vaal Water Management area. Therefore, Sulfate was considered for salt loads calculations in this study.

The summary of the findings are described below:

- The average Sulfate loads in the Leeuspruit West will show an increase of approximately 70% due to the additional volume of water being discharged. This is based on the assumption that discharge will be treated to the discharge water quality specifications of the AWTF (Sulfate – 350 mg/L). The concentrations of Sulfate will decrease from 417 mg/L to a minimum of 350 mg/L due to increased flows of on average 15 000 m^3/day. A decrease in concentrations of Sulfate of around 13% is anticipated due to increased flows of better quality water;
- Based on the groundwater study (Environmental Impact Assessment for Sibanye Gold Limited's West Rand Tailings Retreatment Project, Digby Wells, 2015), the reclamation on the current TSF's and placement on one large facility are positive in

the long run for the catchment, as they are currently a source of pollution. Based on average Sulfate concentrations of 322 mg/L measured at the 1 m pipeline outlet, estimated decrease in salt loads range from 37 to 55%;

- A floodline assessment was undertaken for the section of the Leeuspruit located north of the RTSF and associated infrastructure, together with the unnamed tributary located south of the RTSF. Flood modelling results show that the current placement of the RTSF and associated infrastructures is located outside of the 1:100 year floodline and the 100 m river buffer. The floodline assessment was also undertaken at various river crossings so as to determine the 1:50 and 1:100 year flood elevations at these crossings to allow for adequate designs to be implemented; and
- Major surface water impacts identified include the decrease in flows to the Wonderfonteinspruit and the increase in flows to the Leeuspruit.

The impacts as a result of the reduced flows to the Wonderfonteinspruit include reduction of water quantity; however the impact on the availability of water to downstream users is not significant, as the river still has sufficient capacity to provide an estimated 350 m^3/day, based on an estimation of 10 m^3 per user. Since most of the uses include irrigation of crops and livestock watering, this estimate is conservative. No mitigation is possible, however the impact of reduction in flow is considered to be moderate. Monitoring should continue for the following monitoring points:

- Wonderfonteinspruit system qualities and flows upstream of Cooke 1 Shaft discharge;
- The Cooke 1 discharge itself;
- Wonderfonteinspruit downstream at road crossing above Donaldson Dam;
- Outlet from Donaldson Dam;
- Outlet from WWTW into 1m pipe;
- K10 into 1m pipe, outlet of 1m Pipe, discharge of Driefontein;
- R500 road crossing of Wonderfonteinspruit;
- Flow and quality below Peter Wright Dam;
- Flow and quality from Ezulweni into Leeuspruit East; and
- Leeuspruit West above any discharge and below the AWTF.

The impact of increased flows due to water being discharged from the treatment plant into the Leeuspruit will have an overall positive impact on the river water quantity. Minor overflows along smaller dams located along the Leeuspruit may occur, due to the constant additional flow which may not necessarily have occurred during normal flow conditions. The additional flows amount to approximately 0.1 m^3/s and is insufficient to have an effect on the delineated floodlines for this section of the Leeuspruit. The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the discharge water quality specifications of the AWTF.

The groundwater assessment (Digby Wells, 2015) indicated that seepage from the RTSF can negatively influence the groundwater quality in the underlying aquifers during the operational phase, if no mitigation is undertaken and also impact the streams. Once the plume reaches the streams, it can migrate at a faster rate compared to the speed of the groundwater flow and could have Medium to High impact on the down-gradient riverine ecosystem and communities. Mitigation is therefore required.

Although the proposed blast curtain would be crucial to contain the pollution plume, it has a side effect since it will lower the water table from its natural position in the outer ring of the drain. Thus, the water quality impacts will be reduced, but the area/extent of the impact on the groundwater levels would increase.

The average seepage rate from the RTSF (which is dependent on the permeability of the TSF material) is estimated to be 3.21x10-4 m/d (SRL, 2015). This is expected to last for up to 100 years after closure and it is only then the rate will start to decrease (assuming cover is in place). For the blast curtain to work effectively, it has to intercept at least 120% of the seeped water (i.e. 4,810 m^3/d). This is because the curtain is also draining from the outer periphery. The plume can escape away from the curtain if it is pumped at less than this.

Dewatering the blast curtain will have a side effect in terms of lowering the water table around the periphery of the RTSF, outside the perimeter of the blast curtain drain. The predicted cone of dewatering at the end of operation extends across the Leeuspruit. Considering the shallow water level within the project area, the drawdown could be more than 25 m in some localities. Dewatering can potentially affect and reduce the flow rate of the Leeuspruit and its tributes, but water in the Leeuspruit flows much faster compared to the seepage rate through the stream floor and subsequently the stream flow won't be impacted significantly by the grout curtain dewatering activities.

Mitigation measures relating to the impact of flooding to the pipeline crossings include placement of the pipeline outside of the 1:100 year flood inundated area.

The re-mining of old tailings facilities, treating of the material and removal of Sulfate and then deposition on a proposed new facility will have an overall positive impact on the surface water quality and quantity.

The abstraction of groundwater at the blast curtain could potentially deplete the Leeuspruit flow rate. This can be mitigated by re-introducing the treated water from the AWTF into the Leeuspruit, at a point downgradient of the RTSF.

Another option of impact mitigation (other than with a blast curtain) would be the use of a liner to minimise the infiltration of contaminants from the RTSF to the groundwater. However, if a liner is implemented without the removal of sulphides (using the acid plant), the runoffs that originate from the RTSF will be more acidic and dissolve heavy metals. This can affect the Leeuspruit negatively, unless the runoff is intercepted with a cut-off drain before it reaches the river. The water can then be treated by the AWTF before being discharged.

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Abbreviation	Description
AMD	Acid mine drainage
CPP	Central Processing Plant
CUP	Cooke Uranium Project
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
GPS	Global Positioning System
km	Kilometre
m	Metre
mm	Millimetre
mS/m	milli Siemens per metre
m^3	Cubic metre
ha	hectares
MAE	Mean Annual Evaporation
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
Mg/L	Milligrams per litre
MRA	Mining Right Area
SANAS	South African National Accreditation System
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
WRC	Water Research Commission
WRD	Waste Rock Dump
WRTRP	West Rand Tailings Retreatment Project
WMA	Water Management Area
WQO	Water Quality Objectives
WULA	Water Use Licence Application

1 Introduction

There is a long history of gold and uranium mining in the broader West Rand area with mining having produced an estimated 1.3 billion tonnes of surface tailings, containing in excess of 170 mlbs (million pounds) of uranium and 11 million ounces (moz) of gold. Sibanye Gold Limited (Sibanye Gold) currently owns the majority of the tonnage and its gold and uranium content. Sibanye Gold plans to exploit these resources to develop a strong, long life and high yield surface retreatment and extraction business. Key to the successful execution of this development strategy is the proposed West Rand Tailings Retreatment Project (WRTRP). The concept of the WRTRP has been well researched and has a 7 year history of extensive metallurgical test work and design by a number of major mining houses. A pre-feasibility study (PFS) completed during 2013 for the WRTRP has confirmed that there is a significant opportunity to extract value from the Sibanye Gold surface resources.

The WRTRP involves the construction of a large-scale Central Processing Plant (CPP) for the recovery of gold, uranium and sulfur from the available resources. The CPP, centrally located to the West Rand resources, will be developed in phases to eventually treat 1.5 Mt/month up to 4Mt/month of tailings and current arising's from the operating mines.

Digby Wells Environmental (Digby Wells) was appointed by Sibanye Gold Limited (Sibanye Gold) to conduct a specialist hydrogeological study in support of the Environmental Impact Assessment (EIA)/Environmental Management Plan (EMP) and Integrated Water Use Licence Application (IWULA) of the proposed WRTRP. The locality map indicating the WRTRP location and infrastructures are shown in Figure 1-1.

1.1 Project Background

Sibanye Gold Limited's (Sibanye Gold) Tailings Storage Facility (TSF) holdings in the West Rand can be divided into three blocks; the Northern, Southern and Western Blocks. Each of these blocks contains a number of historical TSFs. It is proposed that each of the blocks will be reclaimed in a phased approach. Initially the Driefontein 3 TSF (Western Block) together with the Cooke TSF (Northern Block) will be reclaimed. Following reclamation of Driefontein 3 TSF, the Driefontein 5 TSF (Western Block) and Cooke 4 Dam South (C4S) (Southern Block) will be reclaimed.

- Western Block comprises: Driefontein 1, 2, 3, 4 and 5 TSFs, and Libanon TSF. Once the Driefontein 3 and 5 TSFs have been reclaimed the remainder of the Driefontein TSFs, namely Driefontein 1, 2 and 4 and the Libanon TSF, will be processed through the CPP.
- Northern Block comprises: Cooke TSF, Venterspost North TSF, Venterspost South TSF and Millsite Complex (38, 39 and 40/41 and Valley). Venterspost North and South TSFs and Millsite Complex (38, 39 and 40/41 and Valley).
- Southern Block comprises: Kloof No.1 TSF, Kloof No.2 TSF, South Shaft TSF (future), Twin Shaft TSF (future), Leeudoorn TSF and C4S TSF. Following completion

of the Module 3 float and gold plants, Kloof 1 and 2 TSFs, South Shaft TSF (future), Twin Shaft TSF (future) and Leeudoorn TSF will be reclaimed.

Once commissioned the proposed project will initially reclaim and treat the TSFs at a rate of 1.4 Mt/m (1Mt/m from Driefontein 3 followed sequentially by Driefontein 5 and C4S, and 0.4 Mt/m from Cooke TSF). Reclamation and processing capacity will ultimately ramp up to 4 Mt/m over an anticipated period of 8 years. At the 4Mt/m tailings retreatment capacity, each of the blocks will be reclaimed and processed simultaneously.

The tailings material will be centrally treated in a Central Processing Plant (CPP). In addition to gold and uranium extraction, sulfur will be extracted to produce sulfuric acid, an important reagent required for uranium leaching.

To minimise the upfront capital required for the West Rand Tailings Retreatment Project (WRTRP), only essential infrastructure will be developed during initial implementation. Existing and available infrastructure may be used to process gold and uranium until the volumetric increase in tonnage necessitates the need to expand the CPP.

The new RTSF will be located in an area that has been extensively studied as part of the original West Wits Project (WWP) and Cooke Uranium Project (CUP) projects. The deposition area on which the project is focussing has been termed the Regional TSF (RTSF) and is anticipated to accommodate the entire tonnage from the district. The proposed RTSF will be one large facility as opposed to the two independent deposition facilities proposed by the WWP and CUP respectively.

Note: Amendments to various Mine Work Programmes (MWPs) and Environmental Management Plans (EMPs) will be applied for in due course pending the inclusion of additional TSFs as the WRTRP grows to process 4 Mt/m. The RTSF will be assessed for impacts associated with the complete footprint and full tonnage to ensure that the site is suitable for all future deposition requirements.

1.2 Initial Implementation

Due to capital constraints in developing a project of this magnitude, it needs to be implemented over time. The initial investment and development will be focused on those assets that will put the project in a position to partially fund the remaining development.

This entails the design and construction of the CPP (gold module, floatation plant, uranium plant, acid plant and a roaster) to retreat up to 1.4 Mt/m from the Driefontein 3 and 5 TSFs, C4S TSF and the Cooke TSF. Driefontein 3, 5 and C4S TSFs will be mined sequentially over 11 years, whilst the Cooke TSF will be mined concurrently with these for a period of 16 years. The resultant tailings will be deposited onto the new RTSF.

A high grade uranium concentrate, produced at the CPP, will be transported to Ezulwini (50 000 tonnes per month) for the extraction of uranium and gold. The tailings from this process will be deposited on the existing operational Ezulwini North TSF.

The activities listed in Table 1-1 will be assessed in this impact assessment and baseline study.

Table 1-1: Primary activities of the WRTRP

Category	Activity
Infrastructure	Pipeline Routes (water, slurry and tailings).
	West Block Thickeners (WBT) and West, North and South Bulk Water Storage (BWS) complexes.
	Cooke thickener.
	Collection sumps and pump stations at the Driefontein TSF 3 and 5, Ezulwini South TSF and Cooke TSF.
	CPP incorporating Module 1 float and gold plants and No1 uranium, roaster and acid plants) and RTSF.
	RTSF Return Water Dams (RWD) and the Advanced Water Treatment Facility (AWTF).
Processes	Abstraction of water: K10 shaft. Cooke 1 and 2. Cooke 4 storage tank.
	Disposal of the residue from the AWTF.
	Hydraulic reclamation of the TSFs (which include temporary storage of the slurry in a sump).
	Gold, uranium and sulfur extraction at the CPP (tailings to RTSF) and possible uranium extraction at Ezulwini (tailings to Ezulwini North Dump).
	Water distribution at the AWTF for discharge or sale.
Pumping in Western Block	Pumping water from K10 to the Bulk Water Storage Facility (BWSF) located next to the WBT.
	Pumping water from the BWSF to the Driefontein TSFs that will be reclaimed.
	Pumping slurry from the TSF sump to the WBT (for Driefontein TSF 3 and 5).
	Pumping the thickened slurry from the WBT to the CPP (2 pipeline route options).
Pumping in Southern Block	Possible pumping 50 kt/m of uranium and sulfur rich slurry from the CPP to Ezulwini for extraction of uranium.
	Pumping of up to 1.5 Mt/m of tailings to the RTSF.
	Pumping water from the RTSF return water Dams to the AWTF.
	Discharging treated water to the Leeuspruit West.
	Return Water from the CPP to the C4S BWSF
	Pumping from the C4S to the CPP.
	Pumping residue from the AWTF to the RTSF.
Pumping in Northern Block	Pumping 400 kt/m of tailings from the Cooke Dump to the Cooke thickener.
	Pumping from the Cooke thickener to the CPP.via a booster station at Ezulwini
Electricity supply	Power supply from West Drie 6 substation to Driefontein TSF 3.
	Power supply from West Drie Gold substation to Driefontein TSF 5.
	Power supply from East Drie Shaft substation to WBT and BWSF.

Category	Activity
	Power supply from Kloof 1 substation to the CPP.
	Power supply from Kloof 4 substation to the RTSF and AWTF.
	Power supply from the Cooke substation to the Cooke thickener.
	Power supply from the Cooke Plant to the Cooke TSF
	Power supply from Ezulwini plant to the C4S TSF

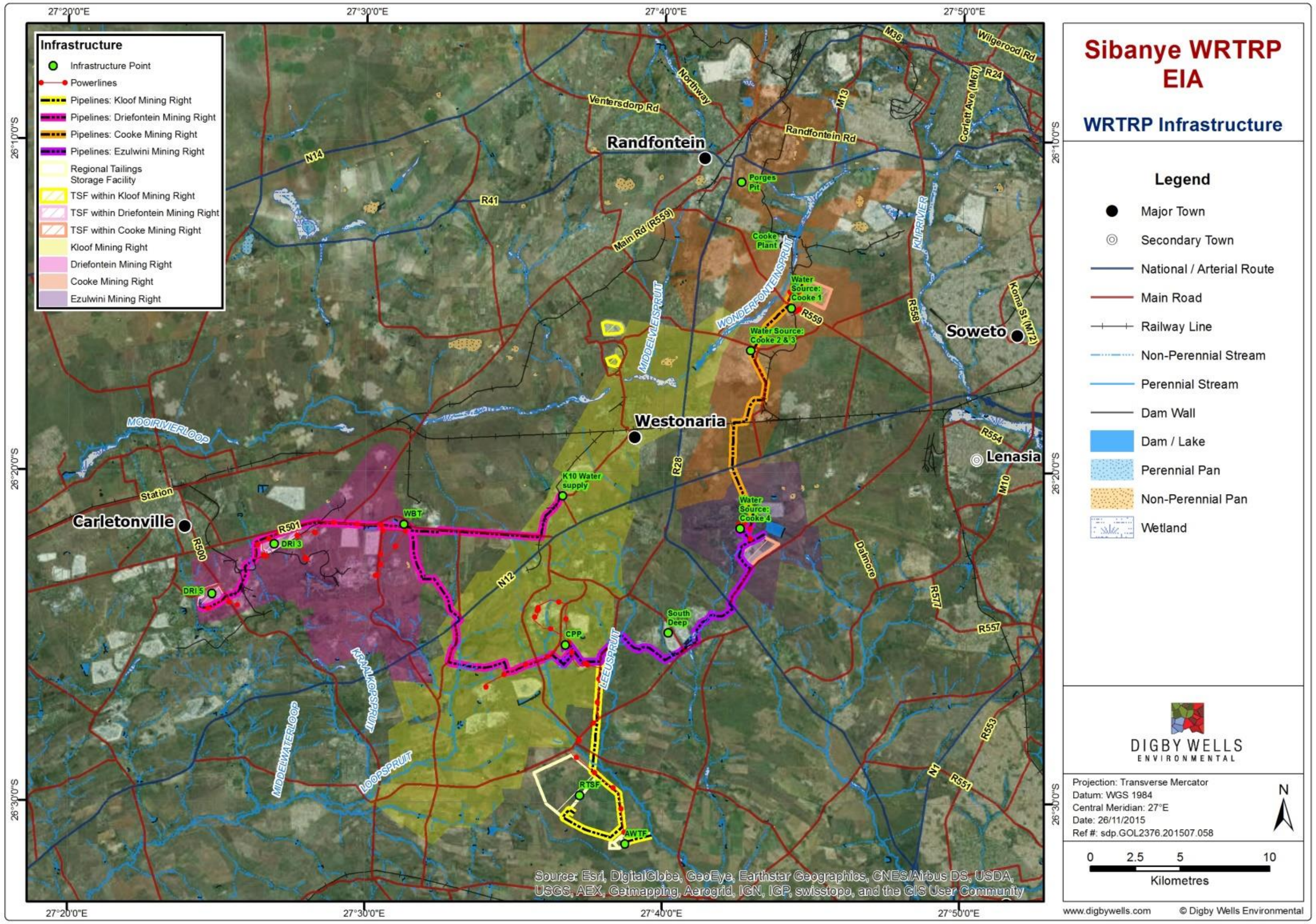

Figure 1-1: Locality of the WRTRP and Infrastructures

2 Details of the Specialist

Sivan Dhaver is a surface water hydrologist with over 9 years working experience within the consulting environment focused specifically in the mining industry. He holds an Honours Degree in Hydrology from the University of Zululand (South Africa). Sivan has completed numerous surface water specialist studies including, water balances, storm water management plans and flood modelling within Africa and South Africa.

Mashudu Rafundisani is a surface water specialist with two years working experience in the Surface Water Department of Digby Wells Environmental. He holds an Honours Degree in Environmental Management from the University of Venda (South Africa). Mashudu has completed numerous surface specialist studies including water quality assessments, integrated water and waste management plans, water balances, storm water management plans and flood modelling.

Curriculum vitae's are included in Appendix A.

3 Aims and Objectives

This aim of this investigation is to determine the current hydrological and surface water quality baseline status with the following objectives:

- Identify all the surface water features (rivers/streams, pan and Dams) within and around the project area;
- Determine the floodline on the Leeuspruit West section that is in proximity to the proposed RSTF; and
- Identify the potential surface water (quality and quantity) impacts that may result from the proposed project based on the established baseline conditions, for the proposed project and provide mitigation and management actions where required.

4 Methodology

The following methodology was used for this study:

4.1 Literature Review and Desktop Assessment

A surface water gap analysis was conducted in June 2014 using a desktop review and analysis of relevant information and data provided. Existing surface water reports were used to do the screening assessment, baseline description and obtain the historical water quality information of the rivers that are in proximity to the project area. The documents that were reviewed include, but are not limited to:

- Environmental Impact Report: Proposed Gold Fields West Wits Project, March 2010;
- Golder Associates Africa (Pty) Ltd (Golder) undertook a surface water impact assessment report, 2009;

- Environmental Management Programme for the alignment with the DME requirements, March 2008;
- IWWMPs, IWULAs and IWULs for Driefontein, August 2011;
- Driefontein Gold Mine EMP, August 2011;
- IWWMP for Kloof Gold Mine, April 2010;
- Kloof Gold Mine EMP; August 2011;
- Integrated Water and Waste Management Plan for South Deep Gold Mine, June 2010;
- Amendment of EMPs for COP undertaken by Digby Wells Environmental, April 2013;
- Proposed Geluksdal Tailings Storage Facility and Pipeline Infrastructure, EIA and EMPR, 2012; and
- Geluksdal Floodline Report, Report No: 0056-Rep-001 Rev 1, Ilanda Water Services, 2012.

4.2 Fieldwork and Seasonal Influence

The four primary rivers draining the project area are the Leeuspruit, Klein Wes Rietspruit, Wonderfonteinspruit and the Loopspruit. Summary of the flow diagrams for the Leeuspruit, Wonderfonteinspruit and Klein Wes Rietspruit systems are shown in Figure 4-1, Figure 4-2, and Figure 4-3 respectively.

The Leeuspruit drains surface water runoff emanating from the Ezulwini (Cooke 4) mining areas, and the Kloof mining areas in a south easterly direction towards the Rietspruit, which is a tributary of the Vaal River and flows into the Vaal Barrage.

The Klein Wes Rietspruit surface water runoff emanating from the Ezulwini (Cooke 4) mining areas, and flows in a south easterly direction towards the Rietspruit.

The Wonderfonteinspruit is divided into the Upper and the Lower Wonderfonteinspruit and is responsible for draining surface water runoff emanating from the Driefontein and Kloof mining areas. The source of the Upper Wonderfonteinspruit is the Tudor Dam, located north, past the Donaldson Dam, the Leopards Vlei Dam and the Lancaster Dam. The Upper Wonderfonteinspruit ends at the outflow of the Donaldson Dam, where a 1 m pipeline signifies the beginning of the Lower Wonderfonteinspruit. The Lower Wonderfonteinspruit contains the 1 m pipeline which extends approximately 30 km down the natural drainage path of the Wonderfonteinspruit. This pipeline was constructed to take the river flows over a dolomitic section in order to reduce water ingress.

The Loopspruit also drains a small portion of surface water runoff from the Kloof mining area, eventually flowing westward into the Vaal River.

Initial field assessments were done on 25 March 2015 and 10 July 2015 respectively. The field work was done during the end of the wet season and again during the onset of the dry season. An additional site survey was undertaken in November 2015. This was done to verify the hydrological characteristics within and around the project area, collect water samples from the water resources and undertake the floodline assessments.

Surface water samples were collected from the rivers and Dams within and around the project area. The sampled rivers include the Leeuspruit West, Loopspruit and other unnamed rivers around the project area. Water quality data for the Wonderfonteinspruit and the Klein Wes Rietspruit was provided therefore sampling was not required. The first round of sampling was done on the 25th of March 2015 and the second round was conducted on the 10th of July 2015 to account for seasonal variation.

However, amongst the identified sampling points within and around the project area, some of the rivers/drainages were found to be dry and sampling was not possible.

A floodline assessment for the Leeuspruit and the unnamed tributary which flows along the northern (Leeuspruit) and southern side (unnamed tributary) of the proposed RTSF were also completed during the first site visit.

A final site visit was undertaken on the 2nd November 2015. The purpose of the site visit was to obtain upstream flows from the Wonderfonteinspruit, whilst verifying the discharges into the Upper Wonderfonteinspruit and from the final exit point of the 1 m pipeline on the Lower Wonderfonteinspruit. The Leeuspruit West was also visited subsequent to the above date, but it was dry and flow could not be measured.

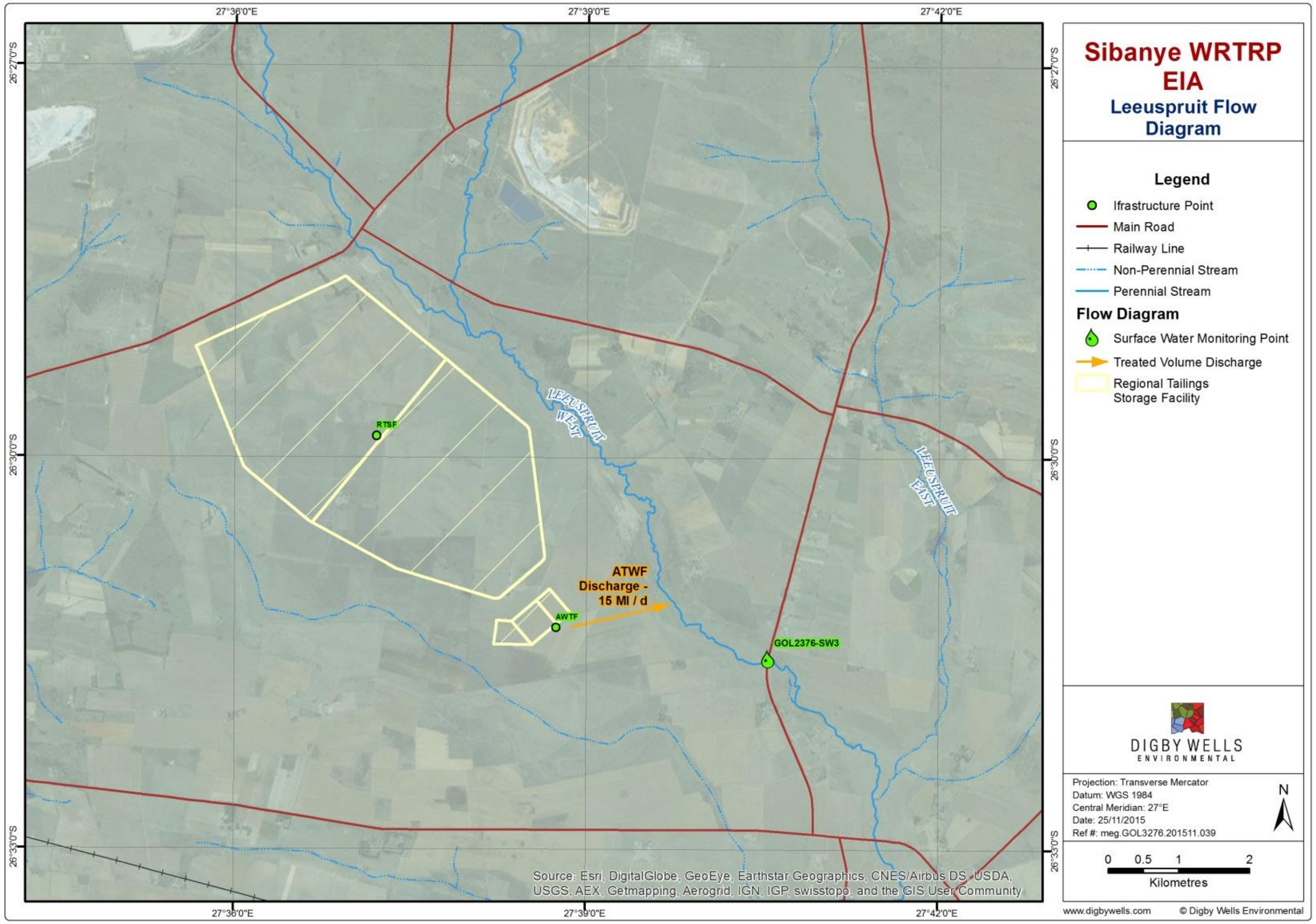

Figure 4-1 Flow diagram for the Leeuspruit

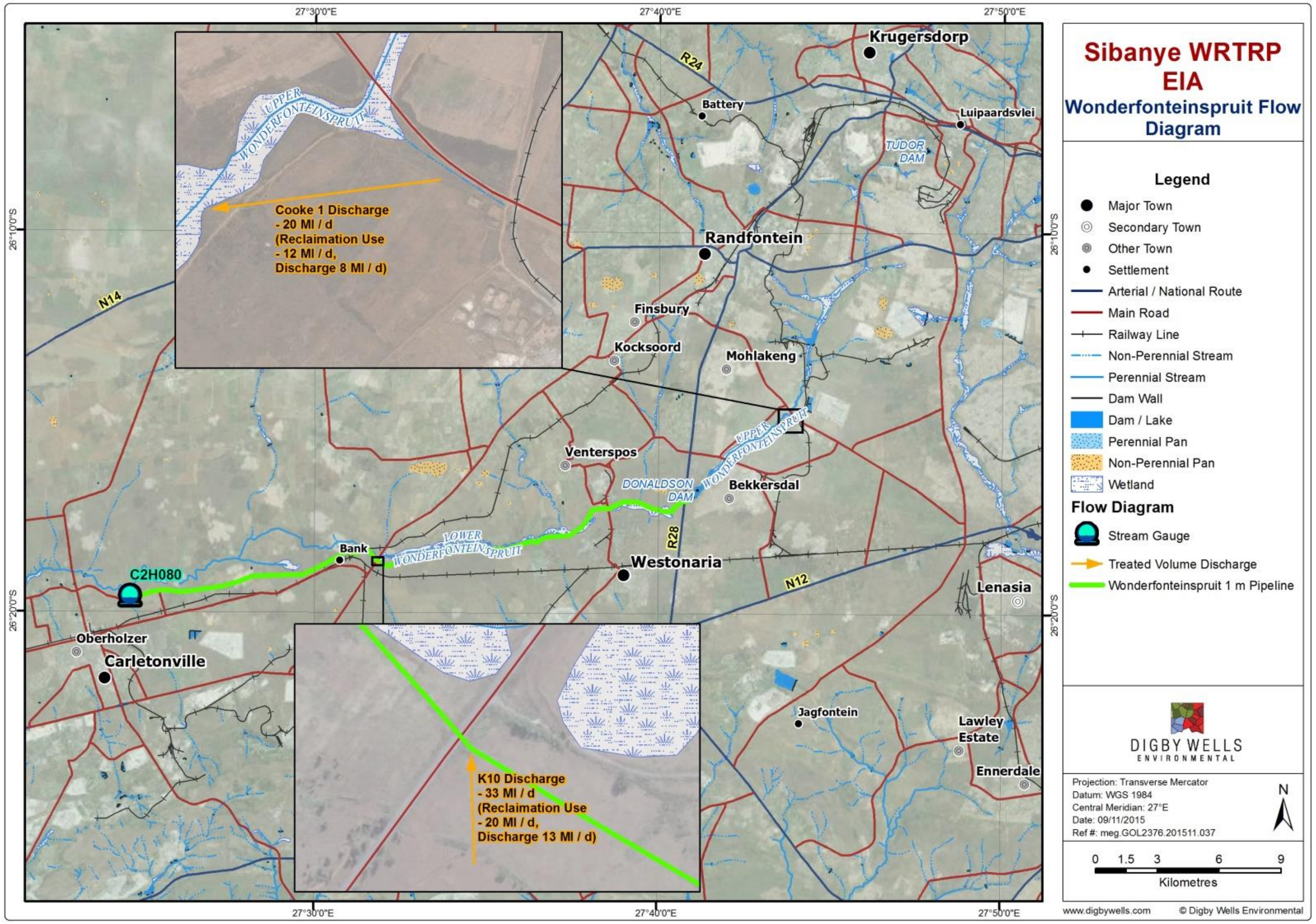

Figure 4-2 Flow diagram for the Wonderfonteinspruit

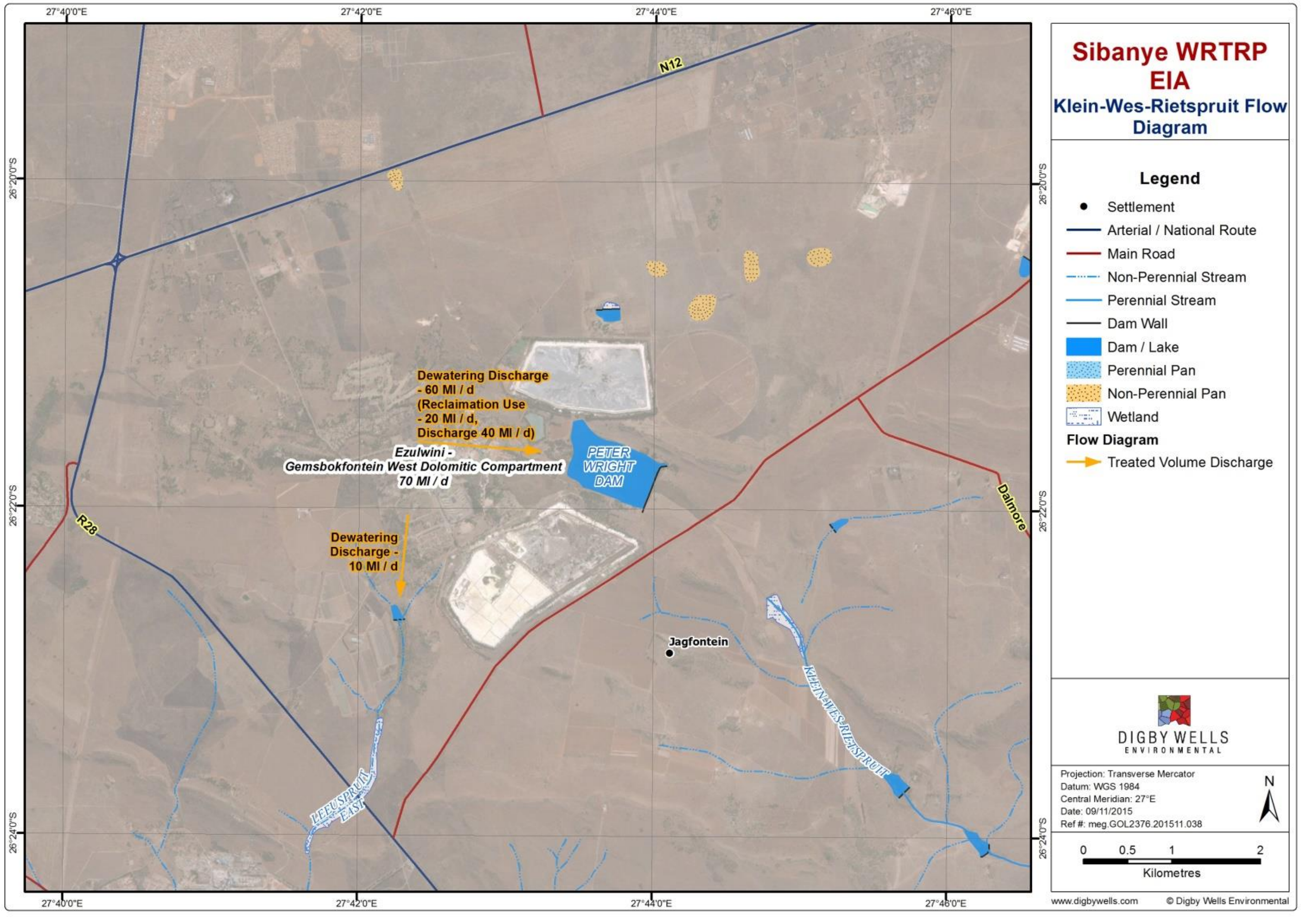

Figure 4-3 Flow diagram for the Klein Wes Rietspruit

5 Assumptions and Limitations

Below is a summary of assumptions and limitations applicable to the surface water report:

- The baseline assessment is based predominantly on desktop information from the existing reports listed in Section 4.1 of this report;
- No flow measuring equipment was installed on site. All flow data was obtained from existing DWS flow gauging stations;
- Flows and floodlines are for environmental purposes only; and
- Additional water quality data provided by the applicant was also used in the baseline water quality description.

6 Screening Assessment for the WRTRP Area

The Cooke mining area has perennial and non-perennial rivers, and a few natural Dams. Rivers on the Cooke MRA include the Wonderfonteinspruit, Rietfonteinspruit, Middelvleispruit and few unnamed drainages. The main watercourse draining this MRA is the Wonderfonteinspruit which passes between the Cooke TSF and Cooke Plant. Water quality in Wonderfonteinspruit has indicated elevated concentrations of Nitrate, Ammonia, Electrical Conductivity, Fluoride and Sulfate, which all exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

The Driefontein MRA falls within two quaternary catchments namely C23E and C23J. The main watercourses in these quaternary catchments include the Mooirivierloop (C23E) and the Loopspruit (C23E), with several non-perennial drainages in both quaternaries. Water quality at sampling point SW06, which is a downstream point on the Loopspruit (C23J) indicate elevated concentrations of Nitrate, Chloride, Electrical Conductivity, Fluoride and Sulfate that exceeds the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment. Elevated concentration of Nitrate, Chloride, Electrical Conductivity and Sulfate that exceeds the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment was observed in the unnamed river which is a tributary of the Mooirivierloop.

The Kloof MRA covers portions of the three main rivers which include the Wonderfonteinspruit, Leeuspruit and Loopspruit. The water quality within these rivers has already been impacted as explained in section 7.5.

The Ezulwini MRA consists of a, non-perennial stream (Klein Wes Rietspruit) and a reservoir called Peter Wright Dam. It should be noted that the Dam does not supply water for domestic use.

The overall water quality has indicated that the rivers are impacted on by mining and other anthropogenic activities.

The screening assessment did not identify any fatal flaws due to surface water impacts associated with the project. This is taking into consideration that the project entails re-mining of the existing TSF’s which will bring about a positive impact by reducing the possible sources of diffuse water pollution in the West Rand. Rehabilitation of the reclaimed TSF areas will restore good drainage surface area and hence improve the runoff catchment yield.

Potential surface water impacts for the newly proposed RTSF and the associated mitigation measures have been assessed in detail for this study.

7 Baseline Environment

This section provides the hydrological baseline assessment for the larger project area. The hydrological baseline will cover the following:

- Hydrological setting (regional hydrology, topography, rivers and drainage); and
- Climate (rainfall, evaporation, wind and temperature).

7.1 Hydrological Setting

South Africa is divided into 19 water management areas (WMA) (National Water Resource Strategy, 2004), managed by separate water boards. Each of the water management areas (WMA) is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A – 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 (WR2005) manual. Each of the quaternary catchments have associated hydrological parameters including area, mean annual precipitation (MAP), mean annual evaporation (MAE), and mean annual runoff (MAR).

7.1.1 Regional Hydrology

The WRTRP is situated in the Upper Vaal Water Management Area (WMA 8), within quaternary catchments C23E, C23J, C23D, C22J and C22H.

The surface water attributes of the affected catchments, namely the MAR in million cubic metres (Mm^3), MAP (mm) and MAE (mm) are summarised in Table 7-1 (WRC, 2005).

Table 7-1: Summary of the surface water attributes for quaternary catchments

Quaternary Catchment	Total Area (km^2)	MAP (mm)	MAR (Mm^3)	MAE (mm)
C22H	454	639	8.38	1650
C22J	669	633	11.81	1650
C23D	510	664	9.12	1650
C23E	850	631	13.41	1675
C23J	890	620	18.49	1670

The C22H quaternary catchment area is 454 km^2 and has an MAR of 8.38 Mm^3. Runoff emanating from this quaternary catchment drains into a south westerly direction into the Klein Wes Rietspruit which in turn flows into the larger Rietspruit.

The C23D quaternary catchment area is 510 km^2 and has an MAR of 9.12 Mm^3. Runoff emanating from this quaternary catchment drains in a south westerly direction into the Wonderfonteinspruit which is the largest river in the quaternary catchment. The C23D quaternary catchment is a contributing catchment to C23E, therefore all runoff from C23D eventually drains to the catchment outlet of C23E.

The C23E quaternary catchment area is 850 km^2 and has an MAR of 13.41 Mm^3. Runoff emanating from this quaternary catchment drains in a south westerly direction via the Mooirivierloop. The C23E quaternary catchment includes urban areas which are greater than 5 km^2.

The C23J quaternary catchment area is 890 km^2 and has an MAR of 18.49 Mm^3. Runoff emanating from this quaternary catchment drains in a south westerly direction via the Loopspruit. The Loopspruit is the largest river within the quaternary catchment.

The C22J quaternary catchment area is 669 km^2 and has an MAR of 11.81 Mm^3. Runoff emanating from this quaternary catchment drains in a southerly direction via the Leeuspruit. The Leeuspruit is the largest river within the quaternary catchment.

7.1.2 Topography

The WRTRP is divided into northern, southern and western blocks. The general topography of these areas is discussed below.

The C22H quaternary catchment forms part of northern block area. Elevations range from 1780 metres above mean sea level (mamsl) at the highest point within the northern block, and drops to 1530 mamsl at the lowest point within the northern block. Average slopes for the northern block range from 0.4% to 1% for majority of the area, whilst the steeper slopes located at the upstream north western quaternary catchment boundary is on average slightly above 1%.

The C23D quaternary catchment makes up the majority of the WRTRP northern block area. Elevations range from 1780 metres above mean sea level (mamsl) at the highest point within the northern block, and drops to 1530 mamsl at the lowest point within the northern block. Average slopes for the northern block range from 0.4% to 1% for majority of the area, whilst the steeper slopes located at the upstream north eastern quaternary catchment boundary range from 1% to 2%.

The C23E quaternary catchment area makes up majority of the WRTRP western block area. Elevations range from 1690 mamsl at the highest point within the western block and drops to 1480 mamsl at the lowest point within the western block. Average slopes for the western block range from 0.5% to 1% for majority of the area, whilst the steeper slopes located at the south eastern quaternary catchment boundary range from 1% to 4%.

The C22J quaternary catchment area makes up majority of the WRTRP southern block area. Elevations range from 1725 mamsl at the highest point within the southern block and drops to 1518 mamsl at the lowest point within the southern block. Average slopes for the southern block range from 0.8% to 1% for majority of the area, whilst the steeper slopes located at the north western quaternary catchment boundary range from 1% to 6%.

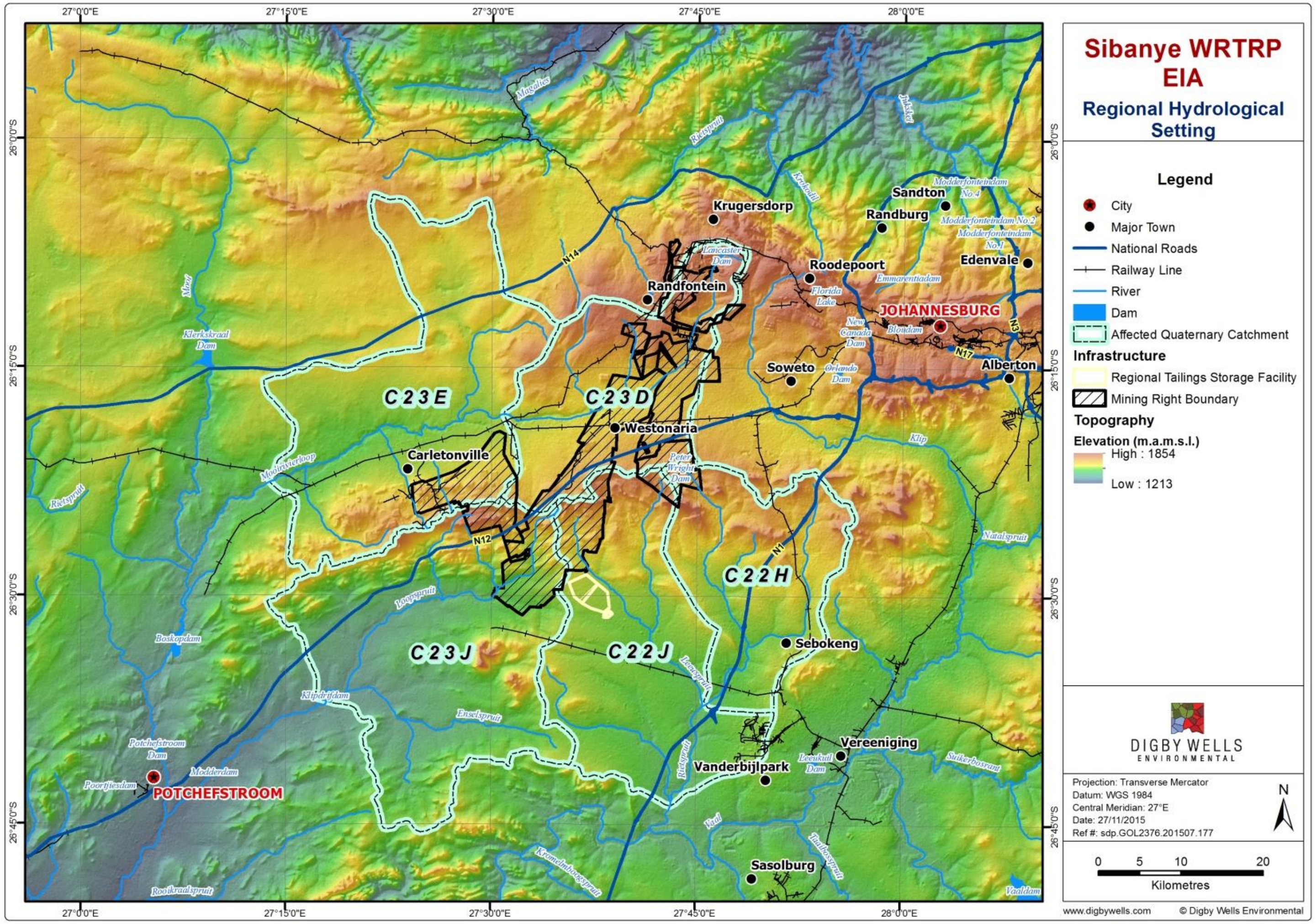

Figure 7-1: Regional Hydrological Setting

7.1.3 Rivers and Drainage

There are a number of rivers draining the WRTRP area, which include the Mooirivierloop, Rietspruit, Wonderfonteinspruit, Loopspruit, Leeuspruit and the Klein Wes Rietspruit which are classified as perennial rivers, together with a few unnamed, non-perennial streams that form tributaries to the main rivers mentioned.

The Wonderfonteinspruit flows in a south westerly direction and eventually drains into the Mooiriver at a point below the Muiskraal Dam, located west of the WRTRP area. This catchment has been changed as most of the normal flow from the Donaldson Dam is directed into a pipe known as the 1m pipe. Other flows from regional WWTW and the K10 shaft also discharge into this pipe. This pipe takes these flows over a dolomitic area to reduce recharge and discharges at a point near Oberholzer. At this discharge point the Driefontein mining complex also discharges large amounts of pumped mine water.

The Leeuspruit is a tributary of the Rietspruit, with the latter joining the Upper Vaal River system at the Vaal Barrage.

The Klein Wes Rietspruit surface water runoff drains in a south easterly direction towards the Rietspruit, with the latter joining the Upper Vaal River system at the Vaal Barrage.

The Loopspruit forms part of the Mooiriver catchment and flows into the Mooiriver at Potchefstroom, located south west of the WRTRP area. All runoff drained by the Loopspruit eventually reaches the Vaal River.

In summary, the Mooirivierloop and the Wonderfonteinspruit drain the northern catchment of the WRTRP area, whilst the Leeuspruit, Klein Wes Rietspruit and the Loopspruit drain the southern catchment of the WRTRP area.

7.2 Climate

This section provides a summary of the climate data specifically the adopted rainfall and evaporation which are to represent the baseline climate conditions for the WRTRP area. It must be noted that rainfall and evaporation shown in this section data was also covered in the Air Quality Study (Air Quality Impact Assessment Report, Digby Wells, 2015).

Precipitation data was obtained from Lakes Environmental (http://www.weblakes.com) online database. Lakes Environmental is able to provide modelled meteorological data for any user defined location. It should be noted that this data is not freely available, and therefore needs to be purchased. Modelled precipitation data for the period January 2012 to December 2014 was obtained for a point in the proposed project area near Westonaria (26.317775 S, 27.650683 E). The 2015 data is not available at the moment.

Evaporation data was obtained from the South African Weather Service (SAWS) for the Westonaria area. The evaporation data amounting to 30 years was obtained for the period 1957 up to 1987.

7.2.1 Rainfall

As shown in Table 7-2, for the three years data considered, the total monthly rainfall (max) and average total monthly rainfall are reported. The MAP of 591 mm indicated in Table 7-2 is based on the sum of the average monthly rainfall recorded for each corresponding month.

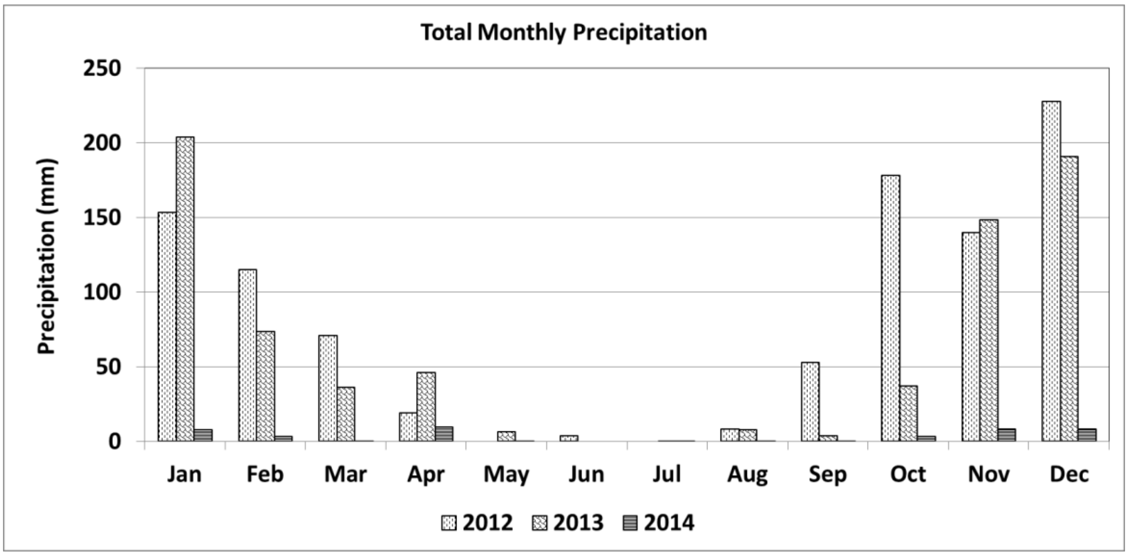

Figure 7-2: Total Monthly Precipitation

Table 7-2: Total Monthly and Average Precipitation Values

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Total Monthly Rainfall (Max).	204.2	115.1	70.9	46.2	6.9	4.1	0.5	8.6	53.1	178.3	148.6	228.1	1065
Average Total Monthly Rainfall	122.0	64.1	35.8	25.1	2.6	1.4	0.3	5.8	19.2	72.9	99.1	142.5	591

7.2.2 Evaporation

As shown in Table 7-3, the annual averages for maximum, minimum and mean monthly evaporation rates for Westonaria area for the period 1957-1987 are 263 mm, 113 mm and 178 mm, respectively. The highest monthly maximum evaporation (322 mm) occurred in October. The rate decreases to the lowest in 68 mm in April. The monthly minimum evaporation ranges between 68 mm (April) and 180 mm in October. The average monthly evaporation is presented in Figure 7-3.

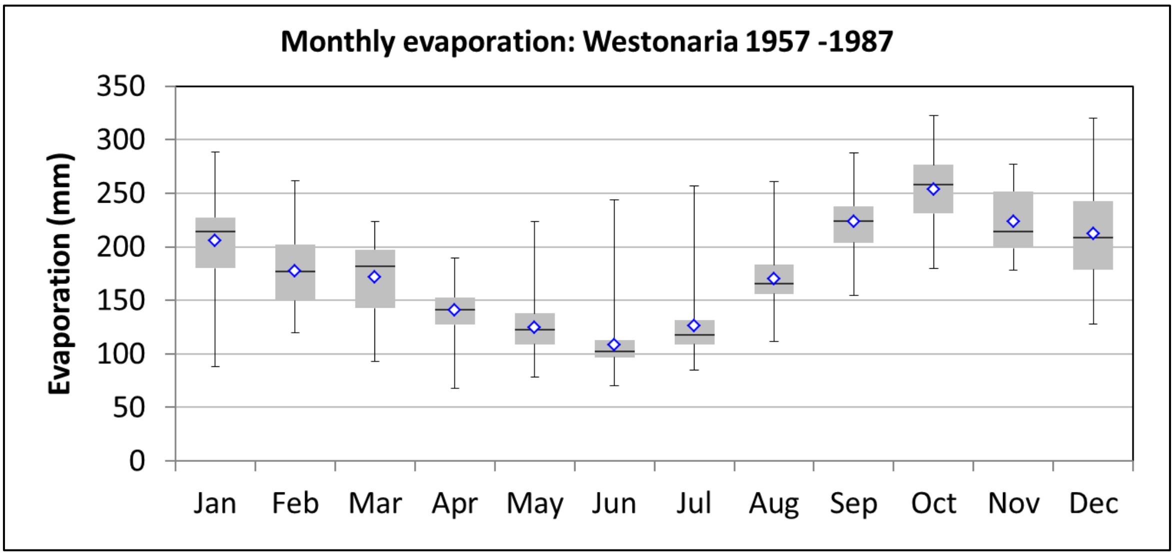

Figure 7-3: Monthly evaporation for Westonaria S-Pan Evaporation Station (1957 – 1987) (Source: South African Weather Service)

Table 7-3: Monthly Evaporation Rates for Westonaria

Evaporation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	289	262	224	190	223	244	257	261	288	322	277	320	263
Monthly Min.	88	120	93	68	79	70	85	111	155	180	178	128	113
Monthly Mean	206	177	171	141	124	109	126	170	224	253	224	212	178

7.3 Mean Annual Runoff

Based on GN 704[1] requirements, all runoff emanating from dirty water areas such as mine infrastructures, including the RTSF area, sumps and CPP need to be contained within these areas, so as not to mix with the downstream clean water areas.

The 1:50 year storm rainfall depth, to be adopted in the design of conveyance and containment infrastructures for all dirty water areas is indicated in Table 7-4 (Sibanye Gold - West Rand Tailings Retreatment Project, SLR Consulting, 2015).

Table 7-4 Summary of storm rainfall depths

	24 Hour Storm Rainfall Depths (mm)						
Return Period (Years)	**2**	**5**	**10**	**20**	**50**	**100**	**200**
Storm Rainfall Depths (mm)	62	83	97	111	128	142	155

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

The majority of the proposed infrastructures are to be located within the Kloof MRA with minor infrastructure located within the Driefontein MRA. Major infrastructures that fall within the Kloof MRA include the CPP, the RTSF and RWD and the AWTF, whilst within the Driefontein MRA the only new proposed infrastructure is the WBT.

The footprint areas of the new proposed infrastructure are characterised as dirty water areas, therefore based on GN 704 requirements, all runoff emanating from these new areas will have to be captured and contained, resulting in a decrease in runoff that will report to the downstream watercourse, thereby decreasing the MAR of the affected quaternary catchment. The proposed infrastructures for the Kloof MRA fall within quaternary catchment C22J, whilst the proposed infrastructure for the Driefontein MRA falls within quaternary catchment C23E.

Losses in MAR will only occur in quaternary catchment C22J and C23E (Table 7-5), however the %age loss of MAR from the mentioned quaternary catchment is considered negligible, at 2% and 0.004% respectively.

Table 7-5 Loss in MAR due to proposed infrastructure

Quaternary Catchment	Total Quaternary Catchment Area (km^2)	Infrastructure Name	Infrastructure Area (Km^2)	Location	River/Drainage	MAR (Mm^3)	% Loss in MAR	Loss in MAR (Mm^3)
C22H	454			Cooke 4 South/ Ezulwini MRS	Klein Wes Rietspruit	8.38	0	0
C22J	669	CPP, RTSF and RWD, AWTF	14.47	Kloof MRA	Leeuspruit West	11.81	2.162	0.2554
C23D	510			Kloof and Cooke MRA	Wonderfonteinspruit	9.12	0	0
C23E	850	WBT	0.03	Driefontein MRA	Wonderfonteinspruit	13.41	0.004	0.0005
C23J	890			Driefontein and Kloof MRA	Loopspruit	18.49	0	0

7.4 Surface Water Users

From the Department of Water and Sanitation's (DWS) water use database, the registered water users within the affected quaternary catchments include mining, irrigation, livestock watering and industry urban and non-urban (Table 7-6). The predominant use of surface water throughout the whole project area is irrigation and livestock watering.

Table 7-6: Surface Water Users

Quaternary Catchment	Primary Drainage	Potential Surface Water Users
C22H	Klein Wes Rietspruit	Sebokeng in upper reaches, Agriculture, Agricultural Holdings
C22J	Leeuspruit	West Rand towns in upper reaches, Mining, Agriculture
C23D	Wonderfonteinspruit	Agriculture, Mining, Carletonville and surrounding towns and Residential areas, Agricultural Holdings
C23E	Mooirivierloop	Towns and Residential areas in upper reaches, Mining in upper reaches, Agriculture, Pivot Irrigation
C23J	Loopspruit	Mining in upper reaches, Agriculture, Potchefstroom in lower reaches

7.5 Surface Water Quality

Thirteen (13) surface water quality samples were collected by Digby Wells from the rivers and Dams within and around the project area. The sampled rivers include the Leeuspruit, Loopspruit and other unnamed rivers around the project area.

The water quality for the Wonderfonteinspruit and the Klein Wes Rietspruit was not investigated through sampling during this study as sufficient data was provided by the applicant. The first round of sampling was undertaken on the 25th of March 2015 and the second round was conducted on the 10th of July 2015. Amongst the identified sampling points within and around the project area, some of the rivers/drainages were found to be dry and sampling was not possible.

Samples were submitted to Aquatico Laboratory (Pty) Ltd, a SANAS accredited laboratory in Pretoria for analysis of their physical and chemical quality status. Table 7-7 and Figure 7-4 indicates the surface water monitoring locations for samples taken by Digby Wells and the applicant.

Table 7-7: Surface Water monitoring locations

Site Name	Latitude	Longitude	Origin of Surface Water Runoff
LP002	-26.4313	27.5522	Kloof Mining Right
LP004	-26.444	27.5494	Kloof Mining Right
LP005	-26.4574	27.5491	Kloof/Driefontein Mining Rights
LP006	-26.4665	27.5484	Kloof/Driefontein Mining Rights
LU014	-26.4733	27.6151	Kloof Mining Right
DSW9	-26.348808	27.431807	Driefontein Mining Right
DSW42	-26.341755	27.4282	Driefontein Mining Right
L1	-26.3665	27.70366	Cooke 4 South/Ezulwini mining rights
L2	-26.3961	27.69999	Cooke 4 South/Ezulwini mining rights
L3	-26.4227	27.68142	Cooke 4 South/Ezulwini mining rights
Klein Wes Rietspruit	-26.401889	27.770547	Ezulwini Mining Right
W12	-26.233	27.73676	Kloof/Cooke Mining Rights
W13	-26.2417	27.73358	Kloof/Cooke Mining Rights
W15	-26.2657	27.69887	Kloof/Cooke Mining Rights
DP006	-26.4237	27.6397	Kloof Mining Right
DP003	-26.4162	27.6346	Kloof Mining Right
LU009	-26.4291	27.6005	Kloof Mining Right
C2H080	-26.326400	27.410600	Kloof Mining Right
GOL2376-SW1	-26.3970	27.645561	Kloof Mining Right
GOL2376-SW2	-26.4549	27.637475	Kloof Mining Right
GOL2376-SW3	-26.5255	27.675763	Kloof Mining Right
GOL2376-SW4	-26.472418	27.616659	Kloof Mining Right
GOL2376-SW5	-26.428294	27.601109	Kloof Mining Right
GOL2376-SW6	-26.479373	27.538946	Kloof/Driefontein Mining Rights
GOL2376-SW7	-26.42150	27.552755	Kloof Mining Right
GOL2376-SW8	-26.41115	27.405821	Driefontein Mining Right
GOL2376-SW9	-26.39815	27.402759	Driefontein Mining Right
GOL2376-SW13	-26.43393	27.552212	Kloof Mining Right

Site Name	Latitude	Longitude	Origin of Surface Water Runoff
GOL2376-SW21	-26.375072	27.5922517060001	Kloof Mining Right
GOL2376-SW23	-26.418215	27.6020881740001	Kloof Mining Right
GOL2376-SW26	-26.453431	27.603918664	Kloof Mining Right

**All coordinates are in decimal degrees using the Geographic (latitude and longitude) WGS 1984 coordinate system*

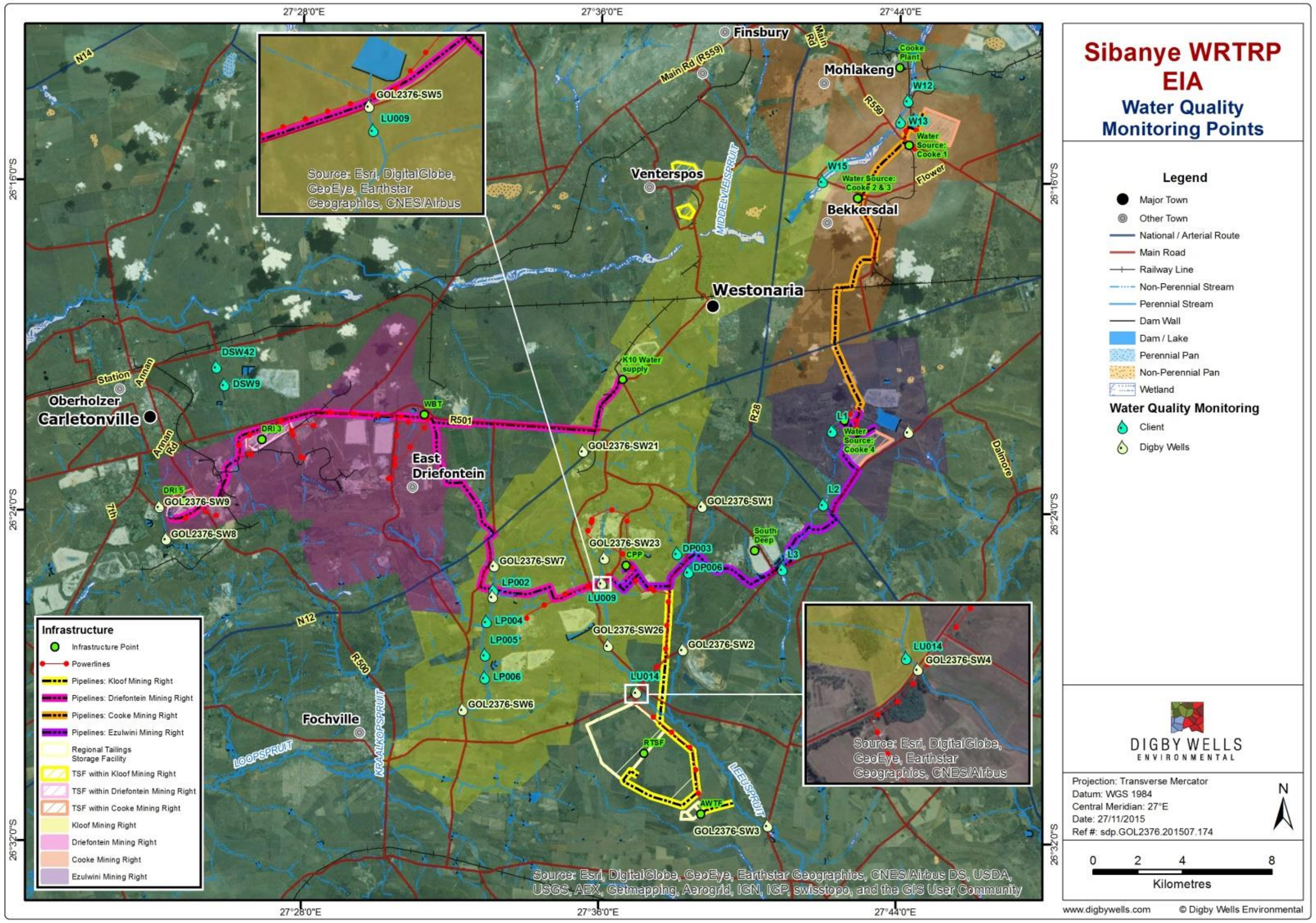

Figure 7-4: Surface Water Monitoring Locations

Additional water quality data (January 2013 to March 2015) was provided to Digby Wells by the applicant and was used to describe the current water quality status throughout the project area.

Non-parametric statistics was used to calculate the variability of available data, which is a measure of how water quality differs over time; this was undertaken using Microsoft Excel. This allows the calculation of the parentage of time for which a specific value/ concentration was not exceeded. The 95th percentile value thus refers to a value that was not exceeded for 95% of the data points while 50th percentile represent the median or average value that was not exceeded for 50% of the data points. For this data set, the current water quality was based on the calculation of the median, 50th percentile and the 95th percentile.

Water quality results have been benchmarked against the South African National Standards (SANS) 241: 2015, drinking water standards. This part of SANS 241 specifies the quality of acceptable drinking water, defined in terms of microbiological, physical, aesthetic and chemical determinants, at the point of delivery. Water that complies with this part of SANS 241 is deemed to present an acceptable health risk for lifetime consumption (this implies an average consumption of 2 litre of water per day for 70 years by a person that weighs 60 kg).

The results were also benchmarked against the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment as the project area lies within the Vaal Dam drainage region/catchment.

The predominant water use around the project area was agriculture (irrigation and livestock watering). For that reason, the results were also benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996).

The water quality guidelines describe the fitness for use of a water resource, while the Water Quality Objectives defines what management action is required for a water resource. The fitness for use of water defines how suitable the quality of water is for its intended use. The following fitness for use categories are linked to the SAWQGs:

- **Ideal** – the use of water is not affected in any way; 100% fit for use by all users at all times; desirable water quality (TWQR);
- **Acceptable** – slight to moderate problems encountered on a few occasions or for short periods of time;
- **Tolerable** – moderate to severe problems are encountered; usually for a limited period only; and
- **Unacceptable** – water cannot be used for its intended use under normal circumstances at any time (DWAF, 2006c).

The water quality results are appended in Appendix B of this report. Table 7-7 presents the coordinates of the sampling points and Table 7-8, Table 7-9 and Table 7-11 present the water quality results benchmarked against SANS 241:2015, the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment and the South African Water Quality Guidelines for Agricultural Use: Irrigation respectively.

Table 7-8: Water Quality Results benchmarked against the SANS 241:2015 Drinking Water Quality Standards

Sample ID			pH-Value at 25° C	Conductivity at 25° C in mS/m	Total Dissolved Solids	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Chlorides as Cl	Sulfate as SO_4	Nitrate NO_3 as N	Fluoride as F	Aluminium as Al	Iron as Fe	Manganese as Mn	Free and Saline Ammonia as N
SANS241:2015	**Standard limits)**		5-9.5	<170	<1200	<150	<70	<200	<50	<300	<250	<11	<1.5	<0.3	<0.3	<0.1	<1.5
		Date	**pH**	**EC mS/m**	**TDS mg/L**	**Ca mg/L**	**Mg mg/L**	**Na mg/L**	**K mg/L**	**Cl mg/L**	**SO_4 mg/L**	**NO_3-N mg/L**	**F mg/L**	**Al mg/L**	**Fe mg/L**	**Mn mg/L**	**Ammonia mg/L**
LP002		**03/03/2015**	6.9	8	34	7	5	5	0	5	7	0	0.2	0.1	0.0	0.0	0.00
LP004		**03/03/2015**	7.2	92	688	95	31	75	0	31	95	1	0.4	0.0	0.0	0.0	0.00
LP005		**03/03/2015**	7.5	93	708	96	31	75	0	31	96	1	0.4	0.0	0.0	0.0	0.00
LP006		**03/03/2015**	8.0	101	754	106	36	78	0	36	106	1	0.4	0.0	0.0	0.0	0.00
LU014		**02/03/2015**	7.5	113	970	124	50	65	0	50	124	0	0.4	0.0	0.0	0.0	0.00
DSW9	**50th percentile**	**2013 to 2015**	8.3	90	662	183	212	52	0	42	278	1	0.3	0.1	0.0	0.0	0.0
	95th percentile		8.8	101	1009	224	225	61	0	49	304	2	0.6	0.1	0.1	0.1	0.1
DSW42	**50th percentile**	**2013 to 2015**	8.3	74	520	158	192	26	0	35	143	1	0.1	0.1	0.0	0.0	0.0
	95th percentile		8.5	80	579	175	207	29	0	38	149	1	0.2	0.1	0.1	0.0	0.1
L1	**50th percentile**	**Jan 2013-March 2015**	7.7	90	743	96	41	32	0	19	428	2	0.5	0.0	0.0	0.1	2.9
	95th percentile		8.2	100	933	125	55	53	0	29	502	5	0.7	0.1	0.0	0.4	6.1
L2	**50th percentile**	**Jan 2013-March 2015**	7.5	88	696	84	48	37	0	17	387	1	0.6	0.0	0.0	0.1	0.2
	95th percentile		8.0	94	889	155	62	44	0	24	410	1	1.1	0.0	0.0	0.3	0.4
L3	**50th percentile**	**Jan 2013-March 2015**	7.6	114	877.0	119	38	76	0	70	415	2	0.4	0.0	0.0	1.2	2.1
	95th percentile		8.0	173	1480.0	186	54	144	0	97	719	5	0.7	0.1	0.0	9.7	4.6
W12	**50th percentile**	**Jan 2013-March 2015**	7.8	75	460.0	59	18	57	0	36	415	75	0.4	0.0	0.1	1.4	4.0
	95th percentile		8.1	82	538.2	116	22	85	0	50	719	215	0.7	0.1	0.1	3.7	18.4
W13	**50th percentile**	**Jan 2013-March 2015**	7.8	75	474.0	55	19	57	0	40	82	8	0.4	0.0	0.0	1.3	4.8
	95th percentile		8.1	82	606.0	119	25	92	0	52	236	14	0.5	0.1	0.0	3.0	19.8
W15	**50th percentile**	**Jan 2013-March 2015**	8.0	94	692.0	86	28	73	0	50	267	5	0.3	0.0	0.1	0.0	3.6
	95th percentile		8.3	107	853.6	128	48	105	0	64	310	9	0.6	0.0	0.2	0.6	6.7

Sample ID		pH-Value at 25° C	Conductivity at 25° C in mS/m	Total Dissolved Solids	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Chlorides as Cl	Sulfate as SO_4	Nitrate NO_3 as N	Fluoride as F	Aluminium as Al	Iron as Fe	Manganese as Mn	Free and Saline Ammonia as N
SANS241:2015	Standard limits)	5-9.5	<170	<1200	<150	<70	<200	<50	<300	<250	<11	<1.5	<0.3	<0.3	<0.1	<1.5
	Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	NO_3-N mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L	Ammonia mg/L
Klein Wes Rietspruit		7.7	85	690	93	41	32		19	379	0.9	0.4	0.0	0.0	0.0	2.4
C2H080		7.6	103	747	98	39	80		53	322	3	0.3	0.0	0.3	0.0	1.0
DP006	02/03/2015	7.7	11	82	11	6.6	6	0	4	6	0	0.0	0.004	0.0	0.2	0.2
DP003	02/03/2015	7.0	36	306	33	23.1	14	0	65	14	0	0.0	0.021	0.0	0.2	0.2
LU009	02/03/2015	7.6	114	896	133	55	63	0	112	386	1	0.0	0.001	0.019	0.0	0.1
GOL2376-SW1	25/03/2015	7.0	5	32	3	3	3	1	5	1	0	0.3	-0.003	0.115	-0.001	0.1
GOL2376-SW2	25/03/2015	7.7	57	358	49	28	36	5	42	78	0	0.3	-0.003	-0.003	0.003	0.2
GOL2376-SW3	25/03/2015	7.9	120	764	149	50	72	11	98	417	1	0.4	-0.003	-0.003	-0.001	0.2
GOL2376-SW4	25/03/2015	8.3	119	826	156	50	67	10	90	454	2	0.3	-0.003	-0.003	-0.001	0.1
GOL2376-SW5	25/03/2015	7.8	123	862	157	46	70	13	83	494	3	0.3	-0.003	-0.003	-0.001	0.1
GOL2376-SW6	25/03/2015	8.1	101	654	102	41	81	8	90	315	1	0.4	-0.003	-0.003	-0.001	0.2
GOL2376-SW7	25/03/2015	7.6	7	48	4	4	3	1	6	1	0	0.2	-0.003	-0.003	-0.001	0.1
GOL2376-SW8	10/07/2015	8.4	110	777	107	43	81	5	88	362	1	0.3	-0.002	-0.004	-0.002	0.1
GOL2376-SW9	10/07/2015	8.3	111	790	109	44	84	6	90	372	1	0.3	-0.002	-0.004	0.196	0.1
GOL2376-SW13	10/07/2015	8.2	91	616	82	28	77	6	70	283	4	0.5	-0.002	-0.004	-0.002	0.1
GOL2376-SW21	10/07/2015	8.8	89	628	70	42	66	2	55	343	2	0.6	-0.002	-0.004	-0.002	0.0
GOL2376-SW23	10/07/2015	7.8	131	985	142	58	77	6	95	490	10	0.4	-0.002	-0.004	0.060	0.0
GOL2376-SW26	10/07/2015	8.3	117	810	126	48	73	7	109	358	1	0.4	-0.002	-0.004	-0.002	0.0

Monitoring points L3, W12, W13 and W15 have shown elevated concentrations of Manganese and Ammonia that exceed the SANS drinking water standard of 0.5 mg/L and 2 mg/L respectively. Iron was exceeded at monitoring point LU009.

Monitoring points L1, L3 and W12 indicated Sulfate concentrations of 502 mg/L, 719 mg/L and 719 mg/L respectively, which exceed the SANS drinking water standard for Sulfate (250 mg/L).

Monitoring points W12 and W13 indicated Nitrate concentrations of 215 mg/L and 14 mg/L respectively, that were higher that the SANS drinking water standard of 11 mg/L.

The Klein Wes Rietspruit monitoring point, shows elevated Sulfate concentrations (379 mg/L) and Ammonia (2.4 mg/L), which exceed the SANS drinking water standards for the mentioned parameters.

The monitoring location of the Wonderfonteinspruit directly downstream of the 1 m pipeline is represented by monitoring point C2H080. From the results the SANS drinking water standards for Sulfate had been exceeded, with the measured Sulfate quality being 322 mg/L.

Table 7-9: Water Quality Results benchmarked against the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment

Sample ID			Nitrate NO_3 as N	Chlorides as Cl	Total Alkalinity as $CaCO_3$	Sulfate as SO_4	Conductivity at 25° C in mS/m	pH-Value at 25° C	Free and Saline Ammonia as N	Fluoride as F	Phosphate as PO_4	Aluminium as Al	Iron as Fe	Manganese as Mn	Magnesium as Mg
In-stream Water Quality Guidelines for the Vaal Barrage sub-catchment		Ideal	<0.5	<5		<20	<18	6.5-8.5	<0.2	--	--				<8
		Acceptable	0.3-3	5-50		20-100	18-30	-	0.2-0.5	<0.5	<0.03	<0.3	<0.5	<0.15	8-30
		Tolerable	3-6	50-75		100-200	30-70	-	0.5-1.0	0.5-1	0.03-0.05	0.3-0.5	0.5-1.0	0.15-0.20	30-70
		Unacceptable	>6	>75		>200	>70	<6.5;>8.5	>1	>1	>0.05	>0.5	>1.0	>0.2	>70
		Dates													
LP002		03/03/2015	18.0	4.9	0	7.2	8.3	6.9	0.0	20.0	0.2	0.1	0.0	0.0	5
LP004		03/03/2015	237.0	31.0	0	94.8	91.7	7.2	0.0	127.1	0.4	0.0	0.0	0.0	31
LP005		03/03/2015	240.0	30.8	0	96.0	93.3	7.5	0.0	126.3	0.4	0.0	0.0	0.0	31
LP006		03/03/2015	265.0	35.8	0	106.0	101.0	8.0	0.0	147.8	0.4	0.0	0.0	0.0	36
LU014		02/03/2015	310.0	49.8	0	124.0	113.0	7.5	0.0	204.2	0.4	0.0	0.0	0.0	50
DSW9	50th percentile	2013 to 2015	1.5	42.5	0	278.0	89.8	8.3	0.0	0.3	0.1	0.1	0.0	0.0	212
	95th percentile		2.0	49.1	0	303.8	100.9	8.8	0.1	0.6	0.1	0.1	0.1	0.1	225
DSW42	50th percentile	2013 to 2015	1.2	35.0	0	143.0	74.1	8.3	0.0	0.1	0.3	0.1	0.0	0.0	192
	95th percentile		1.3	38.3	0	148.8	80.2	8.5	0.1	0.2	0.3	0.1	0.1	0.0	207
L1	50th percentile	Jan 2013-March 2015	2.3	19		428	90	7.7	2.9	0.45		0.0	0.0	0.1	41
	95th percentile		5.3	29.2		502	99.8	8.24	6.1	0.74		0.1	0.0	0.4	55
L2	50th percentile	Jan 2013-March 2015	0.6	16.5		387	87.5	7.5	0.2	0.6		0.0	0.0	0.1	48
	95th percentile		0.775	24		410	93.75	7.975	0.37	1.05		0.0	0.0	0.3	62
L3	50th percentile	Jan 2013-March 2015	1.9	70		415	114	7.6	2.1	0.43		0.0	0.0	1.2	38
	95th percentile		5.45	97.4		718.8	172.8	8.04	4.6	0.745		0.1	0.0	9.7	54

Sample ID			Nitrate NO_3 as N	Chlorides as Cl	Total Alkalinity as $CaCO_3$	Sulfate as SO_4	Conductivity at 25° C in mS/m	pH-Value at 25° C	Free and Saline Ammonia as N	Fluoride as F	Phosphate as PO_4	Aluminium as Al	Iron as Fe	Manganese as Mn	Magnesium as Mg
W12	**50th percentile**	**Jan 2013-March 2015**	74.5	36		415	75	7.8	4	0.4		0.0	0.1	1.4	18
	95th percentile		215.25	50.2		718.8	82.4	8.1	18.4	0.725		0.1	0.1	3.7	22
W13	**50th percentile**	**Jan 2013-March 2015**	7.8	40		82	75	7.8	4.8	0.4		0.0	0.0	1.3	19
	95th percentile		14.2	52.2		235.8	82.2	8.12	19.8	0.525		0.1	0.0	3.0	25
W15	**50th percentile**	**Jan 2013-March 2015**	5.2	50		267	94	8	3.6	0.3		0.0	0.1	0.0	28
	95th percentile		8.74	64		310	107	8.3	6.74	0.56		0.0	0.2	0.6	48
Klein Wes Rietspruit			0.9	19		379	85	7.7	2.4	0.4	0.2	0.0	0.0	0.0	41
C2H080			2.6	53		322	103	7.6	1.0	0.3	3.0	0.0	0.3	0.0	39
DP006		**02/03/2015**	0.3	3.56		5.72	10.8	7.67	0.15	0		0.004	0.0	0.2	6.6
DP003		**02/03/2015**	0.3	64.7		13.5	36	7.02	0.22	0		0.021	0.0	0.2	23.1
LU009		**02/03/2015**	1.4	112		386	114	7.63	0.08	0		0.001	0.019	0.0	55
GOL2376-SW1		**25/03/2015**	0.24	5.48	19.2	0.53	5.25	6.97	0.11	0.25	0.08	-0.003	0.115	-0.001	3
GOL2376-SW2		**25/03/2015**	0.21	41.5	205	78	56.5	7.72	0.22	0.34	0.06	-0.003	-0.003	0.003	28
GOL2376-SW3		**25/03/2015**	0.84	97.7	149	417	120	7.89	0.22	0.39	0.06	-0.003	-0.003	-0.001	50
GOL2376-SW4		**25/03/2015**	1.52	89.9	139	454	119	8.28	0.13	0.32	0.06	-0.003	-0.003	-0.001	50
GOL2376-SW5		**25/03/2015**	2.53	82.8	133	494	123	7.76	0.1	0.3	0.08	-0.003	-0.003	-0.001	46
GOL2376-SW6		**25/03/2015**	1.16	90.1	131	315	101	8.14	0.15	0.41	0.44	-0.003	-0.003	-0.001	41
GOL2376-SW7		**25/03/2015**	0.17	5.83	24.5	0.9	6.5	7.55	0.11	0.22	0.07	-0.003	-0.003	-0.001	4
GOL2376-SW8		**10/07/2015**	0.833	88.2		362	110	8.35	0.079	0.319	0.017	-0.002	-0.004	-0.002	43
GOL2376-SW9		**10/07/2015**	0.554	90.1		372	111	8.29	0.083	0.337	-0.002	-0.002	-0.004	0.196	44
GOL2376-SW13		**10/07/2015**	4	70		283	91	8.17	0.068	0.457	0.509	-0.002	-0.004	-0.002	28
GOL2376-SW21		**10/07/2015**	1.55	54.6		343	89.4	8.8	0.006	0.633	-0.002	-0.002	-0.004	-0.002	42
GOL2376-SW23		**10/07/2015**	9.86	95.1		490	131	7.82	0.009	0.353	-0.002	-0.002	-0.004	0.060	58
GOL2376-SW26		**10/07/2015**	1.19	109		358	117	8.34	0.031	0.372	-0.002	-0.002	-0.004	-0.002	48

The In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment are more stringent than the SANS 241:2015 drinking water quality standards. The surface water quality assessment thus represents a worst case scenario (use of strict Barrage WQO) as in-stream guidelines for smaller more impacted streams could potentially be less stringent for example, the new proposed RQOs for the Mooirivier allow for an EC of 111 mS/m (compared to Barrage value of 70 mS/m) and sulfate values of 500 mg/L compared to the 200 mg/L for the Barrage. Summary of the water quality guidelines for the RQOs mentioned are shown in Table 7-10 below. The in-stream guidelines for the Rietspruit in fact allows for an EC of 120 mS/m and sulfate of 500 mg/L.

Table 7-10 Summary of Water Quality Objectives (Blank cells indicate no RQO value provided)

WATER QUALITY (µg/L)	Klein Wes Rietspruit	Leeuspruit	Loopspruit	Wonderfonteinspruit
NOTE	Based on RQO's for Klipriver (Far upstream); not set for C22H	Based on RQO's for Klipriver (Far upstream); not set for C22H	Based on RQO for UL 2 (see WFS) or C23L (Mooirivier- downstream of UL 2) as listed below	Based on downstream RQO for Mooirivierloop (C23E)
EC (mS/m)	111	111	111	111
Sulfates (mg/L)			500	
F (mg/L)	3	3		3
Al	150	150		150
As	130	130		130
Cd hard	5	5		5
Cr (VI)	200	200		200
Cu hard	8	8		8
Hg	1.7	1.7		1.7
Mn	1300	1300		1300
Pb hard	13	13		13
Uranium				15
Se	30	30		30
Zn	36	36		36
Chlorine (free Cl)				5
Phosphate (mg/L)			0.125*	0.125
Nitrate (mg/L)				4
Nitrite (mg/L)				4
Dissolved oxygen (mg/L)	7			7

In general, Sulfate, Nitrate, Electrical Conductivity, Ammonia and Fluoride indicate high concentrations that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment at most sampling points as indicated in Table 7-9.

High pH levels that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment (<6.5 and > 8.5) were observed at sampling sites DSW9 and SW12.

Surface water runoff draining from the Ezulwini, Cooke 4 and the Kloof mining complexes ultimately report to sampling points SW03, L2, L3 and SW05. Monitoring point SW03 located downstream of the RTSF and associated infrastructure, on the Leeuspruit, indicated a high Sulfate concentration (417 mg/L), with existing mine sampling points L2 and L3 located on the upstream tributary of the Leeuspruit measuring Sulfate concentrations of 387 mg/L and 415 mg/L respectively. Sampling point SW05, located within the Kloof mining complex, on a tributary of the Leeuspruit, indicate a Sulfate concentration of 494 mg/L.

At the Driefontein mining complex, most of the water quality monitoring points was dry, however sampling sites SW08 and SW09, taken on the upstream and downstream tributary of the Wonderfonteinspruit indicate Sulfate concentrations of 362 mg/L and 372 mg/L respectively.

Water quality monitoring points LP004, LP005, LP006, LU014 and W12 indicate high concentrations of Nitrate, with the latter four exceeding 230 mg/L. Sampling points LP004, LP005 and LP006 drain a portion of the Kloof and Driefontein mining areas, whilst LU014 and W12 drain a portion of the Kloof and Cooke mining areas.

When compared against the South African Water Quality Guidelines for Agricultural Use: Irrigation (Table 7-11), Manganese is the only chemical of concern with isolated exceedances of pH and Sodium also measured.

High pH levels exceeding the standards (<6.5 or >8.4) were observed at sampling points DSW9, DSW42 and SW21. Measurements were 8.8, 8.5 and 8.8 respectively.

Table 7-11: Water Quality Results benchmarked against the South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996)

Sample ID			pH-Value at 25° C	Conductivity at 25° C in mS/m	Total Dissolved Solids	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Chlorides as Cl	Sulfate as SO_4	Nitrate NO_3 as N	Fluoride as F	Aluminium as Al	Iron as Fe	Manganese as Mn	Free and Saline Ammonia as N
South Africa Water Quality Guidelines: Agriculture Irrigation	Ideal		<6.5 - >8.4	N/A	N/A	N/A	N/A	115	N/A	N/A	N/A	N/A	2	5	5	0.02	N/A
	Max. Allowable		<6.5 - >8.4	>540**	N/A	N/A	N/A	>460	N/A	N/A	N/A	N/A	>15.0	>20	>20	>10.0	N/A
		Date	pH	EC mS/m	TDS mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Cl mg/L	SO_4 mg/L	NO_3-N mg/L	F mg/L	Al mg/L	Fe mg/L	Mn mg/L	Ammonia mg/L
LP002		03/03/2015	6.9	8	34	7	5	5	0	5	7	0	0.2	0.1	0.0	0.0	0.00
LP004		03/03/2015	7.2	92	688	95	31	75	0	31	95	1	0.4	0.0	0.0	0.0	0.00
LP005		03/03/2015	7.5	93	708	96	31	75	0	31	96	1	0.4	0.0	0.0	0.0	0.00
LP006		03/03/2015	8.0	101	754	106	36	78	0	36	106	1	0.4	0.0	0.0	0.0	0.00
LU014		02/03/2015	7.5	113	970	124	50	65	0	50	124	0	0.4	0.0	0.0	0.0	0.00
DSW9	50th percentile	2013 to 2015	8.3	90	662	183	212	52	0	42	278	1	0.3	0.1	0.0	0.0	0.0
	95th percentile		8.8	101	1009	224	225	61	0	49	304	2	0.6	0.1	0.1	0.1	0.1
DSW42	50th percentile	2013 to 2015	8.3	74	520	158	192	26	0	35	143	1	0.1	0.1	0.0	0.0	0.0
	95th percentile		8.5	80	579	175	207	29	0	38	149	1	0.2	0.1	0.1	0.0	0.1
L1	50th percentile	Jan 2013-March 2015	7.7	90	743	96	41	32	0	19	428	2	0.5	0.0	0.0	0.1	2.9
	95th percentile		8.2	100	933	125	55	53	0	29	502	5	0.7	0.1	0.0	0.4	6.1
L2	50th percentile	Jan 2013-March 2015	7.5	88	696	84	48	37	0	17	387	1	0.6	0.0	0.0	0.1	0.2
	95th percentile		8.0	94	889	155	62	44	0	24	410	1	1.1	0.0	0.0	0.3	0.4
L3	50th percentile	Jan 2013-March 2015	7.6	114	877.0	119	38	76	0	70	415	2	0.4	0.0	0.0	1.2	2.1
	95th percentile		8.0	173	1480.0	186	54	144	0	97	719	5	0.7	0.1	0.0	9.7	4.6
W12	50th percentile	Jan 2013-March 2015	7.8	75	460.0	59	18	57	0	36	415	75	0.4	0.0	0.1	1.4	4.0
	95th percentile		8.1	82	538.2	116	22	85	0	50	719	215	0.7	0.1	0.1	3.7	18.4
W13	50th percentile	Jan 2013-March 2015	7.8	75	474.0	55	19	57	0	40	82	8	0.4	0.0	0.0	1.3	4.8
	95th percentile		8.1	82	606.0	119	25	92	0	52	236	14	0.5	0.1	0.0	3.0	19.8
W15	50th percentile	Jan 2013-March 2015	8.0	94	692.0	86	28	73	0	50	267	5	0.3	0.0	0.1	0.0	3.6
	95th percentile		8.3	107	853.6	128	48	105	0	64	310	9	0.6	0.0	0.2	0.6	6.7

Sample ID		pH-Value at 25° C	Conductivity at 25° C in mS/m	Total Dissolved Solids	Calcium as Ca	Magnesium as Mg	Sodium as Na	Potassium as K	Chlorides as Cl	Sulfate as SO_4	Nitrate NO_3 as N	Fluoride as F	Aluminium as Al	Iron as Fe	Manganese as Mn	Free and Saline Ammonia as N
Klein Wes Rietspruit		7.7	85	690	93	41	32		19	379	0.9	0.4	0.0	0.0	0.0	2.4
C2H080		7.6	103	747	98	39	80		53	322	2.6	0.3	0.0	0.3	0.0	1.0
DP006	**02/03/2015**	7.7	11	82	11	6.6	6	0	4	6	0	0.0	0.004	0.0	0.2	0.2
DP003	**02/03/2015**	7.0	36	306	33	23.1	14	0	65	14	0	0.0	0.021	0.0	0.2	0.2
LU009	**02/03/2015**	7.6	114	896	133	55	63	0	112	386	1	0.0	0.001	0.019	0.0	0.1
GOL2376-SW1	**25/03/2015**	7.0	5	32	3	3	3	1	5	1	0	0.3	-0.003*	0.115	-0.001*	0.1
GOL2376-SW2	**25/03/2015**	7.7	57	358	49	28	36	5	42	78	0	0.3	-0.003	-0.003	0.003	0.2
GOL2376-SW3	**25/03/2015**	7.9	120	764	149	50	72	11	98	417	1	0.4	-0.003	-0.003	-0.001	0.2
GOL2376-SW4	**25/03/2015**	8.3	119	826	156	50	67	10	90	454	2	0.3	-0.003	-0.003	-0.001	0.1
GOL2376-SW5	**25/03/2015**	7.8	123	862	157	46	70	13	83	494	3	0.3	-0.003	-0.003	-0.001	0.1
GOL2376-SW6	**25/03/2015**	8.1	101	654	102	41	81	8	90	315	1	0.4	-0.003	-0.003	-0.001	0.2
GOL2376-SW7	**25/03/2015**	7.6	7	48	4	4	3	1	6	1	0	0.2	-0.003	-0.003	-0.001	0.1
GOL2376-SW8	**10/07/2015**	8.4	110	777	107	43	81	5	88	362	1	0.3	-0.002	-0.004	-0.002	0.1
GOL2376-SW9	**10/07/2015**	8.3	111	790	109	44	84	6	90	372	1	0.3	-0.002	-0.004	0.196	0.1
GOL2376-SW13	**10/07/2015**	8.2	91	616	82	28	77	6	70	283	4	0.5	-0.002	-0.004	-0.002	0.1
GOL2376-SW21	**10/07/2015**	8.8	89	628	70	42	66	2	55	343	2	0.6	-0.002	-0.004	-0.002	0.0
GOL2376-SW23	**10/07/2015**	7.8	131	985	142	58	77	6	95	490	10	0.4	-0.002	-0.004	0.060	0.0
GOL2376-SW26	**10/07/2015**	8.3	117	810	126	48	73	7	109	358	1	0.4	-0.002	-0.004	-0.002	0.0

*Negative implies below lab detection limit.

Manganese is a relatively abundant element, constituting approximately 0.1% of the earth's crust. It is found in solution predominantly as the manganous Mn(II) ion, which can be stabilised by complexation to humic acids. On oxidation to the manganic, ion, Mn(IV), manganese tends to precipitate out of solution to form a black hydrated oxide, which is responsible for the staining problems often associated with manganese bearing waters. Its concentration in the soil solution is largely determined by soil pH and oxidation-reduction reactions. This is further modified by sorption and desorption reactions with the soil exchange complex. Manganese is reduced (and the solubility increased) under waterlogged conditions in association with low pH (DWAF, 1996). The study area is also underlain by dolomites, commonly associated with elevated manganese concentrations in local water sources.

7.5.1 Overall Water Quality

The project area falls within Upper Vaal WMA 8, with major rivers and their respective tributaries draining into the Vaal River. For this reason water quality results were benchmarked against the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

The overall water quality data indicated elevated concentrations of Sulfate, Nitrate, Fluoride, Manganese and Ammonia; exceeding the mentioned standards. This indicates that rivers within this area are already impacted. The project area is comprised of various land uses which includes mining, old tailings storage facilities, industrial areas, residential areas, and agricultural activities. All these land uses could possibly have contributed to the current water quality status of the identified rivers and drainages.

Ammonia occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of the nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. It is also discharged into water bodies by some industrial processes and as a component of municipal or community waste. Higher concentrations could be an indication of organic pollution such as from domestic sewage, industrial waste and fertiliser run-off. Ammonia is therefore a useful indicator of organic pollution (Chapman, 1996). This will also contribute in high Nitrate concentrations from when microorganisms break down organic residues such as decaying plants, fertilizers, and manure.

Possible sources of chloride could be wastewater runoff, agricultural runoff, and industrial effluent.

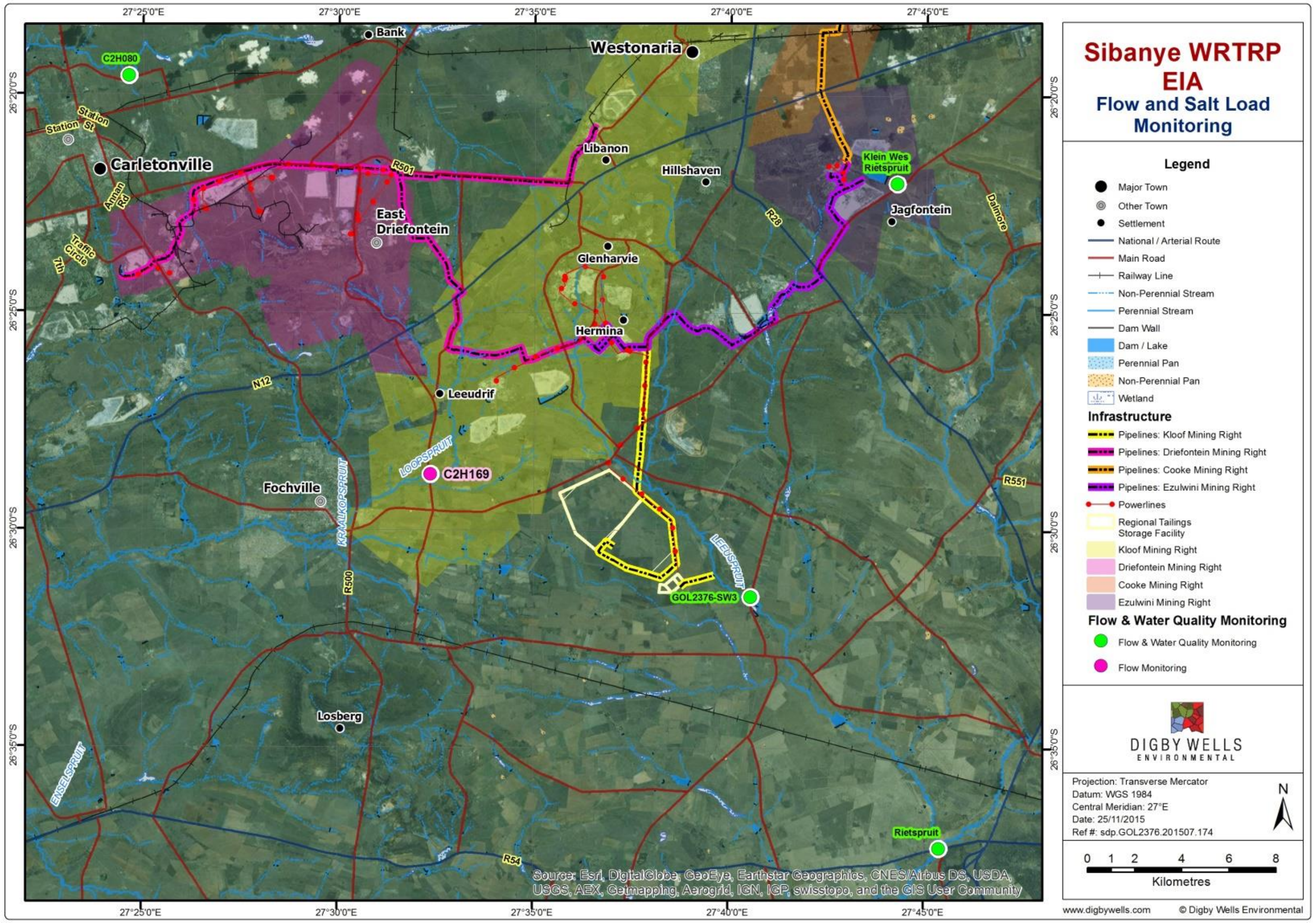

Figure 7-5: Flow and Salt Load Monitoring

7.6 Surface Water Quantity

Surface water drainage within the project area occurs in three directions, with the main rivers being the Leeuspruit, Klein Wes Rietspruit, the Wonderfonteinspruit and the Loopspruit. Each of the mentioned rivers drain runoff emanating from a specific quaternary catchment as indicated in Figure 7-1 and Table 7-5. As mentioned the runoff from quaternary catchment C23D and C23E is drained by the Wonderfonteinspruit, quaternary catchment C22J by the Leeuspruit, quaternary catchment C22H by the Klein Wes Rietspruit, and C23J by the Loopspruit.

The following sections will quantify the flow from these rivers whilst also looking at the impacts of the project on their respective flow. A summary of the flow gauging stations is presented in Figure 7-5.

7.6.1 Wonderfonteinspruit

The Wonderfonteinspruit is divided into the Upper and the Lower Wonderfonteinspruit and is responsible for draining surface water runoff emanating from the Cooke, Driefontein and Kloof mining areas. The source of the Upper Wonderfonteinspruit is the Tudor Dam, located north, of the Donaldson Dam, the Leopards Vlei Dam and the Lancaster Dam. The Upper Wonderfonteinspruit ends at the outflow of the Donaldson Dam, where a 1 m pipeline signifies the beginning of the Lower Wonderfonteinspruit. The Lower Wonderfonteinspruit is made up of the 1 m pipeline which extends approximately 30 km down the natural drainage path of the Wonderfonteinspruit.

Approximately 33 Ml/day (33 000 m^3/day) is being discharged into the Wonderfonteinspruit from the K10 Shaft together with additional discharges of 20 Ml/d (20 000 m^3/day) from Cooke 1 Shaft.

It must be noted that over and above the 53 Ml/day entering the 1 m pipeline, on the Upper Wonderfonteinspruit there are discharges into the Wonderfonteinspruit of approximately 15 - 20 Ml/d from the Flip Human Waste Water Treatment Works (WWTW), and on the Lower Wonderfonteinspruit, approximately 10 Ml/d is discharged directly into the 1 m pipeline from the Hannes van Niekerk WWTW. Therefore, total flows discharged to the Wonderfonteinspruit via the 1 m pipeline currently, amounts to 78 Ml/day (78 000 m^3/day).

During re-mining approximately 20 Ml/d (20 000 m^3/day) from K10 Shaft will be used within the RTSF process, together with 12 Ml/d from Cooke 1 Shaft, resulting in total discharges to the 1 m pipeline decreasing from 53 Ml/day (53 000 m^3/day) as a result of mine discharges to 21 Ml/d (21 000 m^3/day) as a result of an estimated 32 Ml/day (32 000 m^3/day) being used for the reclamation process.

Downstream flow gauging station C2H080 is used to represent the current flows measured at the exiting the 1 m pipeline. The mentioned gauging station has a record length of over a year (January 2014 to February 2015). Summary of flows currently measured at C2H080 and anticipated flow reduction is indicated in Table 7-12. Current flows are measured to be

72 123 m^3/day on average. Decrease in flows in the Wonderfonteinspruit is expected to range between 37 to 55% at the outlet of the 1 m pipeline.

Currently at the downstream end of the 1 m pipeline, approximately 130 M/day is being measured as a result of Driefontein discharges of 50 Ml/day, as well as approximately 80 Ml/day discharged from the 1 m pipeline. During re-mining 32 Ml/day will be removed from the pipeline, resulting in flows decreasing to 98 Ml/day, which should be still sufficient to accommodate the downstream users.

Table 7-12 Summary of flow data for C2H080 (Wonderfonteinspruit pipe discharge point)

Month	Average Flows (m^3/day) – Current	Average Flows (predicted) (m^3/day) - During re-mining
January	70006	38006
February	66401	34401
March	79602	47602
April	70837	38837
May	66715	34715
June	77652	45652
July	71681	39681
August	87647	55647
September	80061	48061
October	57867	25867
November	67706	35706
December	69296	37296

7.6.2 Leeuspruit West

Flow estimations on the Leeuspruit West were estimated based on the catchment size contributing to the runoff on the downstream section of the mentioned river together with changes in runoff response due to seasonality (represented by runoff factors). The catchment area reporting to the downstream section amounts to 107 km^2, with the runoff factors adopted to best represent conditions during the wet and dry seasons (0.05 for the wet season and 0.03 for the dry season). The simplified flow equation used to estimate flow is indicated in Table 7-13.

Table 7-13 Details of flow equation

Calculated variable	Details of calculations or reference
Flow (m^3/day)	(Area (m^2) *(monthly rainfall (m)*runoff factor)/no of days in month

During re-mining 15 Ml/day will be discharged into the Leeuspruit from the AWTF. An increase in current observed flow is therefore anticipated. Summary of the flow data for the Leeuspruit West is shown in Table 7-14.

Table 7-14 Summary of flow data for the Leeuspruit West

Month	Monthly Rainfall (mm)	Monthly Runoff (m^3/day) - Current	Monthly Runoff (m^3/day) - During re-mining
January	122	21055	36055
February	64.1	12033	27033
March	35.8	6178	21178
April	25.1	2686	17686
May	2.6	269	15269
June	1.4	150	15150
July	0.3	31	15031
August	5.8	601	15601
September	19.2	2054	17054
October	72.9	12581	27581
November	99.1	17673	32673
December	142.5	24593	39593

Flows on the Leeuspruit can range from no flows during the dry season to a max of 24 593 m^3/day during the wet season. Flows on the Leeuspruit will increase from no flows been observed during the dry season to a constant 15 000 m^3/day flowing down the section of the Leeuspruit when re-mining commences. During the wet season peak flows can be as much as 39 593 m^3/day.

7.6.3 Klein Wes Rietspruit

Actual flow data for the Klein Wes Rietspruit was obtained from a flow measuring point located downstream of the Peter Wright Dam (Table 7-15). The flow data record length ranges from January 2014 to September 2015.

Currently approximately 70 Ml/day is abstracted as a result of underground dewatering activities at the Ezulwini Gemsbokfontein West dolomitic compartments. From the 70 Ml/day abstracted 10 Ml/day is discharged to the Leeuspruit (East), and the remaining 60 Ml/day is discharged to the Klein Wes Rietspruit. During re-mining of the TSFs, 20 Ml/day will be used to mine the 1 Mt/mth from Cooke 4 South (C4S), resulting in a decrease of discharges from 60 Ml/day to 40 Ml/day. Therefore there will be a decrease in current flows measured at the Klein Wes Rietspruit.

Table 7-15 Summary of flow on the Klein Wes Rietspruit

Month	Average Flows (m^3/day) - Current	Average Flows (m^3/day) - During re-mining
January	65212	45212
February	60335	40335
March	67055	47055
April	66561	46561
May	69912	49912
June	69752	49752
July	71064	51064
August	75453	55453
September	73807	53807
October	73227	53227
November	70546	50546
December	72423	52423

Average (actual) flows in the Klein Wes Rietspruit is estimated to be 69 612 m^3/day. Decrease in flows in the Klein Wes Rietspruit is expected to range between 27 to 33% downstream of the Peter Wright Dam. Water users include farming, cultivation, grazing. Estimated water use is estimated conservatively at 5000 m^3/day. The water usage from the Klein Wes Rietspruit in comparison to what is available is actually available during re-mining is still sufficient to cater for the demand.

7.6.4 Loopspruit

To estimate the flows on the Loopspruit River two nearby gauging stations where investigated, which include C2H051 located on the Kraalkopspruit and C2H169 located on the Loopspruit. No data is available for station C2H169, therefore to better estimate the flows at C2H169 area weighting of the available flows for C2H051 was undertaken.

Area weighting involves adjusting the flows obtained from station C2H051 based on the ratio of its catchment area with the catchment area of flow gauging station C2H169. The catchment area of C2H051 is 5.4 km^2, whilst the catchment area of gauging station C2H169 is 54.9 km^2. This indicates that the flow on the Loopspruit should be close to ten times the flow measured at C2H051. This method is considered applicable in this particular case as the catchment characteristics which dictate the runoff reporting to the watercourses are fairly similar. A summary of the weighted flows for the Loopspruit are shown below in Table 7-16.

Table 7-16 Estimated flows on the Loopspruit

Months	**Average Flows (m^3/day) - C2H051 (Kraalkopspruit)**	**Estimated Flows (m^3/day) - C2H169 (Loopspruit)**
January	546	5348
February	605	5923
March	788	7720
April	633	6204
May	598	5858
June	597	5853
July	528	5169
August	444	4351
September	412	4035
October	588	5756
November	476	4665
December	477	4672
Average	**558**	**5463**

Average flows in the Loopspruit is estimated to be around 5 463 m^3/day. There are no planned discharges or abstraction from the Loopspruit currently being considered.

7.6.5 Downstream Surface Water Monitoring at Rietspruit

Currently flows reporting to the downstream section at the Rietspruit after the confluence of the Leeuspruit experience an increase in flows. This is due to the 10 Ml/day being discharged to the Leeuspruit East, and the 60 Ml/day being discharged to the Klein Wes Rietspruit. Flows from these watercourses will eventually report to the mentioned monitoring location on the Rietspruit.

During re-mining 15 Ml/day will be discharged from the AWTF together; however there will be a decrease in flows into the Klein Wes Rietspruit (20 Ml/day). Therefore in summary, flows will show a decrease on the Rietspruit.

Below (Table 7-17) is a summary of the decrease in flows during re-mining. Average decrease in salt loads is approximately 6% on the Rietspruit.

Table 7-17 Summary of Flows on the Rietspruit

Month	Current				During re-mining			
	Current Flows in Leeuspruit (West)	**Current Flows in Leeuspruit (East)**	**Current Flows in Klein Wes Rietspruit**	**Total Flows (downstream of Rietspruit and Leeuspruit (West) confluence**	**Flows in Leeuspruit (West)**	**Flows in Leeuspruit (East)**	**Flows in Klein Wes Rietspruit**	**Total Flows (downstream of Rietspruit and Leeuspruit (West) confluence**
January	21055	10000	65212	*96267*	36055	10000	45212	*91267*
February	12033	10000	60335	*82367*	27033	10000	40335	*77367*
March	6178	10000	67055	*83233*	21178	10000	47055	*78233*
April	2686	10000	66561	*79246*	17686	10000	46561	*74246*
May	269	10000	69912	*80181*	15269	10000	49912	*75181*
June	150	10000	69752	*79902*	15150	10000	49752	*74902*
July	31	10000	71064	*81095*	15031	10000	51064	*76095*
August	601	10000	75453	*86054*	15601	10000	55453	*81054*
September	2054	10000	73807	*85862*	17054	10000	53807	*80862*
October	12581	10000	73227	*95808*	27581	10000	53227	*90808*
November	17673	10000	70546	*98219*	32673	10000	50546	*93219*
December	24593	10000	72423	*107016*	39593	10000	52423	*102016*

7.7 Salt Loads

7.7.1 Methodology

The salt balance was calculated based on the simple mass balance equation adopted in the Department of Water and Sanitation (DWS) (formerly DWAF) Best Practice Guidelines G2: Water and Salt Balance, 2006. The equation is listed in Table 7-18.

Table 7-18 Details of salt balance equation

Calculated variable	Details of calculations or reference
Salt Balance (kg/month)	Flow (m^3/day) *0.001 *Salt Concentration (mg/L)*no of days in month

The salt loads were estimated based on the current flow in the Wonderfonteinspruit, Klein Wes Rietspruit and the Leeuspruit.

When pollution loads and discharge compliance requirements are under consideration, it is appropriate to use Sulfate, TDS or EC for determining salt loads (BPG: Water and Salt Balances, 2006). Sulfate indicated concentrations that exceed the Vaal Barrage WQO. Therefore, Sulfate was considered for salt loads calculations in this study, however TDS was also compared in the sections to follow.

A summary of the applicable gauging stations and the water quality monitoring points used are shown in Figure 7-5.

7.7.2 Wonderfonteinspruit Salt Load

Water quality data to estimate the reduction in salt loads was obtained for the final outlet at the 1 m pipeline from the applicant. Flow data as described in section 7.6, together with the water quality data was then used to estimate the reductions in salt loads during re-mining at the outlet of the 1 m pipeline on the Wonderfonteinspruit.

Summary of salt loads estimated at the outlet of the 1 m pipeline currently and during re-mining is indicated in Table 7-19 and Table 7-20 respectively.

Table 7-19 Summary of current salt loads at the outlet of the Wonderfonteinspruit pipeline

Month	Average Flows (m^3/day)	Concentration : SO_4 (mg/l)	Concentration : TDS (mg/l)	Loads (kg/month) - TDS	Loads (kg/month) - SO_4
January	70006	322	747	1621127	698516
February	66401	322	747	1413636	609112
March	79602	322	747	1843347	794267
April	70837	322	747	1587448	684004
May	66715	322	747	1544930	665684
June	77652	322	747	1740191	749818

July	71681	322	747	1659920	715231
August	87647	322	747	2029631	874533
September	80061	322	747	1794176	773080
October	57867	322	747	1340028	577395
November	67706	322	747	1517303	653780
December	69296	322	747	1604688	691433
TOTAL LOAD (tons/annum)				**19696**	**8487**

Table 7-20 Summary of estimated salt loads during re-mining

Month	Average Flows (m^3/day)	Concentration : SO_4 (mg/l)	Concentration : TDS (mg/l)	Loads (kg/month) - TDS	Loads (kg/month) - SO_4
January	38006	322	747	880103	379222
February	34401	322	747	732372	315566
March	47602	322	747	1102323	474972
April	38837	322	747	870328	375010
May	34715	322	747	803906	346389
June	45652	322	747	1023071	440824
July	39681	322	747	918896	395937
August	55647	322	747	1288607	555239
September	48061	322	747	1077056	464085
October	25867	322	747	599004	258101
November	35706	322	747	800183	344785
December	37296	322	747	863664	372138
TOTAL LOAD (tons/annum)				**10960**	**4722**

Note: Operational flow relates to flow during the operational phase of the project.

Based on average Sulfate concentrations of 322 mg/L, together with TDS concentrations of 747 mg/L measured at the 1 m pipeline outlet, estimated decrease in salt loads range from 37 to 55%.

7.7.3 Leeuspruit Salt Load

Table 7-21 presents a summary of the current and predicted salts loads (during RTSF operational phase) in the Leeuspruit. The Sulfate and TDS concentrations were based on the Digby Wells water quality monitoring point SW3. This is a once off sample taken on March 2015 which recorded Sulfate concentrations of 417 mg/L and TDS concentrations of 764 mg/L.

The average Sulfate load has shown an increase of on average 70% due to the additional volume being discharged into the Leeuspruit West, as indicated in Table 7-21. This is based on the assumption that discharge will be treated to the discharge water quality specification of the AWTF, whilst the TDS load showed an increase of approximately 62% (see Table 7-22).

The Sulfate concentrations will decrease from 417 mg/L to a minimum of 350 mg/L (July) due to increased flows of on average 15 000 m^3/day (Table 7-21). A decrease in Sulfate concentrations of around 12% on average is anticipated due to increased flows.

The TDS concentrations will decrease from 764 mg/L to a minimum of 361 mg/L (July) due to increased flows as mentioned (Table 7-22). A decrease in TDS concentrations of around 38% on average is anticipated due to increased flows.

The following assumption must be noted:

- A concentration of 350 mg/L for Sulfate was used to estimate the discharge water quality from the RTSF and as mentioned is based on the discharge water quality specification of the AWTF; and
- A concentration of 360 mg/L for TDS was used to estimate the discharge water quality from the RTSF and as mentioned is based on the discharge water quality specification of the AWTF.

Table 7-21 Summary of current and predicted RTSF operational phase Sulfate loads on the Leeuspruit

Leeuspruit									
Month	Current Flow (m^3/day)	Additional Flow (m^3/day)	Operational Flow (m^3/day)	Concentration : SO4 (mg/l) - Current (RIVER)	Concentration : SO4 (mg/l) (AWTF Qualities) During re-mining	Loads (SO4) - Kg/month (RIVER)	Loads (SO4) - Kg/month (AWTF) During re-mining	Concentration : SO4 (mg/l) - Operational Phase	Loads (SO4) - Operational Phase
January	21055	15000	36055	417	350	272176	162750	389	434926
February	12033	15000	27033	417	350	143004	149625	380	292629
March	6178	15000	21178	417	350	79868	162750	370	242618
April	2686	15000	17686	417	350	33598	157500	360	191098
May	269	15000	15269	417	350	3480	162750	351	166230
June	150	15000	15150	417	350	1874	157500	351	159374
July	31	15000	15031	417	350	402	162750	350	163152
August	601	15000	15601	417	350	7764	162750	353	170514
September	2054	15000	17054	417	350	25701	157500	358	183201
October	12581	15000	27581	417	350	162636	162750	381	325386
November	17673	15000	32673	417	350	221087	157500	386	378587
December	24593	15000	39593	417	350	317910	162750	392	480660
TOTAL LOAD (tons/annum)						**1269**	**1919**		**3188**

Table 7-22 Summary of current and predicted RTSF operational phase TDS loads on the Leeuspruit

Leeuspruit									
Month	Current Flow (m^3/day)	Additional Flow (m^3/day)	Operational Flow (m^3/day)	Concentration : TDS (mg/l) - Current (RIVER)	Concentration : TDS (mg/l) (AWTF Qualities) During re-mining	Loads (TDS) - Kg/month (RIVER)	Loads (TDS) - Kg/month (AWTF) During re-mining	Concentration : TDS (mg/l) - Operational Phase	Loads (TDS) - Operational Phase
Janaury	21055	15000	36055	764	360	498663	167400	596	666063
February	12033	15000	27033	764	360	262002	153900	540	415902
March	6178	15000	21178	764	360	146329	167400	478	313729
April	2686	15000	17686	764	360	61556	162000	421	223556
May	269	15000	15269	764	360	6376	167400	367	173776
June	150	15000	15150	764	360	3433	162000	364	165433
July	31	15000	15031	764	360	736	167400	361	168136
August	601	15000	15601	764	360	14224	167400	376	181624
September	2054	15000	17054	764	360	47087	162000	409	209087
October	12581	15000	27581	764	360	297971	167400	544	465371
November	17673	15000	32673	764	360	405061	162000	579	567061
December	24593	15000	39593	764	360	582455	167400	611	749855
TOTAL LOAD (tons/annum)						**2326**	**1974**		**4300**

7.7.4 Klein Wes Rietspruit Salt Loads

The current flow and water quality monitoring point on the Klein Wes Rietspruit is located downstream of the Peter Wright Dam. As mentioned during re-mining of the TSFs, 20 Ml/day will be used to mine the 1 Mt/mth from Cooke 4 South (C4S), resulting in a decrease of discharges from 60 Ml/day to 40 Ml/day. Therefore there will be a decrease in current salt loads measured at the Klein Wes Rietspruit downstream of the Peter Wright Dam.

A summary of the current salt loads for both Sulfate and TDS and the estimated salt loads during re-mining is indicated in Table 7-23 and Table 7-24 respectively.

Table 7-23 Summary of estimated current salt loads on the Klein Wes Rietspruit

Month	Average Flows (m^3/day)	Concentration : SO_4 (mg/l)	Concentration : TDS (mg/l)	Loads (kg/month) - SO4	Loads (kg/month) - TDS
January	65212	379	690	766320	1394882
February	60335	379	690	651829	1186481
March	67055	379	690	787978	1434303
April	66561	379	690	756939	1377805
May	69912	379	690	821551	1495415
June	69752	379	690	793230	1443863
July	71064	379	690	835092	1520063
August	75453	379	690	886667	1613941
September	73807	379	690	839348	1527809
October	73227	379	690	860511	1566331
November	70546	379	690	802264	1460308
December	72423	379	690	851063	1549133
TOTAL LOAD (tons/annum)				**9653**	**17570**

Table 7-24 Summary of estimated salt loads during re-mining on the Klein Wes Rietspruit

Month	Average Flows (m^3/day)	Concentration : SO_4 (mg/l)	Concentration : TDS (mg/l)	Loads (kg/month) - SO4	Loads (kg/month) - TDS
January	45212	379	690	531295	967082
February	40335	379	690	435758	793181
March	47055	379	690	552953	1006503
April	46561	379	690	529496	963805
May	49912	379	690	586526	1067615
June	49752	379	690	565786	1029863
July	51064	379	690	600068	1092263
August	55453	379	690	651642	1186141
September	53807	379	690	611904	1113809

October	53227	379	690	625486	1138531
November	50546	379	690	574821	1046308
December	52423	379	690	616038	1121333
TOTAL LOAD (tons/annum)				**6882**	**12526**

Based on average Sulfate concentrations of 379 mg/L and TDS concentrations of 690 mg/L measured downstream of the Peter Wright Dam on the Klein Wes Rietspruit, estimated decrease in salt loads range from 27 to 33%.

7.7.5 Downstream Salt Load Monitoring at Rietspruit

Currently salt loads reporting to the downstream section at the Rietspruit, after the confluence of the Leeuspruit, experiences an increase in salt loading. This is due to the 10 Ml/day being discharged to the Leeuspruit East, and the 60 Ml/day being discharged to the Klein Wes Rietspruit. Salt loads from these watercourses will eventually report to the mentioned monitoring location on the Rietspruit.

During re-mining 15 Ml/day will be discharged from the AWTF together; however there will be a decrease in flows into the Klein Wes Rietspruit (20 Ml/day). Therefore in summary, salt loading will show a decrease on the Rietspruit.

Table 7-25 and Table 7-26 is a summary of the decrease in salt loads during re-mining for Sulfate and TDS. Average decrease in salt loads for Sulfate and TDS on the Rietspruit is approximately 7% and 15% respectively.

Table 7-25 Summary of Sulfate Salt Loads on the Rietspruit

Month	Current				During re-mining			
	Current Loads in Leeuspruit (West)	Current Loads in Leeuspruit (East)	Current Loads in Klein Wes Rietspruit	Total Loads (downstream of Rietspruit and Leeuspruit (West) confluence	Loads in Leeuspruit (West)	Loads in Leeuspruit (East)	Loads in Klein Wes Rietspruit	Total Loads (downstream of Rietspruit and Leeuspruit (West) confluence
January	272176	117512	766320	***1156009***	434926	117512	531295	***1083734***
February	143004	108036	651829	***902869***	292629	108036	435758	***836423***
March	79868	117512	787978	***985358***	242618	117512	552953	***913083***
April	33598	113722	756939	***904259***	191098	113722	529496	***834315***
May	3480	117512	821551	***942544***	166230	117512	586526	***870269***
June	1874	113722	793230	***908826***	159374	113722	565786	***838882***
July	402	117512	835092	***953006***	163152	117512	600068	***880732***
August	7764	117512	886667	***1011943***	170514	117512	651642	***939668***
September	25701	113722	839348	***978770***	183201	113722	611904	***908827***
October	162636	117512	860511	***1140660***	325386	117512	625486	***1068385***
November	221087	113722	802264	***1137073***	378587	113722	574821	***1067130***
December	317910	117512	851063	***1286486***	480660	117512	616038	***1214211***
TOTAL (tons/annum)	**1269**	**1386**	**9653**	**12308**	**3188**	**1386**	**6882**	**11456**

Table 7-26 Summary of TDS Salt Loads on the Rietspruit

Month	Current				During re-mining			
	Current Loads in Leeuspruit (West)	Current Loads in Leeuspruit (East)	Current Loads in Klein Wes Rietspruit	Total Loads (downstream of Rietspruit and Leeuspruit (West) confluence	Loads in Leeuspruit (West)	Loads in Leeuspruit (East)	Loads in Klein Wes Rietspruit	Total Loads (downstream of Rietspruit and Leeuspruit (West) confluence
January	498663	213900	1394882	***2107444***	666063	213900	967082	***1847044***
February	262002	196650	1186481	***1645134***	415902	196650	793181	***1405734***
March	146329	213900	1434303	***1794532***	313729	213900	1006503	***1534132***
April	61556	207000	1377805	***1646362***	223556	207000	963805	***1394362***
May	6376	213900	1495415	***1715691***	173776	213900	1067615	***1455291***
June	3433	207000	1443863	***1654297***	165433	207000	1029863	***1402297***
July	736	213900	1520063	***1734699***	168136	213900	1092263	***1474299***
August	14224	213900	1613941	***1842065***	181624	213900	1186141	***1581665***
September	47087	207000	1527809	***1781895***	209087	207000	1113809	***1529895***
October	297971	213900	1566331	***2078203***	465371	213900	1138531	***1817803***
November	405061	207000	1460308	***2072370***	567061	207000	1046308	***1820370***
December	582455	213900	1549133	***2345487***	749855	213900	1121333	***2085087***
TOTAL (tons/annum)	**2326**	**2522**	**17570**	**22418**	**4300**	**2522**	**12526**	**19348**

8 Floodline Assessment

To inform the infrastructure layout of the mining operation, understand and manage the risks of flooding to the operation and assess compliance with Condition 4 of GN704, modelling of the 1:50 year and the 1:100 year flood-lines is required for the section of the Leeuspruit which passes through the proposed RTSF area, and the adjacent unnamed tributary located on the southern boundary of the RTSF area.

The floodline assessment is also to be used to assess the 1:100 year elevation at each of the pipeline crossings identified, so as to ensure that the pipeline is elevated above the 1:100 year flood inundated areas.

The following section details the approach and the methods used in the development of a hydraulic model for the purpose of defining the floodlines.

8.1 Methodology

8.1.1 Software

HEC-RAS 4.1 was used for the purposes of modelling the flooding associated with a 1:50 year and 1:100 year flood event. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

HEC-GeoRAS is an extension of HEC-RAS which utilises the ArcGIS environment. The HEC-GeoRAS extension is used to extract the cross-sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling and is used again to project the modelled flood levels back onto the DEM to generate floodlines associated with the modelled events.

8.1.2 Hydraulic Structures

One of the key objectives of the site visit was to determine the existence of any hydraulic structures within the modelled section of the Leeuspruit and the unnamed tributary. From the site visit two major hydraulic structures were identified, which are located upstream and downstream of the RTSF area, on the Leeuspruit. Additional hydraulic structures identified along the various river crossings (RC) along the proposed pipeline route are also indicated. It should be noted however that in some instances measurements where estimated from areal imagery and Lidar survey.

The hydraulic structures are indicated in Figure 8-1 and Figure 8-2. A summary of the dimensions of the hydraulic structures is presented in Table 8-1.

Table 8-1: Summary of dimensions of hydraulic structures

Name	Number of Openings	Deck Thickness (m)	Number of Piers	Pier Width (m)	Culvert/bridge Opening width (m)	Culvert height (m)
Bridge 1 (Downstream from RTSF)	7	0.7	6	0.4	6.35	
Bridge 2 (Upstream of RTSF)	3	0.4	2	0.4	6.5	
RC2						
RC5	3	0.6	N/A	N/A	6	1.5
	Broad crested weir modelled downstream of RC5					
RC8	1	0.4	N/A	N/A	10	1
RC8 downstream	1	0.6	N/A	N/A	10	1
RC9	1	0.4	N/A	N/A	10	1
RC13	1	0.4	N/A	N/A	10	1
RC14	1	0.6	N/A	N/A	6	1
RC15	1	0.6	N/A	N/A	7	4
RC16	2	0.6	1	0.5	6	N/A
RC17	Broad crested weir modelled at RC17					

Figure 8-1: Bridge Downstream of RTSF (Bridge 1)

Figure 8-2: Bridge Upstream of RTSF (Bridge 2)

8.1.3 Roughness Coefficients

The Manning's roughness factor (n) is used to describe the flow resistant characteristics of a specific surface. During the site visit it was observed that at certain parts of the watercourse the left and right banks were densely vegetated. The predominant vegetation within the watercourse is of grassland type. The Manning's factor ranged from 0.045 up to 0.2 in some instances so as to account for areas within the watercourses having dense vegetation.

8.2 Peak Flows

The estimated peak flows (m^3/s) are used as input to the HEC-RAS model to calculate the extent of flooding based on the 1:50 and the 1:100 year storm events. For the flood modelling the peak flows for two of the catchments were calculated using the Utilities Programme for Drainage (UPD) software.

8.2.1 Methodology

The methods used to calculate the peak flows are described below.

8.2.1.1 Rational Method

The Rational Method equation is:

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

Where:

Q_T = Peak Flow (m^3/s for specific return period)

C = Runoff Coefficient (dimensionless)

I = Rainfall Intensity (mm/hr)

A = Area (km^2)

The Rational formula has the following assumptions:

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

It was assumed that the flows in the various catchments were in a defined water course. Time of Concentration (time taken for a raindrop to travel from the furthest upstream point in a catchment to the outlet) was calculated using the following formula:

$$T_{c\ channel} = \left(\frac{0.87L^2}{1000\left(\frac{H_{0.85L} - H_{0.10L}}{(1000)(0.75L)}\right)} \right)^{0.385}$$

Where:

$T_{c\ channel}$ = time of concentration for channel flow (hours)

L = hydraulic length of catchment (km)

$H_{0.10L}$ = elevation height at 10% of the length of the watercourse (m)

$H_{0.85L}$ = elevation height at 85% of the length of the watercourse (m)

8.2.1.2 Regional Maximum Flood

The Regional Maximum Flood (RMF) (Department of Water Affairs and Forestry, South Africa, TR137) approach was developed for Southern Africa in the late 1980's and estimates flood peak discharges for the 1:50, 1:100 and 1:200 flood peaks. The RMF is calculated using the Francou-Rodier formula on the basis of the catchment area and a regional K factor. The Francou-Rodier relationship reads:

$$Q_{RMF} = 10^6 \left(\frac{A}{10^8} \right)^{1-0,1K}$$

Where:

Q_{RMF} = regional maximum flood peak flow rate (m_3/s)

K = regional constant

106 = total world MAR (m^3/s)

108 = total world catchment area (km^2)

The Regional Maximum Flood (RMF) can only be applied on large catchments and is based on a regional K factor.

8.2.2 Catchment Hydrology and Adopted Peak Flows

Peak flows were calculated for the three different catchments, with the RMF method adopted for the larger catchment (Catchment 1) and the Rational method adopted for the smaller catchments (Catchment 2 and Catchment 3). A summary of the catchment characteristics shown in Table 8-2 and Table 8-3 is used to obtain the peak flows (Table 8-4).

Table 8-2 Summary of catchment hydrology (RMF Method)

Name	Area (km^2)	K-Factor
Catchment 1	148	4.6
RC5	163.75	4.6

Table 8-3 Summary of catchment hydrology (RATIONAL Method)

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Catchment 2	36	9632	122.46	50.1	1.82	0.317
Catchment 3	36	11586	31.4	28.5	3.81	0.285
RC2	19.13	4506	30	65.6	1.30	0.303
RC8	2.58	3306	69	110.4	0.70	0.305
RC9	13.86	4270	139	103.8	0.67	0.301
RC13	5.65	4637	146	102.4	0.73	0.301
RC14	25.36	8299	79	51.1	1.82	0.305
RC15	7.90	6605	82	65.5	1.38	0.300
RC16	28.58	8806	110	53.1	1.71	0.301
RC21	3.45	2130	36	129.1	0.51	0.313

Table 8-4 Summary of Peak Flows

Name	50 year	100 year
Catchment 1	254.4	333.7
Catchment 2 (RC19 and 26)	149.2	190.4
Catchment 3	76.04	97.7
RC2	100.38	128.42
RC5	354.19	439.16
RC8	22.90	29.62
RC9	114.24	146.14

Name	50 year	100 year
RC13	45.95	59.31
RC14	104.20	133.39
RC15	40.96	52.88
RC16	120.51	154.02
RC21	36.74	47.46

8.3 Key Assumptions

The following assumptions were made:

- The 0.5 m topographic data provided was sufficient to enable hydraulic modelling at a suitable level of detail;
- Based on site observations of the channel and floodplain characteristics, a Manning value of 0.045 up to 0.2 was assigned to both the floodplain and the channel because of the substantial vegetation growth observed within the channel banks and certain areas of the main river channel;
- The Manning values used is considered suitable for use in both the 50 year and 100 year return periods modelled, as well as in representing both the channel and floodplain;
- Hydraulic structures in most instances were estimated from areal imagery and Lidar survey;
- It is assumed that dirty water runoff from the mine infrastructures will contribute to the peak flow measured at the respective catchment outlets. However this may not necessarily be the case. A conservative catchment area is therefore assumed;
- The farmer crossing located on the Leeuspruit is now the preferred crossing for the proposed pipeline. The farmer crossing is not a stable hydraulic structure and it is likely to be washed away during extreme storm events. There will be no backwater effect or impact to flooding of the RTSF or associated infrastructures;
- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate;
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model;
- No flood protection infrastructure was modelled;
- The modelling of the adopted flow through the respective hydraulic structures was undertaken, whilst assuming no blockages were present;
- Floodlines and levels are for environmental use and purposes only; and

- The additional flows amount to 0.1 m^3/s. This is however insufficient to impact the delineated floodlines for the section of the Leeuspruit. Therefore, no abstractions from or discharges into the river section were taken into account during the modelling.

8.4 Results

Modelling of the 1:50 year and 1:100 year floodlines was required for the section of the Leeuspruit which passes on the east side adjacent to the proposed RTSF area, and the adjacent unnamed tributary located on the southern boundary of the RTSF area.

As mentioned, floodlines for all identified river crossings have been modelled and are included in the flood study. The 1:100 year elevation at each of the identified crossings together with the estimated velocities is indicated in Appendix B.

The model results indicated that the RTSF and associated infrastructures (RWD's) fall outside of the 1 in 100 year floodline and the 100 m buffer. The summary of the delineated floodlines are shown in Figure 8-3 to Figure 8-8.

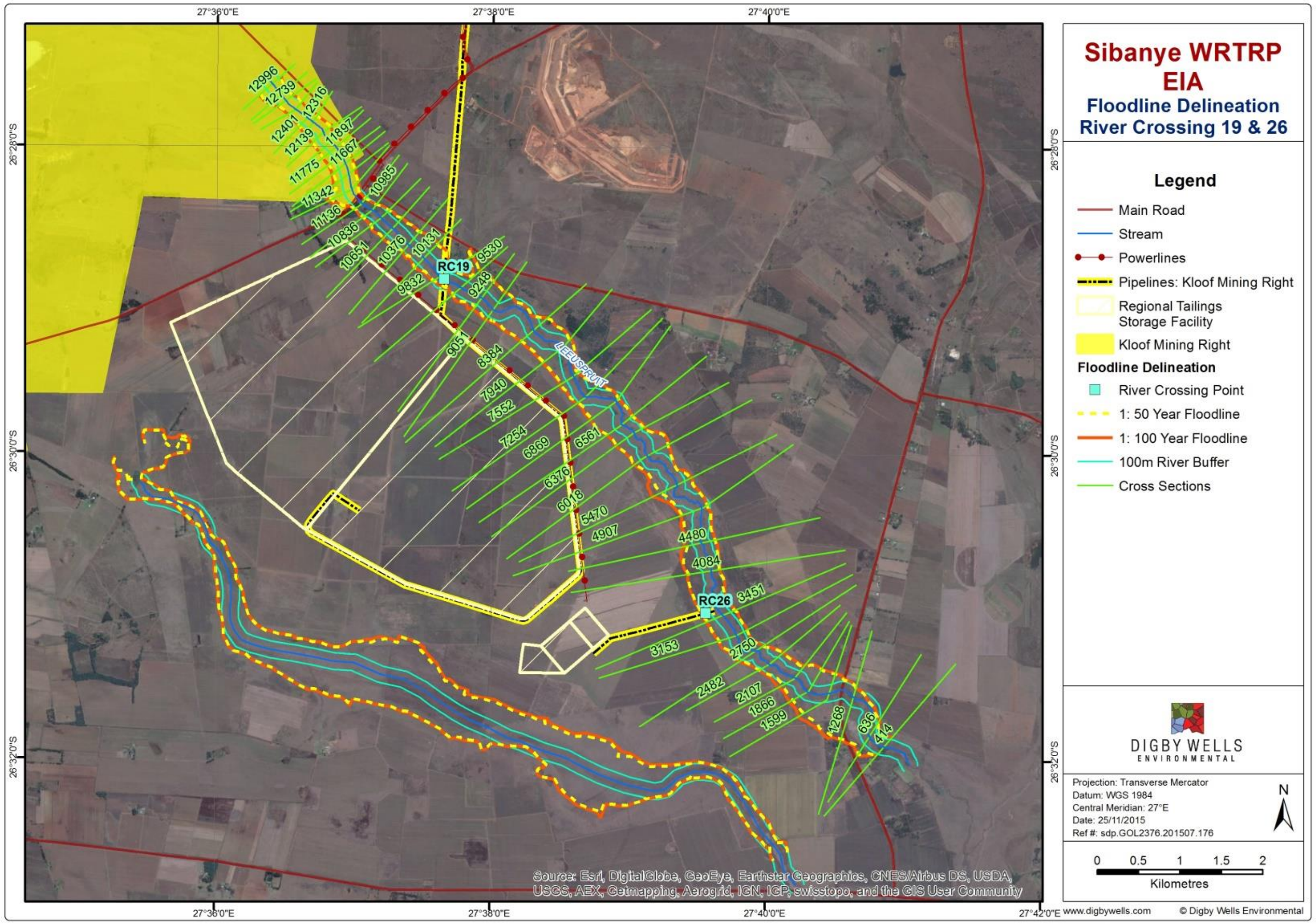

Figure 8-3: 1:50 year and 1:100 Delineated Floodlines Leeuspruit - RC19 and RC26

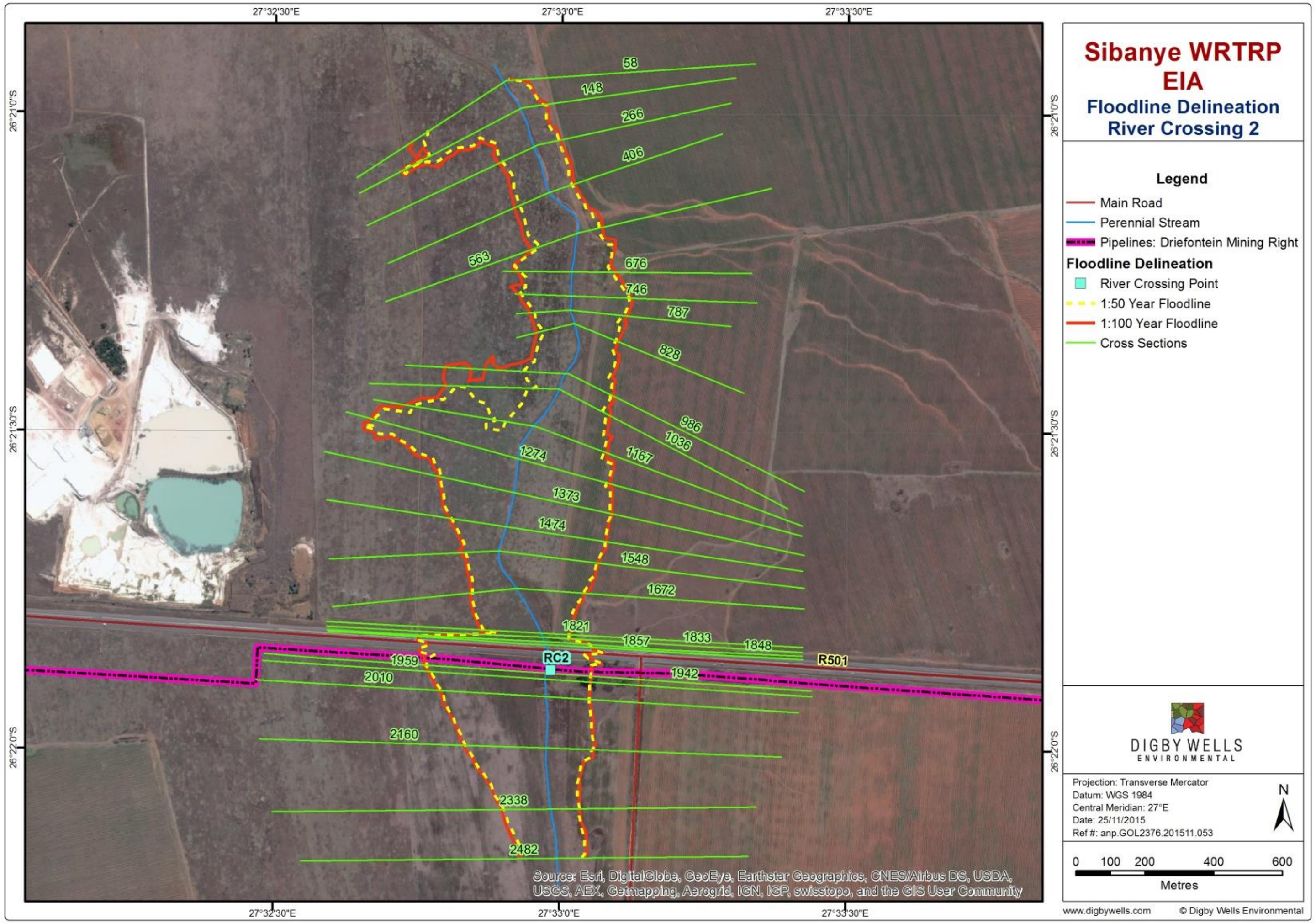

Figure 8-4 1:50 and 1:100 Delineated Floodline for RC2

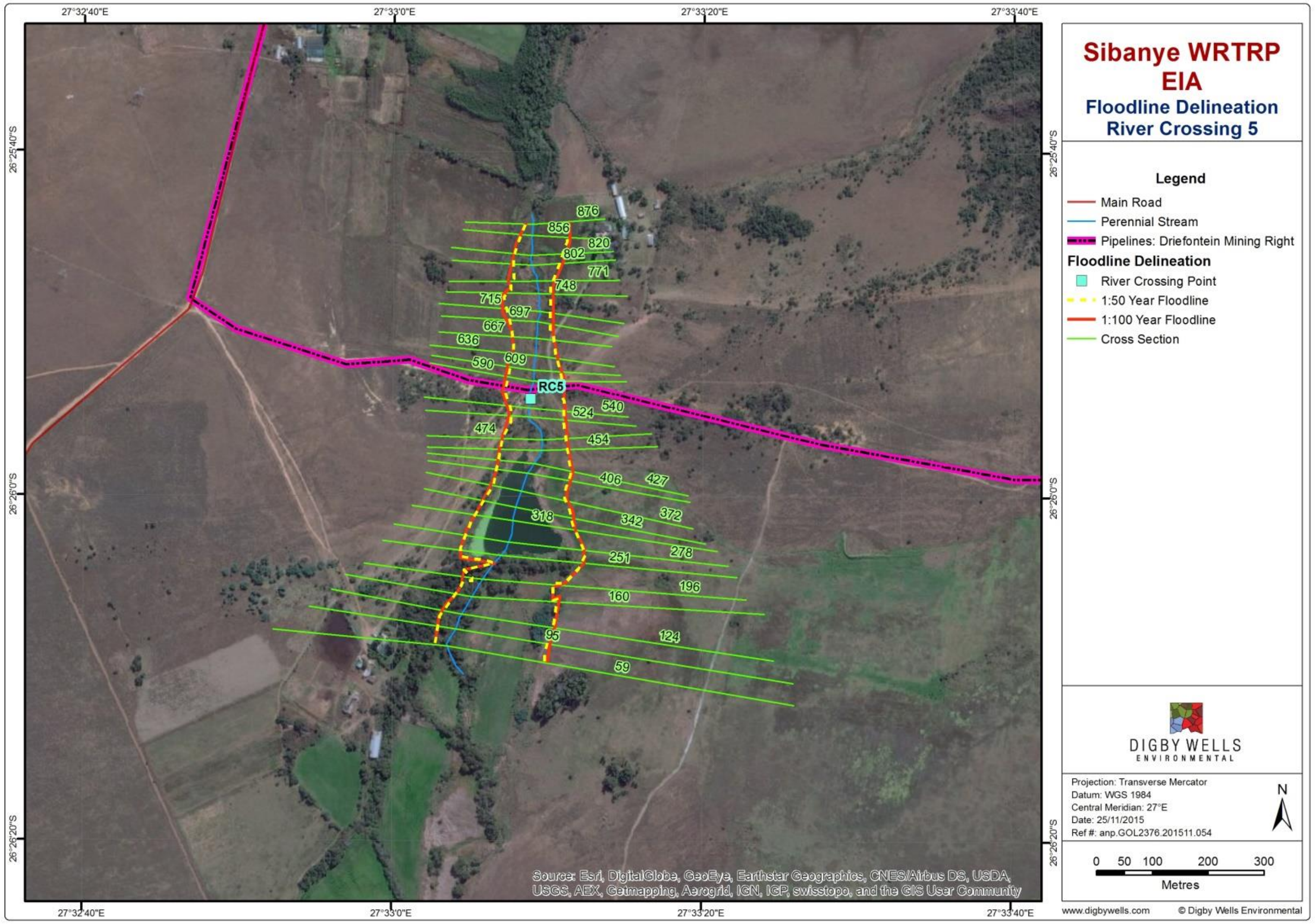

Figure 8-5 1:50 and 1:100 Delineated Floodline for RC5

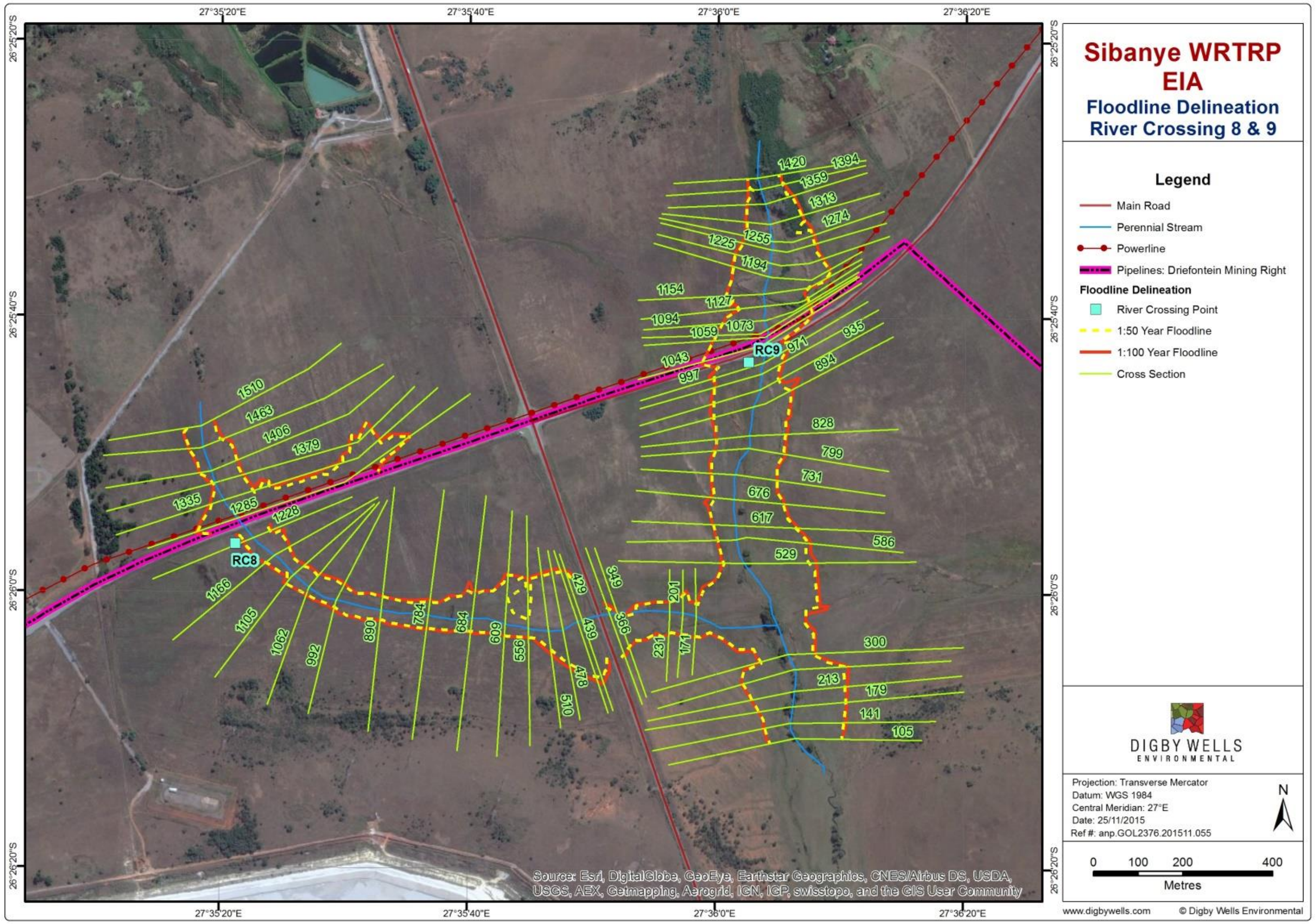

Figure 8-6 1:50 and 1:100 Delineated Floodline for RC8 and RC9

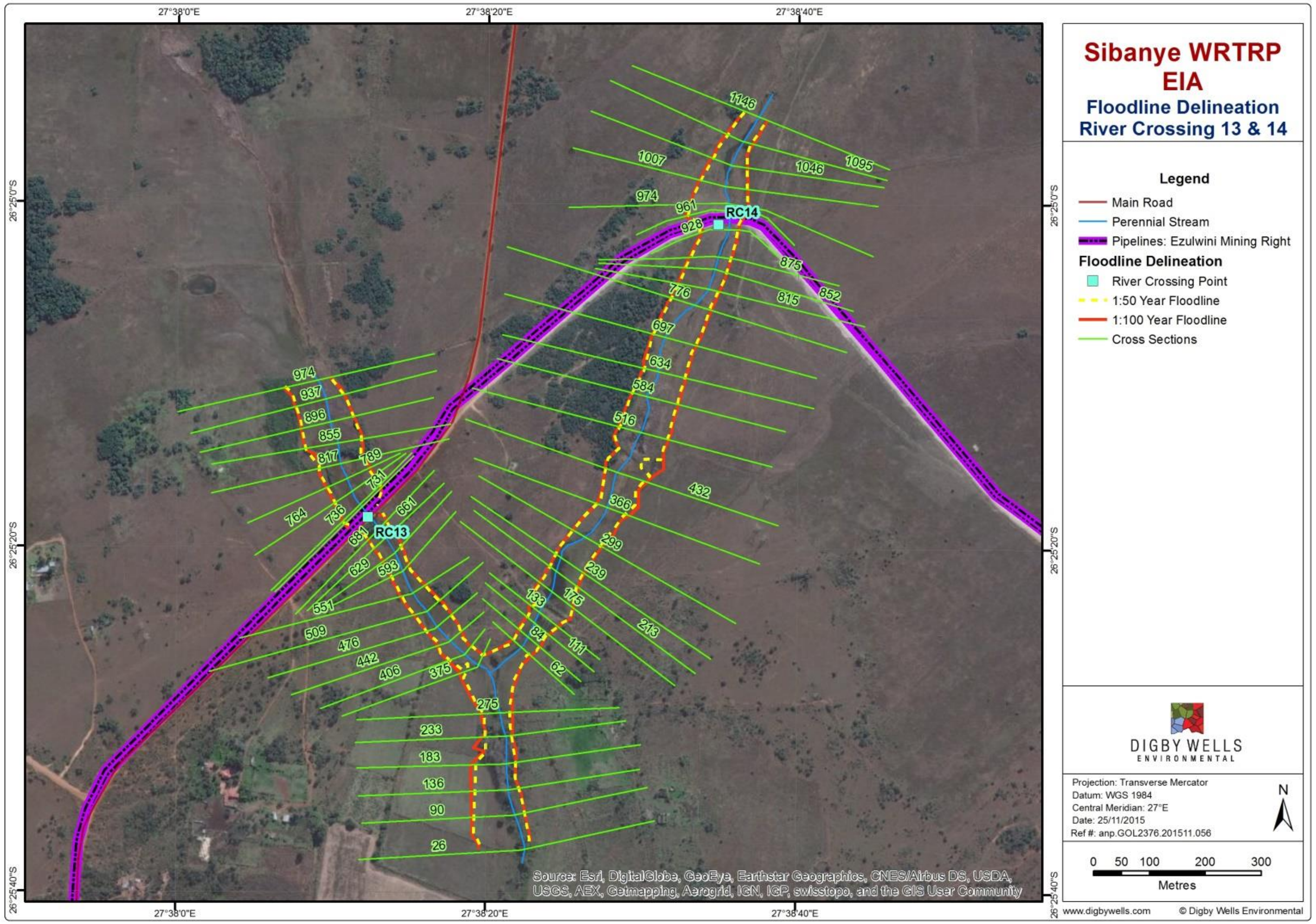

Figure 8-7 1:50 and 1:100 Delineated Floodline for RC13 and RC14

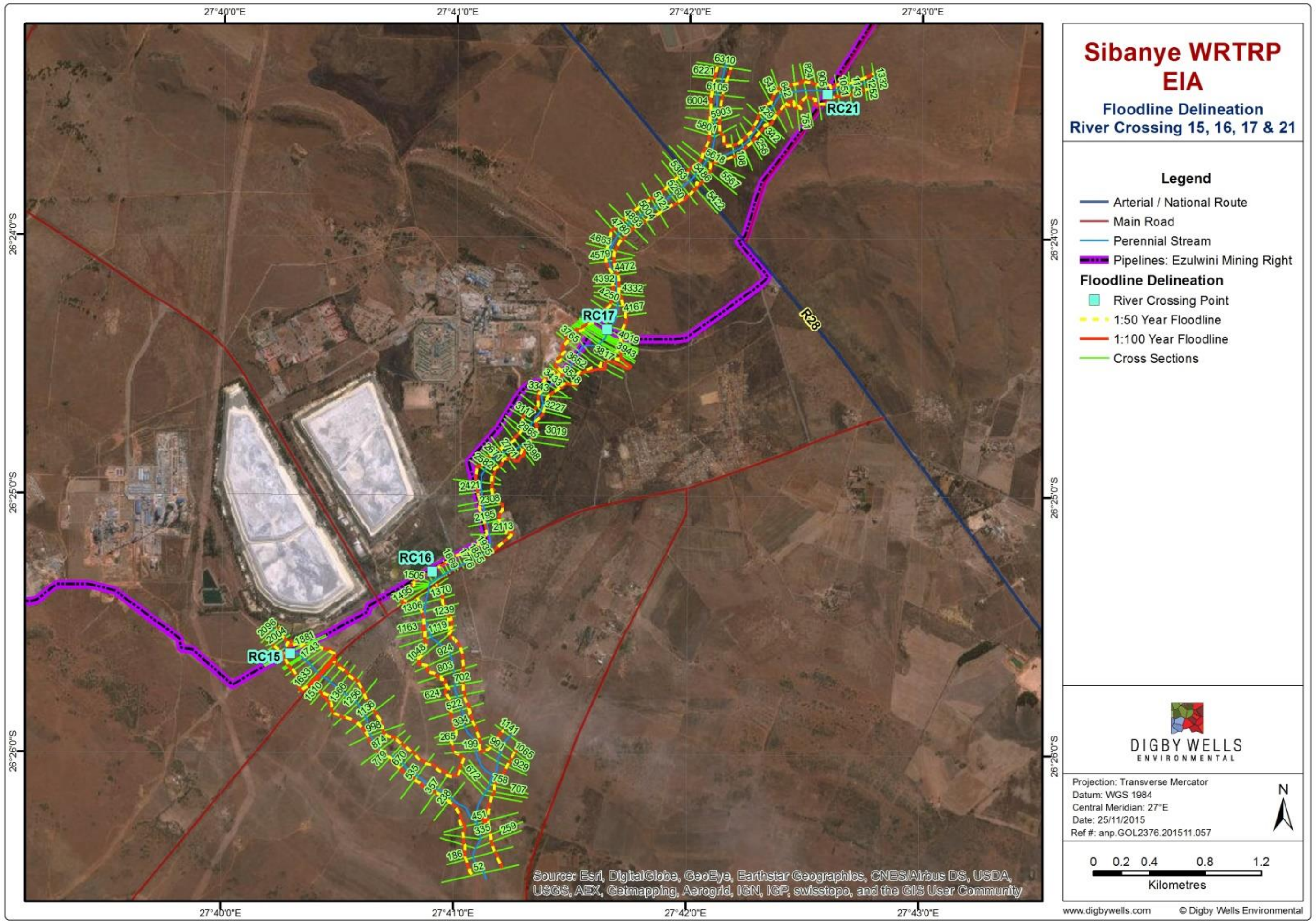

Figure 8-8 1:50 and 1:100 Delineated Floodline for RC15, RC16 and RC17

9 Sensitivity Analysis and No-Go Areas

A sensitivity analysis was completed with reference to the National Water Act, (Act No. 36 of 1998), which provides regulations aimed at protection of water resources in respect of use of water for mining and related activities (also see Wetland Report).

One of the restrictions from this Act states that no person in control of a mine or activity may locate or place any residue deposit, Dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse. The sensitivity areas within the project site are shown in Figure 9-1.

Reg. 704 exemption needs to be applied for any pipelines or pylons constructed within the flood inundated areas or wetland buffer.

9.1 Sensitivities in the Cooke Mining Area

Cooke mining right area has number of rivers (perennial and non-perennial), and few natural Dams. Rivers on this Cooke MRA includes the Wonderfonteinspruit, Rietfonteinspruit, Middelvleispruit and few unnamed drainage lines.

The main water course draining this MRA is the Wonderfonteinspruit passing in between the Cooke TSF and Cooke Plant. Water quality in Wonderfonteinspruit has indicated elevated concentrations of Nitrates, Ammonia, Conductivity, Fluorides and Sulfates that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

Considering the current water quality in the Wonderfonteinspruit, this river should be considered as highly sensitive so as to avoid further deterioration of water quality.

9.2 Sensitivities in the Driefontein Mining Right Area

The Driefontein MRA falls within two quaternary catchments namely C23E and C23J. The main water course in these two quaternaries includes the Mooirivierloop (C23E) and the Loopspruit (C23E), with several non-perennial drainages in both quaternaries.

Water quality at sampling point SW6, which is a downstream point on the Loopspruit (C23E) indicated elevated concentrations of Nitrate, Chloride, Electrical Conductivity, Fluoride and Sulfate that exceeds the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

Sampling points SW8 and SW9 are sampling points on the unnamed tributary associated with the Mooirivierloop (C23E). Elevated concentrations of Nitrate, Chloride, Electrical Conductivity and Sulfate, exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

This is an indication of contamination in these two rivers, and they should be regarded as highly sensitive to avoid further deterioration of the water quality.

9.3 Sensitivities in the Kloof Mining Area

The Kloof MRA covers portions of the three main rivers which include Wonderfonteinspruit, Leeuspruit and Loopspruit. The water quality within these rivers has already been impacted as explained in section 7.5.

Baseline results show that the overall Present Ecological Status (PES) of the reach of the Leeuspruit and Loopspruit as was found to be in a largely modified (class D) state due to poor water quality and modification to instream and riparian habitats (Digby Wells Aquatic Ecology Report, 2015).

Due to the largely modified state of the Leeuspruit, the impact of the RTSF on water quality will contribute toward the cumulative decline in the PES. However, should mitigation actions be followed the likelihood of the impact occurring can be reduced (Digby Wells Aquatic Ecology Report, 2015).

No significant impacts are expected in the Loopspruit as a result of the proposed activities (Digby Wells Aquatic Ecology Report, 2015).

9.4 Sensitivities within the Ezulwini Mining Area

The Ezulwini MRA consists of an unnamed, non-perennial stream and a reservoir called Peter Wright Dam. The Dam does not supply water for domestic use. However, these two water courses should be regarded as medium sensitive due to possible overflow that can occur during high rainfall events.

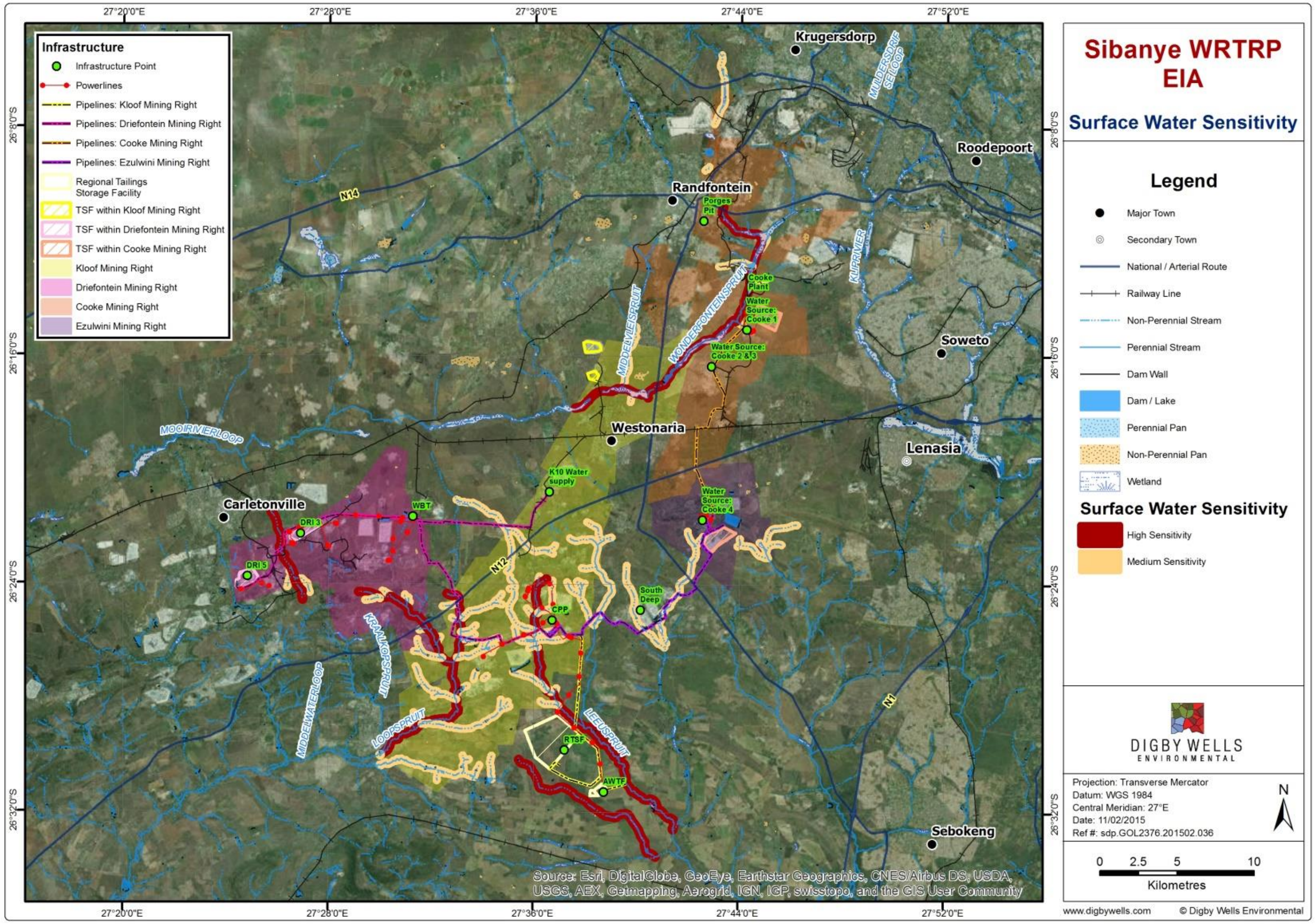

Figure 9-1: Sensitive and No-go Areas

10 Impact Assessment

10.1 Overview

Impacts are broadly assessed based on magnitude and receptor sensitivity. This permits the assessment practitioner to determine impact significance and mitigation.

Based on international guidelines and South African legislation, the following criteria should be taken into account when examining potentially significant impacts:

- Nature of impacts (induced/direct/indirect, positive/negative);
- Duration (short/medium/long-term, permanent(irreversible) / temporary (reversible), frequent/seldom);
- Extent (geographical area, size of affected population/habitat/species);
- Intensity (minimal, severe, replaceable/irreplaceable);
- Probability (high/medium/low probability); and
- Mitigation (as per mitigation hierarchy: avoid, mitigate or offset significant adverse impacts).

10.1.1 Methodology - Impact rating in terms of its nature, extent, duration, probability and significance

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

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

Significance = CONSEQUENCE X PROBABILITY X NATURE

Where

Consequence = intensity + extent + duration

And

Probability = likelihood of an impact occurring

And

Nature = positive or negative impact

The matrix calculates the rating out of 147, whereby intensity, extent, duration and probability are each rated out of seven as indicated in Table 10-1. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation has been applied; post-mitigation is referred to as the residual impact. The significance of an impact is determined and categorised into one of seven categories. The descriptions of the significance ratings are presented in Table 10-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e., there may already be some mitigation included in the engineering design. If the specialist determines the potential impact is still too high, additional mitigation measures should be proposed.

Table 10-1: Impact assessment parameter ratings

RATING	INTENSITY/ REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
7	Irreplaceable loss or Damage to biological or physical resources or **highly** sensitive environments. Irreplaceable Damage to **highly sensitive** cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or Damage to biological or physical resources or **moderate to highly** sensitive environments. Irreplaceable Damage to cultural/social resources of **moderate to highly** sensitivity.	Great improvement to the overall conditions of a large %age of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

RATING	INTENSITY/ REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
5	Serious loss and/or Damage to physical or biological resources or **highly** sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable Damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or Damage to physical or biological resources or **moderately** sensitive environments, limiting ecosystem function. On-going serious social issues. Significant Damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

RATING	INTENSITY/ REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
3	Moderate loss and/or Damage to biological or physical resources of **low to moderately** sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	**Minor loss and/or effects** to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small %age of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

RATING	INTENSITY/ REPLACABILITY		EXTENT	DURATION/REVERSIBILITY	PROBABILITY
	Negative impacts	Positive impacts			
1	**Minimal to no loss** and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable Damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small %age of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 10-2: Probability/Consequence Matrix

Significance

Probability \ Consequence	-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
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

Consequence

Table 10-3: Significance Rating Description[2]

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

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

10.2 Project Activity Assessed

The assessment of surface water quality and quantity impacts associated with the reclamation of the various dumps is detailed in this section. Table 10-4 details the activities proposed for the reclamation project.

Table 10-4: Primary activities of the WRTRP

Category	Activity
Infrastructure	Pipeline Routes (water, slurry and tailings).
	West, (WBT) and West, North and South Bulk Water Storage (BWS) complexes.
	Cooke thickener.
	Collection sumps and pump stations at the Driefontein TSF 3 and 5, Ezulwini South TSF and Cooke TSF.
	CPP incorporating Module 1 float and gold plants and No1 uranium, roaster and acid plants) and RTSF.
	RTSF Return Water Dams (RWD) and the Advanced Water Treatment Facility (AWTF).
Processes	Abstraction of water: K10 shaft. Cooke 1 and 2. Shaft storage tank
	Disposal of the residue from the AWTF.
	Hydraulic reclamation of the TSFs (which include temporary storage of the slurry in a sump).
	Gold, uranium and L extraction at the CPP (tailings to RTSF) and possible uranium extraction at Ezulwini (tailings to Ezulwini North Dump).
	Water distribution at the AWTF for discharge or sale.
Pumping in Western Block	Pumping water from K10 to the BWSF located next to the WBT.
	Pumping water from the BWSF to the Driefontein TSFs that will be reclaimed.
	Pumping slurry from the TSF sump to the WBT (for Driefontein TSF 3 and 5).
	Pumping the thickened slurry from the WBT to the CPP (2 pipeline route options).
Pumping in Southern Block	Possible pumping 50 kt/m of uranium and L rich slurry from the CPP to Ezulwini for extraction of uranium.
	Pumping of up to 1.4 Mt/m of tailings to the RTSF.
	Pumping water from the RTSF return water Dams to the AWTF.
	Discharging treated water to the Leeuspruit.
	Pumping of 1 Mt/m of tailings from the C4S to CPP
	Pumping water from the CPP to C4S
	Pumping residue from the AWTF to the RTSF.
Pumping in Northern Block	Pumping 400 kt/m of tailings from the Cooke Dump to the Cooke thickener.
	Pumping from the Cooke thickener to the CPP via the booster station at Ezulwini plant.
Electricity supply	Power supply from West Drie 6 substation to Driefontein TSF 3.
	Power supply from West Drie Gold substation to Driefontein TSF 5.

Category	Activity
	Power supply from East Drie Shaft substation to WBT and BWSF.
	Power supply from Kloof 1 substation to the CPP.
	Power supply from Kloof 4 substation to the RTSF and AWTF.
	Power supply from the Cooke substation to the Cooke thickener.
	Power supply from the Cooke Plant to the Cooke TSF
	Power supply from Ezulwini plant to the C4S TSF

10.3 Summary of Impacts

A summary of all impacts for all phases is provided in Table 10-5.

Table 10-5: Interactions and Impacts for all Project Phases

Interaction	Impact
Site clearing and grubbing(Construction phase)	Increase sedimentation on downstream watercourses due to exposed surfaces resulting in siltation of surface water resources.
	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas.
Construction of infrastructure (pipelines, sumps, CPP, RTSF complex, RTSF return water Dam AWTF). (Construction phase)	Flooding of pipeline structures at river crossings.
	Reduction in catchment yield.
	The risk of mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas due to SWMP failure, resulting in dirty water reporting to the downstream catchment.
	Seepages/spillages of excess rainfall stored on the RTSF and the RWD to the Leeuspruit.
Reduction of discharged water on the Wonderfonteinspruit during operational phase.	Decrease water discharged to the Wonderfonteinspruit River. Resulting in inadequate water supply for the downstream users or eco systems on the Wonderfonteinspruit. Decreased salt load due to less water being discharged.
Discharges of water from the AWTF into the Leeuspruit during operational phase.	Overflowing of small Dams located on the Leeuspruit resulting in backing up of water upstream.
	Positive impact of dilution due to treated water being added to the current Leeuspruit flows.
	Possible downstream flooding of the river banks due to additional flows.
Operation of sumps and pumps and	The risk of pump failure and overflow from sumps.

Interaction	Impact
pollution control Dams	Risk of spillages from pipelines. Risk of spillage from plant area. Risk of spillage from RTSF area.
Decommissioning activities	The risk of water pollution from accidental spillages of decommissioned infrastructure and RTSF
Post closure	The risk of water pollution from rehabilitated infrastructures
	Positive impact of catchment yield due to runoff from rehabilitated reclaimed areas reporting into the nearby water courses.

11 Kloof Mining Right Area Impact Assessment

11.1 Construction Phase

11.1.1 Impact Description

The construction phase of the project will cover the infrastructure development which will include all the activities mentioned in the infrastructure category in the summary of the activity list shown in Table 10-4. These activities include the following:

- The CPP;
- The water supply and pipelines from K10;
- The RTSF;
- The RW Dam facilities;
- The AWTF and discharge pipeline; and
- The slurry pipe lines to the RTSF.

During the construction phase, the following interactions will occur as a result of infrastructure development, site clearing and grubbing and the construction of infrastructures (pipelines, sumps, CPP, RTSF complex).

As a result of site clearing and grubbing the following potential impacts are predicted:

- Increase in sedimentation of surface water during construction caused by an increase in runoff from the cleared and stripped areas which are high in suspended solids; and
- Increase of surface runoff and potentially contaminated water that needs to be maintained in the areas where site clearing and grubbing occur.

As a result of infrastructure development the following potential impacts are predicted:

- Storage or contained water within the RTSF and the RTSF RWD/AWTF during the construction phase may result in seepages/spillages downstream;
- Contamination of clean water runoff after mixing with dirty water runoff emanating from within the infrastructure areas;
- Reduction of catchment yield as a result of the footprint areas of the proposed infrastructure. The footprint areas will no longer form part of the natural downstream catchment thereby potentially resulting in a decrease of runoff downstream. The RTSF only occupies 2% and the CPP occupies less than 1% of the C23J quaternary catchment; therefore the reduction of catchment yield may be very small or negligible; and
- Flooding of the pipeline at various river crossings (see floodline section 8).

11.1.2 Management Objectives

The management objectives adopted during the construction phase relate specifically to Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704), which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The three main conditions of GN 704 applicable to this project are:

- *Condition 4* which defines the area in which mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, Dam or reservoir together with any associated structure or any other facility should be situated outside the 1:100 year floodline. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year floodline. Where the floodline is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

11.1.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the construction phase are described together with the targets required to ensure mitigation of the impacts.

11.1.3.1 Mixing of Clean and Dirty Water (site clearing and grubbing)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from cleared site areas. This could result in dirty water reporting to the downstream clean water catchment, the following actions are required:

- The runoff from the upstream clean water catchment is to be diverted away from the proposed infrastructure. Temporary surface water ditches are to be constructed on the upstream boundary of the TSF, which will meet GN 704 requirements regarding the separation of clean and dirty water runoff. All clean water runoff will therefore be diverted away from the cleared area. The temporary surface ditches are to be sized such that the 1:50 year peak discharge can be contained within it.
- Surface water quality monitoring should continue on the monitoring locations indicated in Table 7-7. Monitoring parameters should be in compliance to the WUL.
- This will enable detection of the water quality impacts and therefore ensure that necessary mitigation measures are implemented.

11.1.3.2 Increased Sedimentation

To manage the impact of increase sedimentation on downstream watercourses due to exposed surfaces resulting in siltation of surface water resources, the following targets are required.

Within the cleared area along the downstream boundary, temporary ditches are to be constructed along with a temporary excavated storage area. All dirty water runoff will then be captured and contained within the temporary storage facility. The temporary storage facility is to be sized based on the runoff volume generated from the cleared area for the 1:50 year storm event. The water contained in the storage facility should be used during the construction phase as much as possible, thereby ensuring the mentioned storage facility is operated empty. The temporary ditches are to be sized such that the 1:50 year peak discharge can be contained.

11.1.3.3 Flooding

To manage the impact of flooding of RTSF and associated infrastructures together with the pipeline crossings, the following targets are required.

Floodlines will be required on all watercourses within proximity to the RTSF and associated infrastructure. Based on GN 704, the mine infrastructure in question should fall outside of the 1:100 year floodline or 100 m away, whichever is greater. The 1:50 year and 1:100 year flood lines for the section of the Leeuspruit and the unnamed tributary in close proximity to the RTSF and associated infrastructure was completed. The 1:100 year flood inundation areas, together with a 100 m buffer around the Leeuspruit and the unnamed tributary are indicated in Figure 8-3.

The pipeline routes which intersect various drainage paths/rivers need to be assessed such that the elevation of the pipe at the crossings lie above the 1:100 year modelled flood elevation. To undertake this, the 1:100 year peak flows will be calculated at the respective river crossings to determine maximum flows during flood conditions.

11.1.3.4 Reduction in Catchment Yield

The RTSF occupies 2% and the CPP occupies less than 1% of the C23J quaternary catchment; therefore the reduction of catchment yield may be very small or negligible. The loss of catchment yield due to introduction of the proposed RTSF and other associated infrastructure will be compensated by the treated water discharge into the Leeuspruit. The summary of the decrease in MAR as a result of the mentioned infrastructure footprint areas are indicated in Table 7-5. As mentioned a decrease in runoff of around 0.25 Mm^3 per annum is anticipated.

11.1.3.5 Mixing of Clean and Dirty Water (infrastructure development)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from newly constructed infrastructure. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

Based on GN 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. Therefore clean water emanating from upstream of the CPP, TSF and RWD will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event.

All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas is captured and contained to a dirty water containment facility. The proposed channels should be lined and sized to cater for the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event. It is recommended that the containment facility be operated such that water captured in these facilities is used within the mine operations between a reasonable period of time, so as to ensure that capacity is always available to store the mentioned 1:50 year storm volume.

11.1.3.6 Seepages from the RTSF and RWD

To manage the impact of seepages of water contained on the RTSF and the RWD the following targets are required. Also see groundwater report for modelling in this regard.

During the period of construction of the RTSF and RWD, high storm events could result in excessive ponding within the RTSF and RWD. Depending on the extent of the ponding this water could either be allowed to remain and evaporate naturally or it could be pumped out. It is recommended that the volume contained should be pumped out and re-used where required during the construction phase of the project.

Surface water quality monitoring should continue on the monitoring locations indicated in Table 7-7. Monitoring parameters should be in compliance to the WUL.

This will enable detection of the water quality impacts and therefore ensure that necessary mitigation measures are implemented.

11.1.4 Impact Ratings

Table 11-1 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 11-1 Construction phase impact ratings for activities taking place in the Kloof MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction : Site clearing for the Construction of Infrastructure			
Impact Description: Increase in sedimentation due to exposed surfaces			
Prior to mitigation/ management			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Minor (negative) – 50
Extent	Municipal Area (4)	Sediments may be washed further downstream than the project site	
Intensity	Moderate(4)	May moderately affect already impacted water resources	
Probability	Likely (5)	It is likely that sedimentation will occur	
Nature	negative		
Mitigation/ Management actions			
▪ Construct temporary ditches and a temporary storage area along the downstream boundary to capture sediments. Water within temporary storage area can be used for construction and should be operated empty.			
Post- mitigation			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Negligible (negative) – 24
Extent	Limited (2)	Sediments will be contained on the project site	

Dimension	Rating	Motivation	Significance
Intensity	Moderate - (2)	May moderately affect water resources if sediments are not contained correctly	
Probability	Probable (4)	Has occurred elsewhere and may occur again	
Nature	negative		
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment.			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May affect water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal River	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Temporary surface water ditches/berms are to be constructed on the upstream boundary of the TSF to capture/divert clean water and to separate from cleared areas.			
Post- mitigation			
Duration	Short term (2)	Will only last for the duration of the construction phase	Negligible (negative) – 28
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		
Activity and Interaction: Construction of infrastructure (pipelines, AWTF, RTSF, RTSF RWD).			
Impact Description: Flooding of RTSF and pipeline crossings			
Prior to mitigation/ management			

Dimension	Rating	Motivation	Significance
Duration	Permanent (7)	Flooding of the RTSF may occur beyond the construction phase and beyond the project life as the RTSF will remain indefinitely	Minor (negative) – 48
Extent	Region (5)	Runoff from the RTSF under exceptional flooding (greater than 1:100 year flood) may affect surface water resources on a regional scale	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	Unlikely (3)	Highly unlikely as the RTSF is outside of the 1:100 year floodline and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Mitigation/ Management actions			
▪ Ensure that the RTSF and associated infrastructure is outside of the 1:100 year floodline; and ▪ Ensure that all pipelines are constructed above the 1:100 year flood elevation.			
Post- mitigation			
Duration	Permanent (7)	The RTSF will remain indefinitely and there is always a possibility that an exceptional flood greater than the 1:100 year peak flood may occur	Minor (negative) – 39
Extent	Limited (2)	If flood protection measures are implemented then the extent is restricted to the project site	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	unlikely (3)	Highly unlikely as the RTSF is outside of the 1:100 year floodline and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Activity and Interaction: Construction of infrastructure (AWTF, CPP, RTSF and RTSF RWD).			
Impact Description: Reduction in catchment yield			

Dimension	Rating	Motivation	Significance
Prior to mitigation/ management			
Duration	Beyond project life (6)	The RTSF and associated infrastructure will remain indefinitely and will result in a loss of catchment area	Minor (negative) – 66
Extent	Local (3)	Will affect the contribution of water from the regional catchment	
Intensity	Low negative - (2)	May impact on already moderately impacted surface water resources	
Probability	Highly probable (6)	The RTSF and associated infrastructure have to be constructed for this project resulting in a reduction of catchment yield	
Nature	negative		
Mitigation/ Management actions			
▪ There is no mitigation for the loss of catchment yield. The MAR analysis shows that the reduction in flow to the downstream quaternary catchments is negligible, with only 2% to 3% of the MAR being lost.			
Post- mitigation			
Duration	Beyond project life (6)	The RTSF and associated infrastructure will remain indefinitely and will result in a loss of catchment area	Minor (negative) – 66
Extent	Local (3)	Will affect the contribution of water from the regional catchment	
Intensity	Low negative - (2)	May impact on already moderately impacted surface water resources	
Probability	Highly probable (6)	The RTSF and associated infrastructure have to be constructed for this project resulting in a reduction of catchment yield	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines, sumps, AWTF, CPP, RTSF, RTSF RWD).			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas resulting in dirty water reporting to the downstream clean water catchment.			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80

Dimension	Rating	Motivation	Significance
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High (5)	May impact on highly sensitive environments such as the downstream Vaal River	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Clean water emanating from upstream of the TSF and RWD will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event; and ▪ All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event.			
Post- mitigation			
Duration	Project Life (5)	Will last for the project life	Minor (negative) – 40
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines, sumps, CPP, RTSF, RTSF return water Dam).			
Impact Description: Spillages of excess rainfall stored on the RTSF and the RWD.			
Prior to mitigation/ management			
Duration	Permanent (7)	The RTSF will remain indefinitely and spillages are always possible if not managed correctly	Minor (negative) – 60
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Has occurred and may occur here	

Dimension	Rating	Motivation	Significance
Nature	negative		
Mitigation/ Management actions			
▪ High storm events may result in excessive ponding within the RTSF. It is recommended that excess water be managed by discharging in a controlled manner.			
Post- mitigation			
Duration	Permanent (7)	The RTSF will remain indefinitely and spillages are always possible if not managed correctly	Minor (negative) – 45
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Unlikely (3)	There is a possibility that the impact may occur	
Nature	negative		

11.2 Operational Phase

11.2.1 Impact Description

The following interactions will occur as a result of operational phase of the project, operation of pumps, and discharging of treated water to the Leeuspruit.

As a result of the discharge of water from the AWTF the following potential impacts are predicted:

- During re-mining water will be extracted from K10 Shaft and Cooke 1 Shaft resulting in a decrease of flows reporting to the exit point at the 1 m pipeline on the Wonderfonteinspruit. Decrease in flows due to the abstraction of water from K10 Shaft and Cooke 1 Shaft amount to 32 Ml/day;
- Overflowing of small Dams located long the section of the Leeuspruit downstream of the RTSF, which may result in water backing up in the river;
- Flows on the Leeuspruit West will increase from no flows been observed during the dry season to a constant 15 000 m^3/day flowing down the section of the Leeuspruit when re-mining commences. During the wet season peak flows can be as much as 39 593 m^3/day; and
- The additional flow amounts to 0.1 m^3/s. This is however insufficient to impact the delineated floodlines for this section of the Leeuspruit, this impact is negligible and will

not be rated; and a positive impact of additional treated water which will serve to dilute the current water quality parameters of the Leeuspruit.

As a result of the operation of the sumps and pumps in the AWTF, the following potential impacts are predicted:

- Decrease in flows to the Wonderfonteinspruit;
- Increase in flows to the Leeuspruit;
- Overflow of RWD to the downstream environment; and
- Failure of pumps resulting in dirty water from sumps to overflow to the downstream environment.

The potential impacts as a result of the dewatering at the blast curtain include:

- Depletion of the Leeuspruit and its tributaries due to the lowering of the groundwater level.

The groundwater assessment (Digby Wells, 2015) indicated that seepage from the RTSF can negatively influence the groundwater quality in the underlying aquifers during the operational phase, if no mitigation is undertaken and also impact the streams. Once the plume reaches the streams, it can migrate at a faster rate compared to the speed of the groundwater flow and could have Medium to High impact on the down-gradient riverine ecosystem and communities. Mitigation is therefore required.

Although the proposed blast curtain would be crucial to contain the pollution plume, it has a side effect since it will lower the water table from its natural position in the outer ring of the drain. Thus, the water quality impacts will be reduced, but the area/extent of the impact on the groundwater levels would increase.

The seepage rate from the RTSF is expected to increase and reach a maximum when it is fully operational. The average seepage rate (which is dependent on the permeability of the TSF material) is estimated to be $3.21x10^{-4}$ m/d (SRL, 2015). This is expected to last for up to 100 years after closure and it is only then the rate will start to decrease (assuming cover is in place). For the blast curtain to work effectively, it has to intercept at least 120% of the seeped water (i.e. 4,810 m3/d). This is because the curtain is also draining from the outer periphery. The plume can escape away from the curtain if it is pumped at less than this.

Dewatering the blast curtain will have a side effect in terms of lowering the water table around the periphery of the RTSF, outside the perimeter of the blast curtain drain. The predicted cone of dewatering at the end of operation extends across the Leeuspruit. Considering the shallow water level within the project area, the drawdown could be more than 25 m in some localities. Dewatering can potentially affect and reduce the flow rate of the Leeuspruit and its tributes, but water in the Leeuspruit flows much faster compared to the seepage rate through the stream floor and subsequently the stream flow won't be impacted significantly by the grout curtain dewatering activities.

11.2.2 Management Objectives

The management objectives adopted during the operational phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The two main conditions of GN 704 applicable to this project are:

- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

11.2.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the operational phase are described together with the targets required to ensure mitigation of the impacts occur.

11.2.3.1 Decrease water discharged to the Wonderfonteinspruit

To manage the impact of decrease water discharged to the Wonderfonteinspruit River, the following targets are required.

Approximately 33 Ml/day (33 000 m^3/day) is being discharged into the Wonderfonteinspruit from the K10 Shaft together with additional discharges of 20 Ml/d (20 000 m^3/day) from Cooke 1 Shaft. Therefore, total flows discharged to the Wonderfonteinspruit via the 1 m pipeline currently, amounts to 53 Ml/day (53 000 m^3/day) due to mining activities. It must be noted that over and above the 53 Ml/day entering the 1 m pipeline at Donaldson Dam, on the Upper Wonderfonteinspruit there are discharges into the Wonderfonteinspruit of approximately 15 to 20 Ml/d from the Flip Human Waste Water Treatment Works (WWTW), and at the Lower Wonderfonteinspruit approximately 10 Ml/d is discharged directly into the 1 m pipeline from the Hannes van Niekerk WWTW.

During re-mining approximately 20 Ml/d (20 000 m^3/day) from K10 Shaft will be used within the RTSF process, together with 12 Ml/d from Cooke1, resulting in total discharges to the Wonderfonteinspruit due to mining and excluding the discharges from Driefontein decreasing from 53 Ml/day (53 000 m^3/day) to 21 Ml/d (21 000 m^3/day) as a result of an estimated 32 Ml/day (32 000 m^3/day) being used for the reclamation process.

The users identified along the Wonderfonteinspruit utilise water from the mentioned river for maize farming, cultivation of land and for cattle grazing and watering, with total estimated usage being 3500 m^3/day (based on 100 m^3/day for each of the 35 users identified). This water usage from the Wonderfonteinspruit in comparison to what is available based on the estimated flow data is sufficient, even after decrease in discharges occur, with the estimated decrease in flows in the Wonderfonteinspruit expected to range between 37 to 55 % at the outlet of the 1 m pipeline.

Based on average Sulfate concentrations of 322 mg/L measured at the 1 m pipeline outlet, estimated decrease in salt loads range from 37 to 55%.

11.2.3.2 Overflowing of Small Dams

The overflowing of small Dams within the Leeuspruit is possible due to the additional flow (average 15 Ml/d) that will be discharged into the river. This potential overflow may result in backing up of water upstream of the Dam; however this will not impact any part of the RTSF or associated infrastructure due to the small sizes of the respective Dams.

11.2.3.3 Flooding

Flows on the Leeuspruit will increase from no flows been observed during the dry season to a constant 15 000 m^3/day flowing down the section of the Leeuspruit when re-mining commences. During the wet season peak flows can be as much as 39 593 m^3/day. The peak flows during re-mining for the wet season is approximately 0.5 m^3/s. This is however insufficient to impact the delineated floodlines for the section of the Leeuspruit, this impact is negligible and will not be rated.

Energy dissipation designs will need to be created and installed at the discharge point. It is recommended that an inspection of the Leeuspruit be undertaken prior to the discharge of water and all erosion hotspots (if any) should be highlighted. This should occur for at least 3 km downstream. If needed, rehabilitation interventions could be investigated for high erosion areas. Once discharge occurs, it is recommended that the areas previously identified are monitored to observe any further significant erosion. This should be done at least once a year and if significant erosion problems are identified, a rehabilitation and remediation strategy should be investigated and implemented.

11.2.3.4 Dilution

The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated discharged water is to fall within the discharge water quality specifications of the AWTF.

To enhance the dilution benefits from the discharge of improved quality water to the stream the water could be passed through a processing wetland or a rock lined soakaways at slow speed to ensure that silt settles and any potential of the clean water eroding material as it flows to the stream.

11.2.3.5 Decrease Salt loads downstream of the confluence of the Leeuspruit and the Rietspruit

Decrease in salt loads downstream of the confluence of the Leeuspruit and Rietspruit is predicted due to the current estimated discharges into the Leeuspruit East, West and the decrease in discharges to the Klein Wes Rietspruit.

This impact is seen as a positive due to the decrease in salt loading to the downstream Rietspruit. The estimated flows reporting to this downstream section will also decrease slightly.

11.2.3.6 Spillages from pipeline route between the WBT and TSFs

The location of the current pipeline route between the WBT and the TSFs is alongside a drainage trench which captures flows and conveys it to the Wonderfonteinspruit. Therefore any likelihood of spillages in this section of the pipeline will result in contaminants from the pipeline ending up in the Wonderfonteinspruit.

To mitigate the impact mentioned, source control measures need to be adopted so as to ensure that the potential pollution is contained at source. These include:

- No flanges on the pipeline along the identified stretch, as far as possible;
- Use of flange covers where flanges are being used; and
- Bunding of the specific stretch of the pipeline route, and also ensuring any overflows from the bunds are directed away from the mentioned trench.

11.2.3.7 Discharging of treated water to Leeuspruit

As discussed above, the abstraction at the blast curtain has the potential to deplete the Leeuspruit. This can be mitigated by treating the dewatered water at the AWTF and discharging the treated water back to Leeuspruit, at a point downgradient of the RTSF.

11.2.4 Impact Ratings

Table 11-2 shows the rating for the impacts associated with the operational phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 11-2: Operational phase impact ratings for activities taking place in the Kloof MRA

Dimension	Rating	Motivation	Significance
Abstractions of water from the Wonderfonteinspruit			
Impact Description: Decrease water discharged to the Wonderfonteinspruit River. Resulting in inadequate water supply for the downstream users on the Wonderfonteinspruit River			
Prior to mitigation/ management			

Dimension	Rating	Motivation	Significance
Duration	Project Life (5)	32 Ml/d will be used during the operational life span within the RTSF	Moderate (negative) – 78
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Highly probable (6)	Water will need to be used within the RTSF and it is therefore most likely that the impact will occur	
Nature	negative		
Mitigation/ Management actions			
▪ There are no mitigation measures for this impact. It is estimated that although the flows will decrease between 37 % and 55 %, there will still be sufficient flows in the Wonderfonteinspruit to cater for the current water supply demand.			
Post- mitigation			
Duration	Project Life (5)	32 Ml/d will be used during the operational life span within the RTSF	Moderate (negative) – 78
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Highly probable (6)	Water will need to be used within the RTSF and it is therefore most likely that the impact will occur	
Nature	negative		
Abstractions of water from the Wonderfonteinspruit			
Impact Description :Decrease of salt loads reporting to the Wonderfonteinspruit, due to reduction in discharges			
Prior to mitigation/management			
Duration	Project Life (5)	Decrease of discharges to the Wonderfonteinspruit from 45 Ml/day to 13 Ml/day will occur during the operational phase.	Moderate (positive) – 98
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate high (4)	May impact already moderately impacted surface water resources	
Probability	Certain (7)	Water will need to be used within the RTSF and it is therefore the impact will occur	
Nature	positive		
Enhancement			

Dimension	Rating	Motivation	Significance
▪ During the operational phase, there will be a decrease in flows of approximately 32 Ml/day, resulting in a reduction in flows from 53 Ml/day to 21 Ml/day. Therefore due to the flow reduction, there will be a corresponding salt load reduction.			
Dimension	**Rating**	**Motivation**	**Significance**
Activity and Interaction : Discharges of water from the RTSF into the Leeuspruit			
Impact Description: Overflowing of small Dams located on the Leeuspruit resulting in backing up of water upstream			
Prior to mitigation/ management			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Minor (negative)- (52)
Extent	Municipal Area (4)	The Dams downstream of the project area, within the Leeuspruit catchment could be impacted	
Intensity	Moderately high (4)	On average 15 Ml/day will be discharged into the river with potential backing up of water upstream of the small Dams	
Probability	Probable (4)	Probability will increase, but will not be definite	
Nature	negative		
Mitigation/ Management actions			
▪ No mitigation measures are recommended, as the overflows from the minor Dams will not result in significant backing up of flood waters.			
Post- mitigation			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Minor (negative)- (52)
Extent	Municipal Area (4)	The Dams downstream of the project area, within the Leeuspruit catchment could be impacted	
Intensity	Moderately high (4)	On average 15 Ml/day will be discharged into the river with potential backing up of water upstream of the small Dams	
Probability	Probable (4)	Probability will increase, but will not be definite	
Nature	negative		

Dimension	Rating	Motivation	Significance
Activity and Interaction Discharges of water from the AWTF into the Leeuspruit			
Impact Description: Positive impact of dilution due to treated water being added to the current Leeuspruit flows.			
Prior to mitigation/ management			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Moderate - positive (78)
Extent	Municipal Area (4)	Extent is downstream of the AWTF discharge point.	
Intensity	Moderately high (4)	The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the discharge water quality specifications of the AWTF.	
Probability	Highly probable (6)	The increased flow will occur as long as there is better quality discharge thus dilution will occur	
Nature	Positive		
Mitigation/ Management actions			
▪ Ensure that the water is treated to concentration levels that comply with the discharge water quality specifications of the AWTF.			
Post- mitigation			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Moderate - positive (78)
Extent	Municipal Area (4)	Extent is downstream of the AWTF discharge point.	
Intensity	Moderately high (4)	The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the with the discharge water quality specifications of the AWTF.	
Probability	Highly probable (6)	The increased flow will occur as long as there is better quality discharge thus dilution will occur	

Dimension	Rating	Motivation	Significance
Nature	Positive		
Activity and Interaction Total discharges of water from the AWTF			
Impact Description: Positive impact due to decreasing in salt loads to the Rietspruit			
Prior to mitigation/ management			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Moderate - positive (78)
Extent	Municipal Area (4)	The Dams downstream of the project area, within the Leeuspruit catchment could be impacted	
Intensity	Moderately high (4)	The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the with the discharge water quality specifications of the AWTF.	
Probability	Highly probable (6)	The increased flow will occur as long as there is better quality discharge thus dilution will occur	
Nature	Positive		
Mitigation/ Management actions			
▪ This impact is seen as a positive due to the decrease in salt loading to the downstream Rietspruit. The estimated flows reporting to this downstream section will also decrease slightly.			
Post- mitigation			
Duration	Project Life (5)	The discharge of water will occur throughout the whole operational phase	Moderate - positive (78)
Extent	Municipal Area (4)	The Dams downstream of the project area, within the Leeuspruit catchment could be impacted	
Intensity	Moderately high (4)	The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the with the discharge water quality specifications of the AWTF.	

Dimension	Rating	Motivation	Significance
Probability	Highly probable (6)	The increased flow will occur as long as there is better quality discharge thus dilution will occur	
Nature	Positive		
Activity and Interaction Pumping slurry from the TSF sump to the WBT (for Driefontein TSF 3 and 5).			
Impact Description: Potential spillages being conveyed to the downstream Wonderfonteinspruit.			
Prior to mitigation/ management			
Duration	Project Life (5)	Associated pipelines will remain for duration of project life	Moderate (negative) – 80
Extent	Province/Region (5)	Extent is downstream of the Wonderfonteinspruit.	
Intensity	Moderately to high (6)	Irreplaceable loss or Damage to Wonderfonteinspruit and downstream watercourses, together with surface water users	
Probability	Likely (5)	The impact may occur during the operational life of the mine	
Nature	Positive		
Mitigation/ Management actions			
▪ No flanges on the pipeline along the identified stretch, as far as possible; ▪ Use of flange covers where flanges are being used; ▪ Bunding of the specific stretch of the pipeline route, and also ensuring any overflows from the bunds are directed away from the mentioned trench.			
Post- mitigation			
Duration	Project Life (5)	Associated pipeline will remain for duration of project life	Minor (negative) – 55
Extent	Local (3)	Extent is downstream of the spill area, within the project site.	
Intensity	Moderate - (3)	Moderate loss. Pollution will be contained at source.	
Probability	Likely (5)	The impact may occur during the operational life of the mine	
Nature	negative		
Activity and Interaction: Dewater by the blast curtain at the RTSF.			
Impact Description: Depletion of the Leeuspruit and its tributaries due to lowering of the water table underneath the river bed.			
Prior to mitigation/ management			

Dimension	Rating	Motivation	Significance
Duration	Permanent (7)	The dewatering process and its impact will be permanent	Minor (negative) – 72
Extent	Local (3)	The section of the Leeuspruit that will be impacted by the blast curtain is expected to be local, along a section of approximately 7.5 km	
Intensity	Minor (2)	Considering the flow rate of the river and river bed permeability, the intensity is expected to be minor	
Probability	Almost certain (6)	It is almost certain that the dewatering will affect the surface water flow	
Nature	Negative		
Mitigation/ Management actions			
▪ Monitoring of the Leeuspruit flow rates, up and down gradient of the RTSF; ▪ Re-introduce treated water from the AWTF into the Leeuspruit.			
Post- mitigation			
Duration	Permanent (7)	The depression of the water table will persist throughout the life of operation	Minor (negative) – 60
Extent	Limited (2)	With the re-introduction of the treated water into the Leeuspruit, the impact on the river will be limited	
Intensity	Minimal (1)	Once the abstracted water is treated and at the AWTF and introduced to the river, the environmental significance is rated as minimal	
Probability	Almost certain (6)	The lowering of the water table will almost certainly occur and is likely to result in the depletion of the river	
Nature	negative		

11.3 Decommissioning Phase

11.3.1 Impact Description

The decommissioning phase of the project will cover the decommissioning activities, which must ensure that spillages to the clean water environment area is minimised.

As a result of the decommissioning activities the following potential impact has been identified:

- Water pollution could result from accidental spillages during decommissioning of infrastructures.

The potential impacts as a result of the dewatering at the blast curtain include:

- Depletion of the Leeuspruit and its tributaries due to the lowering of the groundwater level.

11.3.2 Management Objectives

The three main conditions of GN 704 applicable to this project are:

- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.
- *Condition* 9 which describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations. The in stream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, should be remedied so as to comply with these regulations.

11.3.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts.

11.3.3.1 Spillages from decommissioned infrastructure

To manage the impact of spillages to the downstream watercourse, the following targets are required:

- Ensure that the pipelines are emptied of all residual material before decommissioning; and
- Ensure the consideration of the durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.

11.3.3.2 Discharging of treated water to Leeuspruit

The potential depletion of the Leeuspruit as a result of the dewatering of the blast curtain can be mitigated by treating the dewatered water at the AWTF and discharging the treated water back to Leeuspruit, at a point downgradient of the RTSF.

11.3.4 Impact Ratings

Table 11-3 shows the rating for the impacts associated with the decommissioning phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 11-3: Decommissioning phase impact ratings for activities taking place in the Kloof MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: (Decommissioning activities)			
Impact Description: Water pollution from accidental spillages of decommissioned infrastructure			
Prior to mitigation/ management			
Duration	Short term (2)	Equals to the duration of the actual removal of the infrastructure, thus a short duration	Negligible - negative (21)
Extent	Limited (2)	The impact's will be localized to the nearby water resources closest to the spillages	
Intensity	Moderate - negative (3)	This will limit the ecosystem functionality in the vicinity especially if runoff occurs	
Probability	Unlikely (3)	Without due care , spillages may occur	
Mitigation/ Management actions			
▪ Ensure the pipelines are emptied before removal. ▪ The durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning. ▪ Ensure compliance to closure plan for RTSF and demolition and rehabilitation of redundant infrastructure			
Post-Mitigation			
Duration	Short term (2)	As for pre-mitigation	Negligible - negative (12)
Extent	Limited (2)	As for pre-mitigation	

Dimension	Rating	Motivation	Significance
Intensity	Low - negative (2)	The scale of ecosystem Damage will be limited as long as mitigation occurs and the spillage volumes are decreased considerably	
Probability	Improbable (2)	If small volumes are handled and if empty infrastructure is handles, the probability of impacts will be almost diminished	
Activity and Interaction: Dewater by the blast curtain at the RTSF.			
Impact Description: Depletion of the Leeuspruit and its tributaries due to lowering of the water table underneath the river bed.			
Prior to mitigation/ management			
Duration	Permanent (7)	The dewatering process and its impact will be permanent	Minor (negative) – 72
Extent	Local (3)	The section of the Leeuspruit that will be impacted by the blast curtain is expected to be local, along a section of approximately 7.5 km	
Intensity	Minor (2)	Considering the flow rate of the river and river bed permeability, the intensity is expected to be minor	
Probability	Almost certain (6)	It is almost certain that the dewatering will affect the surface water flow	
Nature	Negative		
Mitigation/ Management actions			
▪ Monitoring of the Leeuspruit flow rates, up and down gradient of the RTSF; ▪ Re-introduce treated water from the AWTF into the Leeuspruit.			
Post- mitigation			
Duration	Permanent (7)	The depression of the water table will persist throughout the life of operation	Minor (negative) – 60
Extent	Limited (2)	With the re-introduction of the treated water into the Leeuspruit, the impact on the river will be limited	
Intensity	Minimal (1)	Once the abstracted water is treated and at the AWTF and introduced to the river, the environmental significance is rated as minimal	
Probability	Almost certain (6)	The lowering of the water table will almost certainly occur and is likely to result in the depletion of the river	
Nature	negative		

11.4 Post Closure Phase

11.4.1 Impact Description

The post closure phase of the project will entail the assessment of the concurrent rehabilitation of the historic footprint areas by monitoring, and will address any further rehabilitation requirements.

There will be no major impacts that will directly impact the surface water resources as rehabilitation is already carried out in the decommissioning phase. In this phase monitoring should continue for residual surface water impacts, as well as identification of patchy rehabilitation work and ensuring that these are attended to.

Restoration of the natural drainage patterns will result in an increase of the runoff that reports to the natural water bodies thereby increasing the catchment yield. This will be a positive impact on the on the water resources.

The dewatering at the blast curtain will continue even after closure so as to intercept any contaminants from leaving the RTSF via the underground. This means that the potential impact of the dewatering on the Leeuspruit quantity will continue even after mine closure.

11.4.2 Management Objectives

The management objectives adopted during the post closure phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources, this include:

- Design of sustainable water management measures for closure, and the maintenance of water quantity and quality monitoring should persist; and
- The management objectives adopted during the decommissioning phase relate specifically to GN 704).

11.4.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts:

- Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies;
- Ensure that a sustainable cover on the RTSF will be present so as to prevent erosion and promote ecological succession;
- Ensure that monitoring is in place for at least two to 3 years post closure or as per WUL and closure plan, after rehabilitation and that the land remains free draining post closure, post rehabilitation;

- Monitor parameters such as pH, EC, Sulfate, and Metals or as required by the WUL to enable detection of surface water impacts and determine the trend or fluctuation of the water quality compared to the baseline water quality detailed in section 7.5 of this report;
- It should be ensured that potential impacts have been identified and are covered in the closure plan and the closure financial provisions. If post closure impacts are identified, methods of withholding and treating the water should be further investigated depending on parameters of concern; and
- The post-closure water management plan should take cognisance of the likelihood that the water table will rebound in the rehabilitated footprints and that runoff of residual contaminants could impact the runoff water to the streams.
- Re-introduce treated water from the AWTF into the Leeuspruit.

11.4.4 Impact Ratings

Table 11-4 below show the rating for the impacts associated with the post-closure phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 11-4: Post-closure phase impact ratings for activities taking place in the Kloof MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: (Post closure Impacts)			
Impact Description: Residual water pollution from rehabilitated infrastructure footprints post closure			
Prior to mitigation/ management			
Duration	Medium term (3)	The time of impact varies depending on the residual impacts anticipated, but could last for some years	Minor - negative (40)
Extent	Local (3)	The Impacts will travel as far as the runoff goes, into nearby streams	
Intensity	Moderately high (4)	The impact s negative with moderate intensity as the impacts could add to the existing poor water quality in the streams	
Probability	Probable (4)	Without appropriate mitigation and capping the rehabilitated area residual impacts could , result in contamination	
Mitigation/ Management Actions			

Dimension	Rating	Motivation	Significance
▪ It should be ensured that the potential future impacts have been identified. ▪ The final mine topography should be planned, as far as possible, to be free-draining. ▪ Compliance with closure plan			
Post-Mitigation			
Duration	Medium term (3)	As mitigation is implemented, the erosion will be limited to the times of operation of each small site	Negligible - negative (27)
Extent	Local (3)	Impact limited to the smaller areas cleared and un-rehabilitated each time	
Intensity	Moderate - negative (3)	Mitigation will reduce the intensities of the potential erosion	
Probability	Unlikely (3)	Mitigation will not completely stop erosion but will significantly reduce	
Activity and Interaction: Post closure (rehabilitated area)			
Impact Description: Improvement on Catchment Yield			
Prior to mitigation/ management			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		
Mitigation/ Management actions			
▪ Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies. ▪ Ensure capping on RTSF is sound preventing contamination of run off.			
Post- mitigation			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	

Dimension	Rating	Motivation	Significance
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		
Activity and Interaction: Dewater by the blast curtain at the RTSF.			
Impact Description: Depletion of the Leeuspruit and its tributaries due to lowering of the water table underneath the river bed.			
Prior to mitigation/ management			
Duration	Permanent (7)	The dewatering process and its impact will be permanent	Minor (negative) – 72
Extent	Local (3)	The section of the Leeuspruit that will be impacted by the blast curtain is expected to be local, along a section of approximately 7.5 km	
Intensity	Minor (2)	Considering the flow rate of the river and river bed permeability, the intensity is expected to be minor	
Probability	Almost certain (6)	It is almost certain that the dewatering will affect the surface water flow	
Nature	Negative		
Mitigation/ Management actions			
▪ Monitoring of the Leeuspruit flow rates, up and down gradient of the RTSF; ▪ Re-introduce treated water from the AWTF into the Leeuspruit.			
Post- mitigation			
Duration	Permanent (7)	The depression of the water table will persist throughout the life of operation	Minor (negative) – 60
Extent	Limited (2)	With the re-introduction of the treated water into the Leeuspruit, the impact on the river will be limited	
Intensity	Minimal (1)	Once the abstracted water is treated and at the AWTF and introduced to the river, the environmental significance is rated as minimal	
Probability	Almost certain (6)	The lowering of the water table will almost certainly occur and is likely to result in the depletion of the river	
Nature	negative		

12 Driefontein Mining Area Impact Assessment

12.1 Construction Phase

12.1.1 Impact Description

The construction phase of the project will cover the infrastructure development which will include all the activities mentioned in the infrastructure category in the summary of the activity list shown in Table 1-1 which for the Driefontein MRA involve:

- Hydraulic mining;
- Slurry pump stations;
- Water reservoirs and HP pumps;
- Overland pipes –slurry and water; and
- West Block Thickener and Bulk water storage.

During the construction phase, the following interactions will occur as a result of infrastructure development, site clearing and grubbing and the construction of infrastructures (Collection sumps and pump stations, pipelines and WB).

As a result of site clearing and grubbing the following potential impacts are predicted:

- Increase in sedimentation of surface water during construction caused by an increase in runoff from the cleared and stripped areas which is high in suspended solids; and
- Increase of surface runoff and potentially contaminated water that needs to be maintained in the areas where site clearing and grubbing occur.

As a result of infrastructure development the following potential impacts are predicted:

- Storage of contaminated water/slurry within the sumps during the construction phase may result in seepages/spillages into the nearby natural water bodies;
- Contamination of rivers when dirty water runoff enters the nearby rivers;
- Reduction of catchment yield as a result of the footprint areas of the proposed infrastructure. The footprint areas will no longer form part of the natural downstream catchment thereby potentially resulting in a decrease of runoff downstream. The WBT occupies less than 1% of the C23E quaternary catchment; therefore the reduction of catchment yield may be very small or negligible; and
- Flooding of the pipeline at various river crossings.

12.1.1.1 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704).

The three main conditions of GN 704 applicable to this project are:

- *Condition 4* which defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, Dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

12.1.2 Management Actions and Targets

In this section management actions relating to the activities envisaged during the construction phase are described together with the targets required to ensure mitigation of the impacts occur.

12.1.2.1 Mixing of clean and dirty water (site clearing and grubbing)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from cleared site areas, the following targets are required. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

The runoff from the upstream clean water catchment is to be diverted away from the proposed infrastructures. Temporary surface water ditches/berms are to be constructed on the upstream boundary of cleared areas so as to meet GN 704 requirements regarding the separation of clean and dirty water runoff. All clean water runoff will therefore be diverted away from the cleared area. The temporary surface ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

12.1.2.2 Increased sedimentation

To manage the impact of increase sedimentation on downstream watercourses due to exposed surfaces resulting in siltation of surface water resources, the following targets are required.

Within the cleared area along the downstream boundary, temporary ditches are to be constructed along with a temporary excavated storage area. All dirty water runoff will then be captured and contained within the temporary storage facility. The temporary storage facility is to be sized based on the runoff volume generated from the cleared area for the 1:50 year storm event. The water contained in the storage facility should be used during the construction phase as much as possible, ensuring the mentioned storage facility is operated empty. The temporary ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

12.1.2.3 Reduction in catchment yield

No targets are possible to manage the reduction in catchment yield due to the loss of catchment area as a result of the WBT and other associated infrastructure. However, the WBT will only occupy less than 1% of the C23E quaternary catchment; therefore the reduction of catchment yield may be very small or negligible and this will not be rated.

12.1.2.4 Mixing of clean and dirty water (infrastructure development)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from newly constructed infrastructure, the following targets are required. This could result in dirty water reporting to the downstream clean water catchment, the following actions are required:

Based on GN 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. Therefore clean water emanating from upstream of the infrastructure areas will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event.

All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas is captured and contained to a dirty water containment facility. The proposed channels should be protected and sized to cater for the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event. It is recommended that the containment facility be operated empty such that water captured within these facilities is used within the mine operations between a reasonable time intervals, so as to ensure that capacity is always available to store the mentioned 1:50 year storm volume.

12.1.3 Impact Ratings

Table 12-1 below show the rating for the impacts associated with the construction phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 12-1: Construction phase impact ratings for activities taking place in the Driefontein MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearing for the Construction of Infrastructure			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment.			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Temporary surface water ditches/berms are to be constructed on the upstream boundary of the cleared areas to divert clean water to the downstream environment.			
Post- mitigation			
Duration	Short term (2)	Will only last for the duration of the construction phase	Negligible (negative) – 28
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines)			
Impact Description: Flooding of pipeline crossings			
Prior to mitigation/ management			
Duration	Permanent (7)	Flooding of the pipeline crossings may occur beyond the construction phase and beyond the project life.	Minor (negative) – 48

Dimension	Rating	Motivation	Significance
Extent	Region (5)	Flood inundation of pipelines (greater than 1:100 year flood) may affect surface water resources on a regional scale	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	Unlikely (3)	This is unlikely as the pipeline is to be elevated above the 1:100 year flood waters of the respective river crossings. There is a possibility of exceptional flooding which may result in the pipeline being inundated.	
Nature	negative		
Mitigation/ Management actions			
▪ Ensure that all pipelines are constructed above the 1:100 year flood elevation. ▪ Minimum flanges within flood line area ▪ Sound engineering of support infrastructure across floodplain			
Post- mitigation			
Duration	Permanent (7)	Flooding of the pipeline crossings may occur beyond the construction phase and beyond the project life.	
Extent	Limited (2)	If flood protection measures are implemented ,then the extent restricted to the project site	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	Minor (negative) – 39
Probability	unlikely (3)	This is unlikely as the pipeline is to be elevated above the 1:100 year flood waters of the respective river crossings. There is a possibility of exceptional flooding which may result in the pipeline being inundated.	
Nature	negative		

Table 12-2: Mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas

Dimension	Rating	Motivation	Significance
Construction of infrastructures (pipelines, sumps, etc.).			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas resulting in dirty water reporting to the downstream clean water catchment.			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Clean water emanating from upstream of the proposed infrastructures will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event; and ▪ All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event or spillage event			
Post- mitigation			
Duration	Project Life (5)	Will last for the project life	Minor (negative) – 40
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		

12.2 Operational Phase

12.2.1 Impact Description

The operational phase of the project will cover the operation of pumps and abstraction of water.

As a result of the operation of the sumps and pumps the following potential impacts are predicted:

- Overflow of sumps to the downstream surface water resources; and
- Failure of pumps resulting in impacted mine water from sumps to overflow to the downstream environment.

12.2.2 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The two main conditions of GN 704 applicable to this project are:

- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

12.2.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the operational phase are described together with the targets required to ensure mitigation of the impacts occur.

12.2.3.1 Pump failure and overflows from sumps

The management of sumps and pumps at the mining sites are linked. The pumps located at each of the sumps should be installed within closed off/bunded areas to contain material spillages. In times of power failure, manual monitoring of the sump associated with the pump station should be carried out. This ensures that the reclamation activities can be slowed down or emergency procedures can be actioned. The emergency procedures in the event of power failure should at least require that the bunded area is of sufficient volume to contain shut down.

In times of pump failure overflows from sumps to the downstream watercourse may occur. It is therefore recommended that overflow channels be constructed so as to contain any spillages that do occur into the pollution control area. The compartments should be monitored and cleaned whenever spillages do occur, to ensure that the adequate capacity is available to mitigate additional spillages.

12.2.4 Impact Ratings

Table 12-3 show the rating for the impacts associated with the operational phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 12-3: Operational phase impact ratings for activities taking place in the Driefontein MRA

Abstractions of water from the Wonderfonteinspruit			
Impact Description :Decrease of salt loads reporting to the Wonderfonteinspruit, due to reduction in discharges			
Prior to mitigation/management			
Duration	Project Life (5)	Decrease of discharges to the Wonderfonteinspruit from 53 Ml/day to 21 Ml/day will occur during the operational phase.	Moderate (positive) – 98
Extent	Region (5)	May affect downstream water users beyond the project site	
Intensity	Moderate high (4)	May impact already moderately impacted surface water resources	
Probability	Certain (7)	Water will need to be used within the RTSF and it is therefore the impact will occur	
Nature	positive		
Enhancement			
▪ During the operational phase, there will be a decrease in flows of approximately 32 Ml/day, resulting in a reduction in flows from 53 Ml/day to 21 Ml/day. Therefore due to the flow reduction, there will be a corresponding salt load reduction.			
Activity and Interaction Operation of sumps and pumps			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Pump failure and overflow from sumps to contaminate downstream water quality			
Prior to mitigation/ management			
Duration	Project Life (5)	The whole operational phase will see the use of the sumps and pumps	Minor - negative (56)
Extent	Municipal Area (4)	Should overflows occur the impacts will be felt in the immediate catchment and might not be felt at quaternary catchment scale.	
Intensity	High - negative (5)	The management of sumps and pumps are linked.	
Probability	Probable (4)	It is likely that compaction will occur during construction.	
Nature	negative		

<table>
<tr><th colspan="4">Mitigation/ Management actions</th></tr>
<tr><td colspan="4">Construct, monitor and maintain overflow compartments downstream of the sump area.
Ensure emergency procedures in the event of power failure such as operational modifications and the use of a stand-by generator to operate the pump station should the sump be getting full.</td></tr>
<tr><th colspan="4">Post- mitigation</th></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Same as the pre mining</td><td rowspan="5">Negligible - negative (27)</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>The impacts will not be far reaching as long as emergency measures are in place to collect any overflow thus will be limited to the control measures</td></tr>
<tr><td>Intensity</td><td>Low - (2)</td><td>Impacts will be contained with mitigation and control measures</td></tr>
<tr><td>Probability</td><td>Unlikely (3)</td><td>With mitigation the impacts it is unlikely that impacts will occur.</td></tr>
<tr><td>Nature</td><td>negative</td><td></td></tr>
</table>

12.3 Decommissioning Phase

12.3.1 Impact Description

The decommissioning phase of the project will cover the, decommissioning activities, which must be focused on ensuring that spillages unto the clean water environment area is minimised.

As a result of the decommissioning activities the following potential impacts are predicted:

- Water pollution could result from accidental spillages during decommissioning of infrastructures.

12.3.2 Management Objectives

The three main conditions of GN 704 applicable to this project are:

- *Condition 6* which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* which describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.
- *Condition* 9 which describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that

all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations. The in stream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, should be remedied so as to comply with these regulations.

12.3.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts occur.

12.3.3.1 Spillages from decommissioned infrastructure

To manage the impact of spillages unto the downstream watercourse, the following targets described below are required.

- Ensure that the pipelines are emptied of all residual material before decommissioning; and
- Ensure the consideration of the durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.

12.3.4 Impact Ratings

Table 12-4 show the rating for the impacts associated with the decommissioning phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 12-4: Decommissioning phase impact ratings for activities taking place in the Driefontein MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction (Decommissioning activities)			
Impact Description: Water pollution from accidental spillages of decommissioned infrastructure			
Prior to mitigation/ management			
Duration	Short term (2)	Equals to the duration of the actual removal of the infrastructure, thus a short duration	Negligible - negative (21)
Extent	Limited (2)	The impact's will be localized to the nearby water resources closest to the spillages	
Intensity	Moderate - (3)	This will limit the ecosystem functionality in the vicinity especially if runoff occurs	
Probability	Unlikely (3)	Without due care , spillages may occur	
Mitigation/ Management actions			

Dimension	Rating	Motivation	Significance
▪ Empty infrastructure before removal ▪ The durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning			
Post-Mitigation			
Duration	Short term (2)	As for pre-mitigation	Negligible - negative (12)
Extent	Limited (2)	As for pre-mitigation	
Intensity	Low - negative (2)	The scale of ecosystem Damage will be limited as long as mitigation occurs and the spillage volumes are decreased considerably	
Probability	Improbable (2)	If small volumes are handled and if empty infrastructure is handles, the probability of impacts will be almost diminished	

12.4 Post Closure Phase

12.4.1 Impact Description

The post closure phase of the project will entail the assessment of the concurrent rehabilitation of the footprint areas by monitoring, and will address any further rehabilitation requirements.

There will be no major impacts that will directly impact the surface water resources as rehabilitation is already carried out in the decommissioning phase. In this phase monitoring should continue for residual surface water impacts, as well as identification of patchy rehabilitation work and ensuring that these are attended to.

Restoration of the natural drainage patterns will result in an increase of the runoff that reports to the natural water bodies thereby increasing the catchment yield. This will be a positive impact on the on the water resources.

12.4.2 Management Objectives

The management objectives adopted during the post closure phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

- Design of sustainable water management measures for closure and the maintenance of water quantity and quality monitoring should persist; and
- The likelihood of future seepage points, and the impact of these on the receiving water.

12.4.3 Management Actions and Target

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts occur:

- Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies;
- Ensure that monitoring is in place for at least two to 3 years post closure, after rehabilitation and that the land remains free draining post closure, post rehabilitation;
- Monitor the parameters such as: pH, EC, Sulfate, Metals to enable detection of surface water impacts and determine the trend or fluctuation of the water quality as compared to the baseline water quality detailed in section 7.5 of this report;
- It should be ensured that the potential future impacts associated with the mine have been identified and are covered in the closure plan and the closure financial provisions, If post closure impacts are identified, methods of withholding and treating the water should be further investigated depending on parameters of concern; and
- The post-closure water management plan should take cognisance of the likelihood that the water table will rebound in the rehabilitated footprints and that runoff of residual contaminants could impact the runoff water to the streams.

12.4.4 Impact Ratings

Table 12-5 show the rating for the impacts associated with the post-closure phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 12-5: Post-closure phase impact ratings for activities taking place in the Driefontein MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction (Post closure Impacts)			
Impact Description: Residual water pollution from rehabilitated infrastructure footprints post closure			
Prior to mitigation/ management			
Duration	Medium term (3)	The time of impact varies depending on the residual impacts anticipated, but could last for some years	Minor - negative (40)
Extent	Local (3)	The Impacts will travel as far as the runoff goes, into nearby streams.	
Intensity	Moderately high - (4)	The impact s negative with moderate intensity as the impacts could add to the existing poor water quality in the streams	

Dimension	Rating	Motivation	Significance
Probability	Probable (4)	Without appropriate mitigation and capping the rehabilitated area residual impacts could , result in contamination	
Mitigation/ Management actions			
▪ It should be ensured that the potential future impacts from the mine have been identified. ▪ The final mine topography should be planned, as far as possible, to be free-draining.			
Post-Mitigation			
Duration	Medium term (3)	As mitigation is implemented, the erosion will be limited to the times of operation of each small site	Negligible - negative (27)
Extent	Local (3)	Impact limited to the smaller areas cleared and un-rehabilitated each time	
Intensity	Moderate - (3)	Mitigation will reduce the intensities of the potential erosion	
Probability	Unlikely (3)	Mitigation will not completely stop erosion but will significantly reduce	
Activity and Interaction: Post closure (Rehabilitated area)			
Impact Description: Improvement in Catchment Yield			
Prior to mitigation/ management			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well.	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		
Mitigation/ Management actions			
▪ Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies.			
Post- mitigation			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	

Dimension	Rating	Motivation	Significance
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well.	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		

13 Cooke Mining Right Area Impact Assessment

13.1 Construction Phase

13.1.1 Impact Description

The construction phase of the project will cover the infrastructure development which will include all the activities mentioned in the infrastructure category in the summary of the activity list shown in Table 10-4.

During the construction phase, the following interactions will occur as a result of infrastructure development, site clearing and grubbing and the construction of infrastructures (pipelines, sumps and pump stations):

- Increase in sedimentation of surface water during construction caused by an increase in runoff from the cleared and stripped areas which is high in suspended solids; and
- Increase of surface runoff and potentially contaminated water that needs to be maintained in the areas where site clearing and grubbing occur.

As a result of infrastructure development the following potential impacts are predicted:

- Storage of contaminated water/slurry within the sumps during the construction phase may result in seepages/spillages into the nearby natural water bodies;
- Contamination of rivers when dirty water runoff from the reclaimed TSF reports into the nearby rivers;
- Reduction of catchment yield as a result of the footprint areas of the proposed infrastructure. The footprint areas will no longer form part of the natural drainage thereby potentially resulting in a decrease of runoff downstream. The infrastructures will occupy less than 1% of the C23D quaternary catchment; therefore the reduction of catchment yield may be very small or negligible; and
- Flooding of the pipeline at various river crossings.

13.1.1.1 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704.

The three main conditions of GN 704 applicable to this project are:

- *Condition 4* defines the area in which mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, Dam, or reservoir together with any associated structure or any other facility should be situated outside the 1:100 year floodline. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year floodline. Where the floodline is less than 100 metres away from the watercourse, a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows associated with a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

13.1.2 Management Actions and Targets

In this section management actions relating to the activities envisaged during the construction phase are described together with the targets required to ensure mitigation of the impacts occur.

13.1.2.1 Mixing of Clean and Dirty Water (site clearing and grubbing)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from cleared site areas. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

The runoff from the upstream clean water catchment is to be diverted away from the proposed infrastructures. Temporary surface water ditches are to be constructed on the upstream boundary of cleared areas, so as to meet GN 704 requirements regarding the separation of clean and dirty water runoff. All clean water runoff will therefore be diverted away from the cleared area. The temporary surface ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

13.1.2.2 Increased Sedimentation

To manage the impact of increase sedimentation on downstream watercourses due to exposed surfaces resulting in siltation of surface water resources, the following targets are required.

Within the cleared area, along the downstream boundary, temporary ditches are to be constructed along with a temporary excavated storage area. All dirty water runoff will then be captured and contained within the temporary storage facility. The temporary storage facility is to be sized based on the runoff volume generated from the cleared area for the 1:50 year storm event. The water contained in the storage facility should be used during the construction phase as much as possible, ensuring the mentioned storage facility is operated empty. The temporary ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

13.1.2.3 Reduction in Catchment Yield

No targets are possible to manage the reduction in catchment yield due to the loss of catchment area as a result of the WBT and other associated infrastructure. However, the infrastructures will occupy less than 1% of the C23D quaternary catchment; therefore the reduction of catchment yield may be very small or negligible and this will not be rated.

13.1.2.4 Mixing of Clean and Dirty Water (infrastructure development)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from newly constructed infrastructure. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

Based on GN 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. Therefore clean water emanating from upstream of infrastructures will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event.

All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas is captured and contained to a dirty water containment facility. The proposed channels should be lined and sized to cater for the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event. It is recommended that the containment facility be operated empty such that water captured within these facilities is used within the mine operations between a reasonable time interval, so as to ensure that capacity is always available to store the mentioned 1:50 year storm volume.

13.1.3 Impact Ratings

13.1.3.1 Construction Phase

Table 13-1 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 13-1 Construction phase impact ratings for activities taking place in the Cooke MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearing for the Construction of Infrastructure			
Impact Description: Increase in sedimentation due to exposed surfaces			
Prior to mitigation/ management			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Minor (negative) – 50
Extent	Municipal Area (4)	Sediments may be washed further downstream than the project site	
Intensity	Moderate - (4)	May moderately affect already impacted water resources	
Probability	Likely (5)	It is likely that sedimentation will occur	
Nature	negative		
Mitigation/ Management actions			
▪ Construct temporary ditches and a temporary storage area along downstream boundary of cleared areas to capture sediment laden runoff. Water within temporary storage area can be used for construction and should be operated empty.			
Post- mitigation			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Negligible (negative) – 24
Extent	Limited (2)	Sediments will be contained on the project site	
Intensity	Moderate - (2)	May moderately affect water resources if sediments are not contained correctly	
Probability	Probable (4)	Has occurred elsewhere and may occur again	
Nature	negative		
Activity and Interaction: Site clearing for the Construction of Infrastructure			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment..			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		

Dimension	Rating	Motivation	Significance
Mitigation/ Management actions			
▪ Temporary surface water ditches are to be constructed on the upstream boundary of infrastructure areas to divert clean water into the downstream environment.			
Post- mitigation			
Duration	Short term (2)	Will only last for the duration of the construction phase	Negligible (negative) – 28
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines, pump stations, etc.).			
Impact Description: Flooding of pipeline crossings			
Prior to mitigation/ management			
Duration	Permanent (7)	Flooding of the pipelines may occur beyond the construction phase and beyond the project life if the RTSF remains indefinitely	Minor (negative) – 48
Extent	Region (5)	Hazardous substances in the pipelines under exceptional flooding (greater than 1:100 year flood) may affect surface water resources on a regional scale	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	Unlikely (3)	Highly unlikely as the pipeline will be constructed above the 1:100 year flood elevation and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Mitigation/ Management actions			
▪ Ensure that all pipelines are constructed above the 1:100 year flood elevation and/or designed to withstand exceptional rainfall events. ▪ Minimum flanges within flood line area. ▪ Sound engineering of support infrastructure across floodplain.			
Post- mitigation			

Dimension	Rating	Motivation	Significance
Duration	Permanent (7)	The RTSF will remain indefinitely and there is always a possibility that an exceptional flood greater than the 1:100 year peak flood may occur	Minor (negative) – 39
Extent	Limited (2)	If flood protection measures are implemented then restricted to the project site	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	unlikely (3)	Highly unlikely as the RTSF is outside of the 1:100 year floodline and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Construction of infrastructures (pipelines, sumps, RTSF return water Dam).			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas resulting in dirty water reporting to the downstream clean water catchment.			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Clean water emanating from upstream of infrastructure areas will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event. ▪ All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event.			
Post- mitigation			
Duration	Project Life (5)	Will last for the project life	Minor (negative) – 40
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	

Dimension	Rating	Motivation	Significance
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		

13.2 Operational Phase

13.2.1 Impact Description

The operational phase of the project will cover the operation of pumps and abstraction of water.

As a result of the operation of the sumps and pumps the following potential impacts are predicted:

- Overflow of sumps to the downstream surface water resources; and
- Failure of pumps resulting in slurry from sumps to overflow to the downstream environment.

13.2.2 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The two main conditions of GN 704 applicable to this project are:

- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

13.2.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the operational phase are described together with the targets required to ensure mitigation of the impacts occur.

13.2.3.1 Pump Failure and Overflows from Sumps

To manage the impact of contamination of the surface water resources, the following targets are required.

The management of sumps and pumps are linked. The pumps located at each of the sumps should be installed within closed off areas to contain material spillages. During power failure, manual monitoring of the sump associated with the pump station should be carried out. This ensures that the reclamation activities can be slowed down or emergency procedures can be actioned. The emergency procedures in the event of power failure should at least include operational modifications and the use of a stand-by generator to operate the pump station should the sump be getting full.

During pump failure overflows from sumps to the downstream watercourse may occur. It is therefore recommended that overflow compartments be constructed so as to contain any spillages that do occur. The compartments should be monitored and cleaned whenever spillages do occur, to ensure that the adequate capacity is available to mitigate additional spillages.

13.2.4 Impact Ratings

Table 13-2 indicates the rating for the impacts associated with the operational phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 13-2: Operational phase impact ratings for activities taking place in the Cooke MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: Operation of sumps and pumps			
Impact Description: Pump failure and overflow from sumps to contaminate downstream water quality			
Prior to mitigation/ management			
Duration	Project Life (5)	The whole operational phase will see the use of the sumps and pumps	Minor - negative (56)
Extent	Municipal Area (4)	Should overflows occur the impacts will be felt in the immediate catchment and might not be felt at quaternary catchment scale	
Intensity	High - (5)	The management of sumps and pumps are linked	
Probability	Probable (4)	It is likely that compaction will occur during construction	
Nature	negative		
Mitigation/ Management actions			

Dimension	Rating	Motivation	Significance
▪ Construct, monitor and maintain overflow compartments downstream of the sump area. ▪ Ensure emergency procedures in the event of power failure such as operational modifications and the use of a stand-by generator to operate the pump station should the sump be getting full.			
Post- mitigation			
Duration	Project Life (5)	Same as the pre mining	Negligible - negative (27)
Extent	Limited (2)	The impacts will not be far reaching as long as emergency measures are in place to collect any overflow thus will be limited to the control measures	
Intensity	Low - (2)	Impacts will be contained with mitigation and control measures	
Probability	Unlikely (3)	With mitigation the impacts it is unlikely that impacts will occur	
Nature	negative		

13.3 Decommissioning Phase

13.3.1 Impact Description

The decommissioning phase of the project will cover the decommissioning activities, which must be focused on ensuring that spillages unto the clean water environment area is minimised.

As a result of the decommissioning activities the following potential impact has been predicted:

- Water pollution could result from accidental spillages during decommissioning of infrastructures.

13.3.2 Management Objectives

The three main conditions of GN 704 applicable to this project are:

- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.
- *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations. The in stream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, should be remedied so as to comply with these regulations.

13.3.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts occur.

13.3.3.1 Spillages from decommissioned infrastructure

To manage the impact of spillages unto the downstream watercourse, the following targets are required:

- Ensure that the pipelines are emptied of all residual material before decommissioning; and
- Ensure the consideration of the durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.

13.3.4 Impact Ratings

Table 12-3 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 13-3 Decommisioning phase impact ratings for activities taking place in the Cooke MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction (Decommissioning activities)			
Impact Description: Water pollution from accidental spillages of decommissioned infrastructure			
Prior to mitigation/ management			
Duration	Short term (2)	Equals to the duration of the actual removal of the infrastructure, thus a short duration	Negligible - negative (21)
Extent	Limited (2)	The impact's will be localized to the nearby water resources closest to the spillages	
Intensity	Moderate - negative (3)	This will limit the ecosystem functionality in the vicinity especially if runoff occurs	
Probability	Unlikely (3)	Without due care , spillages may occur	
Mitigation/ Management actions			
▪ Empty infrastructure before removal. ▪ The durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.			
Post-Mitigation			
Duration	Short term (2)	As for pre-mitigation	Negligible - negative (12)
Extent	Limited (2)	As for pre-mitigation	
Intensity	Low - negative (2)	The scale of ecosystem Damage will be limited as long as mitigation occurs and the spillage volumes are decreased considerably	
Probability	Improbable (2)	If small volumes are handled and if empty infrastructure is handles, the probability of impacts will be almost diminished	

13.4 Post Closure Phase

13.4.1 Impact Description

The post closure phase of the project will entail the assessment of the concurrent rehabilitation of the footprint areas by monitoring, and will address any further rehabilitation requirements.

There will be no major impacts that will directly impact the surface water resources as rehabilitation is already carried out in the decommissioning phase. In this phase monitoring should continue for residual surface water impacts, as well as identification of ineffective rehabilitation work and ensuring that these are attended to.

Restoration of the natural drainage patterns will result in an increase of the runoff that reports to the natural water bodies thereby increasing the catchment yield. This will be a positive impact on the on the water resources.

13.4.2 Management Objectives

The management objectives adopted during the post closure phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources:

- Design of sustainable water management measures for closure and the maintenance of water quantity and quality monitoring should persist; and
- The likelihood and position of future seepage points, and the impact of these on the receiving water.

13.4.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts occur:

- Ensure that the surface inspection is continuously undertaken to allow clean water runoff to drain onto the natural water bodies;
- Ensure that monitoring is in place for at least two to three years post closure, after rehabilitation and that the land remains free draining post closure, post rehabilitation;
- Monitor the parameters such as pH, EC, Sulfate, and Metals to enable detection of surface water impacts and determine the trend or fluctuation of the water quality compared to the baseline water quality detailed in section 7.5 of this report;
- Potential future impacts from the mine should be covered in the closure plan and the closure financial provisions. If post closure impacts are identified, methods of withholding and treating the water should be further investigated depending on parameters of concern; and
- The post-closure water management plan should take cognisance of the likelihood that the water table will rebound in the rehabilitated footprints and that runoff of residual contaminants could impact the runoff water to the streams.

13.4.4 Impact Ratings

Table 13-1 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 13-4: Post-closure phase impact ratings for activities taking place in the Cooke MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: (Post closure Impacts)			
Impact Description: Residual water pollution from rehabilitated infrastructure footprints post closure			
Prior to mitigation/ management			
Duration	Medium term (3)	The time of impact varies depending on the residual impacts anticipated, but could last for some years	Minor - negative (40)
Extent	Local (3)	The Impacts will travel as far as the runoff goes, into nearby streams	
Intensity	Moderately high - negative (4)	The impact s negative with moderate intensity as the impacts could add to the existing poor water quality in the streams	
Probability	Probable (4)	Without appropriate mitigation and capping the rehabilitated area residual impacts could , result in contamination	
Mitigation/ Management Actions			
▪ Potential future impacts from the mine should have been identified and mitigated accordingly. ▪ The final mine topography should be free-draining as far as possible.			
Post-Mitigation			
Duration	Medium term (3)	As mitigation is implemented, the erosion will be limited to the times of operation of each small site	Negligible - negative (27)
Extent	Local (3)	Impact limited to the smaller areas cleared and un-rehabilitated each time	
Intensity	Moderate - negative (3)	Mitigation will reduce the intensities of the potential erosion	
Probability	Unlikely (3)	Mitigation will not completely stop erosion but will significantly reduce	
Activity and Interaction: Post closure (Rehabilitated area)			
Impact Description: Improvement in catchment yield			
Prior to mitigation/ management			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	

Dimension	Rating	Motivation	Significance
Nature	Positive		
Mitigation/ Management actions			
▪ Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies.			
Post- mitigation			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		

14 Ezulwini Mining Area Impact Assessment

14.1 Construction Phase

14.1.1 Impact Description

The construction phase of the project will cover the infrastructure development which will include all the activities mentioned in the infrastructure category in the summary of the activity list shown in Table 10-4.

During the construction phase the following interactions will occur as a result of infrastructure development, site clearing and grubbing and the construction of infrastructures (pipelines, pump stations, uranium roaster and acid plants):

- Increase in sedimentation of surface water during construction caused by an increase in runoff from the cleared and stripped areas which is high in suspended solids; and
- Increase of surface runoff and potentially contaminated water that needs to be maintained in the areas where site clearing and grubbing occur.

As a result of infrastructure development the following potential impacts are predicted:

- Contamination of clean water runoff by mixing up with dirty water runoff emanating from within the infrastructure areas; and
- Flooding of the pipeline at various river crossings.

14.1.2 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The three main conditions of GN 704 applicable to this project are:

- *Condition 4* defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, Dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year floodline. Any mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year floodline. Where the floodline is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

14.1.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the construction phase are described together with the targets required to ensure mitigation of the impacts occur.

14.1.3.1 Mixing of Clean and Dirty Water (site clearing and grubbing)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from cleared site areas. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

The runoff from the upstream clean water catchment is to be diverted away from the proposed infrastructures. Temporary surface water ditches are to be constructed on the upstream boundary of proposed infrastructures so as to meet GN 704 requirements regarding the separation of clean and dirty water runoff. All clean water runoff will therefore be diverted away from the cleared area. The temporary surface ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

14.1.3.2 Increased Sedimentation

To manage the impact of increase sedimentation on downstream watercourses due to exposed surfaces resulting in siltation of surface water resources, the following targets are required.

Within the cleared area, along the downstream boundary, temporary ditches are to be constructed along with a temporary excavated storage area. All dirty water runoff will then be captured and contained within the temporary storage facility. The temporary storage facility is to be sized based on the runoff volume generated from the cleared area for the 1:50 year storm event. The water contained in the storage facility should be used during the construction phase, ensuring the mentioned storage facility is operated empty. The temporary ditches are to be sized such that the 1:50 year peak discharge can be contained within it.

14.1.3.3 Flooding

To manage the impact of flooding of the pipeline crossings, the following targets are required.

The pipeline routes which intersect various drainage paths/rivers need to be assessed such that the elevation of the pipe at the crossings lie above the 1:100 year modelled flood elevation. To undertake this, the 1:100 year peak flows will be calculated at the respective river crossings to determine maximum flows during flood conditions. The peak flows must then be modelled using a hydraulic programme such as HEC-RAS to determine the maximum elevation reached due to the 1:100 year peak flow. It is recommended that detailed survey 100 m upstream and 100 m downstream of the river crossings be undertaken as input to the model.

14.1.3.4 Mixing of Clean and Dirty Water (infrastructure development)

To manage the impact of mixing of upstream clean water runoff with dirty water runoff from newly constructed infrastructure. This could result in dirty water reporting to the downstream clean water catchment, the following targets are required.

Based on GN 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. Therefore clean water emanating from upstream of the proposed infrastructures will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event.

All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The proposed channels should be lined and sized to cater for the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event. It is recommended that the containment facility be operated empty such that water captured within these facilities are used within the mine operations between a period of 10 days, so as to ensure that capacity is always available to store the mentioned 1:50 year storm volume.

14.1.4 Impact Ratings

14.1.4.1 Construction Phase

Table 14-1 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 14-1 Construction phase impact ratings for activities taking place in the Ezulwini MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: Site clearing for the Construction of Infrastructure			
Impact Description: Increase in sedimentation due to exposed surfaces			
Prior to mitigation/ management			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Minor (negative) – 50
Extent	Municipal Area (4)	Sediments may be washed further downstream than the project site	
Intensity	Moderate - (4)	May moderately affect already impacted water resources	
Probability	Likely (5)	It is likely that sedimentation will occur	
Nature	negative		
Mitigation/ Management actions			
▪ Construct temporary ditches and a temporary storage area along downstream boundary of cleared areas to capture sediments. Water within temporary storage areas can be used for construction and should be operated empty.			
Post- mitigation			
Duration	Short term (2)	Sedimentation will only take place while soil is exposed during the construction phase	Negligible (negative) – 24
Extent	Limited (2)	Sediments will be contained on the project site	
Intensity	Moderate - (2)	May moderately affect water resources if sediments are not contained correctly	
Probability	Probable (4)	Has occurred elsewhere and may occur again	
Nature	negative		
Activity and Interaction: Site clearing for the Construction of Infrastructure			

Dimension	Rating	Motivation	Significance
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment..			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	
Nature	negative		
Mitigation/ Management actions			
▪ Temporary surface water ditches are to be constructed on the upstream boundary of the cleared areas to divert clean water to the downstream environment.			
Post- mitigation			
Duration	Short term (2)	Will only last for the duration of the construction phase	Negligible (negative) – 28
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines, pump stations, uranium roaster and acid plants).			
Impact Description: Flooding of pipeline at various crossings			
Prior to mitigation/ management			
Duration	Permanent (7)	Flooding of the pipelines may occur beyond the construction phase and beyond the project life if the RTSF remains indefinitely	Minor (negative) – 48
Extent	Region (5)	Hazardous substances in the pipelines under exceptional flooding (greater than 1:100 year flood) may affect surface water resources on a regional scale	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	

Dimension	Rating	Motivation	Significance
Probability	Unlikely (3)	Highly unlikely as the pipeline will be constructed above the 1:100 year flood elevation and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Mitigation/ Management actions			
▪ Ensure that all pipelines are constructed above the 1:100 year flood elevation and/or designed to withstand exceptional rainfall. ▪ Minimum flanges within flood line area. ▪ Sound engineering of support infrastructure across floodplain.			
Post- mitigation			
Duration	Permanent (7)	Flooding of the pipelines may occur beyond the construction phase and beyond the project life if the RTSF remains indefinitely	Minor (negative) – 39
Extent	Limited (2)	If flood protection measures are implemented then restricted to the project site	
Intensity	Moderate - (4)	May impact on already moderately impacted surface water resources	
Probability	unlikely (3)	Highly unlikely as the pipeline will be constructed above the 1:100 year flood elevation and can be designed to withstand exceptional rainfall. However, there is always a possibility of exceptional flooding	
Nature	negative		
Activity and Interaction: Construction of infrastructures (pipelines, pump stations, North TSF, uranium, roaster and acid plants).			
Impact Description: Mixing of upstream clean water runoff with dirty water runoff from within infrastructure areas resulting in dirty water reporting to the downstream clean water catchment..			
Prior to mitigation/ management			
Duration	Beyond project life (6)	May continue beyond the project life if not managed correctly	Moderate (negative) – 80
Extent	Region (5)	May impact water quality on a regional basis	
Intensity	High - (5)	May impact on highly sensitive environments such as the downstream Vaal Dam	
Probability	Likely (5)	Is likely to occur if not managed correctly	

Dimension	Rating	Motivation	Significance
Nature	negative		
Mitigation/ Management actions			
▪ Clean water emanating from upstream of the proposed infrastructure areas will be diverted away and discharged to the nearby watercourse or environment. The clean water diversion will be sized to accommodate the 1:50 year storm event. ▪ All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event.			
Post- mitigation			
Duration	Project Life (5)	Will last for the project life	Minor (negative) – 40
Extent	Limited (2)	Limited to the project site if mitigation is applied correctly	
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources	
Probability	Probable (4)	Probable, has occurred elsewhere and may occur here	
Nature	negative		

14.2 Operational Phase

14.2.1 Impact Description

The operational phase of the project will cover the operation of pumps, extraction of uranium and gold and deposition of slurry onto existing operational Ezulwini North TSF.

As a result of the operation of the sumps and pumps the following potential impacts are predicted:

- Currently approximately 70 Ml/day is abstracted as a result of underground dewatering activities at the Ezulwini Gemsbokfontein West dolomitic compartments. From the 70 Ml/day abstracted 10 Ml/day is discharged to the Leeuspruit (East), and the remaining 60 Ml/day is discharged to the Klein Wes Rietspruit. During re-mining of the TSFs, 20 Ml/day will be used to mine the 1 Mt/mth from Cooke 4 South (C4S), resulting in a decrease of discharges from 60 Ml/day to 40 Ml/day. Therefore there will be a decrease in current flows measured at the Klein Wes Rietspruit;
- Overflow of sumps to the downstream surface water resources; and
- Failure of pumps resulting in slurry from sumps to overflow to the downstream environment.

14.2.2 Management Objectives

The management objectives adopted during the construction phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources.

The two main conditions of GN 704 applicable to this project are:

- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.

14.2.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the operational phase are described together with the targets required to ensure mitigation of the impacts occur.

14.2.3.1 Decrease water discharged to the Klein Wes Rietspruit

To manage the impact of decrease water discharged to the Klein Wes Rietspruit, the following mitigation measure is required.

Decrease in flows in the Klein Wes Rietspruit is expected to range between 27 to 33% downstream of the Peter Wright Dam, with average Sulfate concentrations of 379 mg/L measured downstream of the Peter Wright Dam on the Klein Wes Rietspruit, estimated to also decrease in salt loads range from 27 to 33%.

14.2.3.2 Pump Failure and Overflows from Sumps

To manage the impact of contamination of the surface water resources, the following targets are required.

The management of sumps and pumps are linked. The pumps located at each of the sumps should be installed within closed off areas to contain material spillages. During power failure, manual monitoring of the sump associated with the pump station should be carried out. This ensures that the reclamation activities can be slowed down or emergency procedures can be actioned. The emergency procedures in the event of power failure should at least include operational modifications and the use of a stand-by generator to operate the pump station, should the sump be getting full.

During pump failure overflows from sumps to the downstream watercourse may occur. It is therefore recommended that overflow compartments be constructed to contain any spillages that occur. The compartments should be monitored and cleaned whenever spillages occur to ensure that the adequate capacity is available to mitigate additional spillages.

14.2.4 Impact Ratings

Table 14-2 indicates the rating for the impacts associated with the operational phase on surface water. Once all impacts during this phase of the project are described they are rated and summarised in a single table for the specific project phase.

Table 14-2: Operational phase impact ratings for activities taking place in the Ezulwini MRA

Dimension	Rating	Motivation
Abstractions of water from the Klein Wes Rietspruit		
Impact Description: Decrease water discharged to the Klein Wes Rietspruit. Resulting in inadequate water supply for the downstream users on the Klein Wes Rietspruit		
Prior to mitigation/ management		
Duration	Project Life (5)	20 Ml/d will be used to mine Cooke 4 South during the operational life span of the project.
Extent	Region (5)	May affect downstream water users beyond the project site
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources
Probability	Highly probable (6)	Water will need to be used to reclaim the 1 Mt/mth from Cooke 4 South and it is therefore most likely that the impact will occur.
Nature	negative	
Mitigation/ Management actions		
▪ There are no mitigation measures for this impact. It is estimated that although the flows will decrease between 27 % and 33 %, there will still be sufficient flows in the Klein Wes Rietspruit to cater for the current water supply demand.		
Post- mitigation		
Duration	Project Life (5)	20 Ml/d will be used to mine Cooke 4 South during the operational life span of the project.
Extent	Region (5)	May affect downstream water users beyond the project site
Intensity	Moderate - (3)	May impact already moderately impacted surface water resources
Probability	Highly probable (6)	Water will need to be used to reclaim the 1 Mt/mth from Cooke 4 South and it is therefore most likely that the impact will occur.
Nature	negative	

Dimension	Rating	Motivation	Significance

<table>
<tr><th>Dimension</th><th>Rating</th><th colspan="2">Motivation</th></tr>
<tr><td colspan="4">Activity and Interaction: Operation of sumps and pumps</td></tr>
<tr><td colspan="4">Impact Description: Pump failure and overflow from sumps to contaminate downstream water quality.</td></tr>
<tr><td colspan="4">Prior to mitigation/ management</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>The whole operational phase will see the use of the sumps and pumps</td><td rowspan="5">Minor - negative (56)</td></tr>
<tr><td>Extent</td><td>Municipal Area (4)</td><td>Should overflows occur the impacts will be felt in the immediate catchment and might not be felt at quaternary catchment scale</td></tr>
<tr><td>Intensity</td><td>High - (5)</td><td>The management of sumps and pumps are linked</td></tr>
<tr><td>Probability</td><td>Probable (4)</td><td>It is likely that compaction will occur during construction</td></tr>
<tr><td>Nature</td><td>negative</td><td></td></tr>
<tr><td colspan="4">Mitigation/ Management actions</td></tr>
<tr><td colspan="4">▪ Construct, monitor and maintain overflow compartments downstream of the sump area.
▪ Ensure emergency procedures in the event of power failure such as operational modifications and the use of a stand-by generator to operate the pump station should the sump be getting full.</td></tr>
<tr><td colspan="4">Post- mitigation</td></tr>
<tr><td>Duration</td><td>Project Life (5)</td><td>Same as the pre mining</td><td rowspan="5">Negligible - negative (27)</td></tr>
<tr><td>Extent</td><td>Limited (2)</td><td>The impacts will not be far reaching as long as emergency measures are in place to collect any overflow thus will be limited to the control measures</td></tr>
<tr><td>Intensity</td><td>Low - (2)</td><td>Impacts will be contained with mitigation and control measures</td></tr>
<tr><td>Probability</td><td>Unlikely (3)</td><td>With mitigation the impacts it is unlikely that impacts will occur</td></tr>
<tr><td>Nature</td><td>negative</td><td></td></tr>
</table>

14.3 Decommissioning Phase

14.3.1 Impact Description

The decommissioning phase of the project will cover the decommissioning activities, which must be focused on ensuring that spillages unto the clean water environment area is minimised.

As a result of the decommissioning activities the following potential impact has been identified:

- Water pollution could result from accidental spillages during decommissioning of infrastructures.

14.3.2 Management Objectives

The three main conditions of GN 704 applicable to this project are:

- *Condition 6* describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water Dams should have a minimum freeboard of 0.8 m above full supply level.
- *Condition 7* describes the measures which must be taken to protect water resources. All dirty water or substances which may result in pollution should be prevented from entering a water resource (by spillage, seepage, erosion) and ensure that water used in any process is recycled as far as practicable.
- *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations. The in stream and riparian habitat of any water resource, which may have been affected or altered by a mine or activity, should be remedied so as to comply with these regulations.

14.3.3 Management Actions and Targets

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts occur.

14.3.3.1 Spillages from decommissioned infrastructure

To manage the impact of spillages unto the downstream watercourse, the following targets are required:

- Ensure that the pipelines are emptied of all residual material before decommissioning; and
- Ensure the consideration of the durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.

14.3.4 Impact Ratings

Table 14-3 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 14-3: Decommisioning phase impact ratings for activities taking place in the Ezulwini MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction (Decommissioning activities)			
Impact Description: Water pollution from accidental spillages of decommissioned infrastructure.			
Prior to mitigation/ management			
Duration	Short term (2)	Equals to the duration of the actual removal of the infrastructure, thus a short duration	Negligible - negative (21)
Extent	Limited (2)	The impact's will be localized to the nearby water resources closest to the spillages	
Intensity	Moderate - negative (3)	This will limit the ecosystem functionality in the vicinity especially if runoff occurs	
Probability	Unlikely (3)	Without due care , spillages may occur	
Mitigation/ Management actions			
▪ Empty infrastructure before removal. ▪ The durability and longevity of water management designs, e.g. provision of erosion protection for long-term control of erosion and potential pollution to water resources during decommissioning.			
Post-Mitigation			
Duration	Short term (2)	As for pre-mitigation	Negligible - negative (12)
Extent	Limited (2)	As for pre-mitigation	
Intensity	Low - negative (2)	The scale of ecosystem Damage will be limited as long as mitigation occurs and the spillage volumes are decreased considerably	
Probability	Improbable (2)	If small volumes are handled and if empty infrastructure is handles, the probability of impacts will be almost diminished	

14.4 Post Closure Phase

14.4.1 Impact Description

The post closure phase of the project will entail the assessment of the concurrent rehabilitation of the footprint areas by monitoring, and will address any further rehabilitation requirements.

There will be no major impacts that will directly impact the surface water resources as rehabilitation is already carried out in the decommissioning phase. In this phase monitoring should continue for residual surface water impacts, as well as identification of patchy rehabilitation work and ensuring that these are attended to.

Restoration of the natural drainage patterns will result in an increase of the runoff that reports to the natural water bodies, thereby increasing the catchment yield. This will be a positive impact on the on the water resources.

14.4.2 Management Objectives

The management objectives adopted during the post closure phase relate specifically to GN 704, which was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources:

- Design of sustainable water management measures for closure and the maintenance of water quantity and quality monitoring should persist; and
- The likelihood and position of future seepage points, and the impact of these on the receiving water.

14.4.3 Management Actions and Target

In this section management actions relating to the activities envisaged during the decommissioning phase are described together with the targets required to ensure mitigation of the impacts:

- Ensure that the surface inspection is continuously undertaken to allow clean water runoff to drain onto the natural water bodies;
- Monitor the parameters such as pH, EC, Sulfate, and Metals to enable detection of surface water impacts and determine the trend or fluctuation of the water quality as compared to the baseline water quality detailed in section 7.5 of this report;
- Potential impacts from the mine should be covered in the closure plan and the closure financial provisions. If post closure impacts are identified, methods of withholding and treating the water should be further investigated depending on parameters of concern; and
- The post-closure water management plan should take cognisance of the likelihood that the water table will rebound in the rehabilitated footprints and that runoff of residual contaminants could impact the runoff water to the streams.

14.4.4 Impact Ratings

Table 14-4 presents a summary of the ratings of the predicted impacts, together with the ratings achieved after mitigation.

Table 14-4: Post-closure phase impact ratings for activities taking place in the Ezulwini MRA

Dimension	Rating	Motivation	Significance
Activity and Interaction: (Post closure Impacts)			
Impact Description: Residual water pollution from rehabilitated infrastructure footprints post closure			
Prior to mitigation/ management			
Duration	Medium term (3)	The time of impact varies depending on the residual impacts anticipated, but could last for some years	Minor - negative (40)
Extent	Local (3)	The Impacts will travel as far as the runoff goes, into nearby streams	
Intensity	Moderately high - negative (4)	The impact s negative with moderate intensity as the impacts could add to the existing poor water quality in the streams	
Probability	Probable (4)	Without appropriate mitigation and capping the rehabilitated area residual impacts could , result in contamination	
Mitigation/ Management Actions			
▪ Potential impacts from the mine must be included in the closure plan and mitigated accordingly. ▪ The final mine topography should be free-draining, as far as possible.			
Post-Mitigation			
Duration	Medium term (3)	As mitigation is implemented, the erosion will be limited to the times of operation of each small site	Negligible - negative (27)
Extent	Local (3)	Impact limited to the smaller areas cleared and un-rehabilitated each time	
Intensity	Moderate - negative (3)	Mitigation will reduce the intensities of the potential erosion	
Probability	Unlikely (3)	Mitigation will not completely stop erosion but will significantly reduce	
Activity and Interaction: Post closure (Rehabilitated area)			
Impact Description: Improvement in Catchment Yield			
Prior to mitigation/ management			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	

Dimension	Rating	Motivation	Significance
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		
Mitigation/ Management actions			
▪ Ensure that the surface inspection is continuously undertaken to allow runoff to drain onto the natural water bodies.			
Post- mitigation			
Duration	Project Life (7)	This will continue permanently after the closure of the project	Moderate - positive (91)
Extent	Local (3)	The Dams and rivers downstream of the project area catchment could be positively impacted	
Intensity	Moderately high (3)	Rivers around the project area will receive moderately increased runoff and this could benefit the downstream users and the aquatic life as well	
Probability	Certain (7)	The increased catchment yield will occur as long as the drainage patterns are restored	
Nature	Positive		

15 Cumulative Impacts

The baseline water quality data indicated elevated concentrations of Sulfate, Nitrate, Fluoride, Manganese and Ammonia in a number of streams in the project area. This indicates that rivers within this area are already impacted. The area comprises of various land uses which includes mining, industrial areas, residential areas, and agricultural activities. All these land uses could possibly have contributed to this water quality status.

The reclamation of the gold dumps mobilises and expose sulphide minerals such a pyrite (FeS_2) that when exposed to air and water, will oxidize and release large quantities of iron and Sulfate into solution, which is very acidic and thereby referred to as AMD. Therefore, without adequate and effective mitigation measures, the proposed project may further deteriorate the quality of water in the natural water courses.

In the long run it is anticipated that post closure, with the implementation of mitigation and management measures, the surface water environment will benefit by eliminating a long term source of contaminants presented by the present position and contents of the dumps.

Monitoring should be implemented post closure to check for residual impacts. The re-mining of old tailings facilities, re treating of the material and removal of sulphides and then deposition on a proposed new facility will have a positive impact on the environment .This project would therefore contribute to a regional closure strategy that talks to a sustainable solution for both water issues and management of a multitude of poorly sited historical TSFs.

16 Unplanned Events and Low Risks

Low risks and unplanned events could be eminent in the project namely:

- The risk of bursts from pipelines containing slurries with AMD generation potential - and seeps from wet screens debris stockpiles (which are used for screening material from the reclamation site) could contribute to the degradation of surface water quality Potential hydrocarbon and construction material spillages from the construction sites, pump stations and heavy construction machinery could result in surface water quality deterioration as it can be carried to the streams by runoff water.
- Dewatering of the RTSF area as a result grout curtain abstraction could potentially have a small impact on the volume of water flowing down the Leeuspruit. The flow in the Leeuspruit will however be higher compared to the seepage rate through the stream floor and the dewatering cone impact on the Leeuspruit will be minimal.

The management and mitigation measures are summarised in Table 16-1.

Table 16-1: Unplanned events, low risks and their management measures

Unplanned event	Potential impact	Mitigation/ Management/ Monitoring
Construction and Hydrocarbon material spillage	Surface water contamination	Vehicles must only be serviced within designated service bays. Hydrocarbon spill kits must be available on site at all locations where hydrocarbon spills could take place. Storage areas should be lined by temporary means such as using plastic lining for the period of the life of the dump to ensure any spillages can easily be cleaned or contained. Hydrocarbon storage in bunded areas
Slurry pipeline burst	Surface water contamination	Electronic monitoring of pipeline pressure and flow rate differentials to identify a burst as soon as possible. Pipeline design caters for HDPE lined ,majority line welded with minimum flanges Should it occur, emergency valves need to be shut down to prevent spillage of hazardous material. Material must be cleaned up in accordance with the operations hazardous material spillage policy. Where the pipeline crosses streams and wetlands

		monitoring should be carried out annually, no flanges allowed in these areas and catchment Dams provided.
Reduced flow down Leeuspruit near RTSF	Reduced stream flow	The impact is expected to be minimal and with the discharge of water from the water treatment facility there will be no negative water quantity impact on downstream users.

17 Environmental Management Plan

17.1 Environmental and Social Management Plan Structure

The assessment of surface water quality and quantity impacts associated with the reclamation of the various dumps identified several impacts. The more significant impacts from the activities detailed in Table 10-4 are listed in Table 17-1.

Table 17-1: Potentially Significant Impacts of the Reclamation Process on Surface Water

Aspects	Potential Significant impacts
Kloof Mining Right Area	
Construction phase of infrastructures (pipelines, sumps, CPP, RTSF, RTSF return water Dam and water supply from K10 shaft)).	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment.
	Temporary reduction in catchment yield.
Discharges of water from the RTSF into the Leeuspruit –operational phase	Overflowing of small Dams located on the Leeuspruit downstream of the RTSF resulting in backing up of water directly upstream and raising floodline.
	Positive impact of dilution due to treated water being added to the current Leeuspruit flows.
Abstractions of water from the Wonderfonteinspruit	Decrease water discharged to the Wonderfonteinspruit from Cooke 1 & 2 shafts, resulting in inadequate water supply for the downstream users on the Wonderfonteinspruit.. The biophysical information is available and Digby Wells would be able to assist DWS in undertaking a rapid reserve determination.
Driefontein Mining Right Area	
Construction phase of infrastructure (Reclamation pump stations, pipelines, sumps, west block thickener and bulk water storage	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment.

Aspects	Potential Significant impacts
	Temporary reduction in catchment yield.
Cooke Mining Right Area	
Construction phase of infrastructures (Reclamation pump stations, pipelines, sumps, Cooke Dam thickener and bulk water storage	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas.
	Temporary reduction in catchment yield.
Ezulwini Mining Right Area	
Construction phase of infrastructures (Reclamation pump stations, pipelines, sumps, Cooke Dam thickener and bulk water storage	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas resulting in dirty water reporting to the downstream clean water catchment.
	Temporary reduction in catchment yield.
Abstractions of water from the Rietspruit/Kleinwes spruit	Decrease water discharged to the Kleinwes spruit from Cooke 4 shaft, resulting in inadequate water supply for the downstream users.

17.1.1 Summary of Mitigation and Management

Table 17-2 provides a description of the mitigation and management options for the environmental impacts anticipated during the construction, operational, decommissioning and closure phases.

Table 17-2 to Table 17-4 provide a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMP.

Table 17-2: Mitigation

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Site clearing and grubbing	Construction	The historical dams occupy approximately 2,750 ha of land. A 1,350 ha (13.5 km^2) RTSF has been proposed.	Construct temporary ditches/berms and a temporary storage area along downstream boundary of cleared areas to capture sediments. Water within temporary storage area can be used for construction and should be operated empty. All dirty water channels must be constructed and placed within the dirty water infrastructure areas, such that all dirty water runoff emanating from these areas are captured and contained to a dirty water containment facility. The proposed channels should be engineered and sized to cater for the 1:50 year storm event. It is recommended that the containment facility be operated empty such that water captured within these facilities are used within the mine construction operations within a defined period,	Based on the Reg 704 requirements regarding storm water management for mining activities it is noted that all clean and dirty water must be separated. The clean water diversion will be sized to accommodate the 1:50 year storm event. The containment facility should be sized to accommodate the anticipated dirty water runoff as a result of the 1:50 year storm event.	During the construction period all water storage and conveyance structures should be sized accurately.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
			so as to ensure that capacity is always available to store the mentioned 1:50 year storm volume.		
Construction of infrastructures (Pump stations, pipelines, sumps, CPP, RTSF, RTSF return water Dam and AWTF).	Construction	16ha pipe route	The pipeline routes which intersect various drainage paths/rivers need to be assessed/ designed such that the elevation of the pipe at the crossings is located above the 1:100 year modelled flood elevations.	Based on Reg 704, the mine infrastructure in question should fall outside of the 1:100 year floodline or 100 m away, whichever is greater.	During the construction period all pipelines need to be designed at crossings to be above flood line and adequately supported
Abstractions of water from the Wonderfonteinspruit(K10 and Cooke 1 & 2 shafts) and the Kleinwes spruit(Cooke 4 shaft)	Operational	A decrease in the current flow measured of 32Ml/day (32000 m^3/day) of the Wonderfontein and 20 Ml/d of the Kleinwes spruit will occur. Decrease in flows in the Wonderfonteinspruit is expected	Impact assessment required as to the adequacy of the Spruit to support current lawful uses, eco reserves at the reduced volumes. Refer to section 11 above)	The biophysical information is available and Digby Wells would be able to assist DWS in undertaking a rapid reserve determination.	Monitor volumes and eco reserves aquatic status of the stream during operation, no direct mitigation.

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
		to range between 37 to 55% at the outlet of the 1 m pipeline. Decrease in flows in the Klein Wes Rietspruit is expected to range between 27 to 33% downstream of the Peter Wright Dam.			

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
Discharges of water from the RTSF into the Leeuspruit.	Operational	Additional flows of on average 15 Ml/d that will be discharged into the river. Additional flows amount to approximately 0.1 m^3/s or 20% increase	Intercepting fast flow pathways by placing a bund or gabions across the overland flow route prevents the treated water from reaching the watercourse at high velocities. This has the benefit of slowing the flow while trapping sediment being washed from the surrounds	Best Practice Guidelines on Stormwater Management Plan.	During construction of flow control measures and during operational phase for the water use
Operation of sumps and pumps	Operational	10 pump station areas	The spillage pumps located at each of the sumps should be installed within closed off/bunded areas to contain material spillages. During power failure, manual monitoring of the sump pump operation associated with the pump station should be carried out.	Emergency procedures need to be in place and comply with DWA BPG G1.	On commissioning

Activities	**Phase**	**Size and scale of disturbance**	**Mitigation Measures**	**Compliance with standards**	**Time period for implementation**
Decommissioning activities	Decommissioning and closure	1446ha (initial area impacted)	To manage the impact of spillages unto the downstream watercourse the following targets are required. Ensure that the infrastructure is first emptied of all residual material before decommissioning. This can be input of the standard operation procedures at each of the sites to ensure it's carried out. Ensure approved closure plan is executed after Regulator approval	GN 704 *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations.	On closure
Post closure rehabilitation	Post closure rehabilitation	1446ha (initial phase)	Potential impacts from the mine should have been identified and be covered in the closure plan and the closure financial provisions. If post closure impacts are identified, methods of withholding and treating the water should be further investigated depending on parameters of concern for a sustainable regional closure strategy	GN 704 *Condition* 9 describes the temporary or permanent cessation of mine or activity. At cessation of operations, the persons operating a mining activity should ensure that all pollution control measures have been designed, modified, constructed and maintained so as to	

Activities	Phase	Size and scale of disturbance	Mitigation Measures	Compliance with standards	Time period for implementation
				comply with these regulations.	

Table 17-3: Objectives and Outcomes of the EMP

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
Construction of infrastructure (pipelines, sumps, CPP, RTSF, RTSF return water Dam).	Mixing of upstream clean water runoff with dirty water runoff from cleared site areas.	Water quality	Construction	Storm water control.	GN704 NWA BPG: G1
	Reduction in catchment yield				
Abstractions of water from the Wonderfonteinspruit and Kleinwes spruit	Decrease water discharged to the Wonderfonteinspruit River. Resulting in inadequate water supply for the downstream users on the Wonderfonteinspruit and Kleinwes spruit Rivers	Water quantity	Operational	Storm water control.	GN704 NWA BPG: G1
Discharges of water from the RTSF into the Leeuspruit)	Overflowing of small Dams located on the Leeuspruit resulting in backing up of water upstream	Water quality and quantity	Operational	Intercepting fast flow pathways by placing an engineered solution across the overland flow route preventing the discharge from eroding the banks of the watercourse. This has the benefit of slowing the flow and therefore reducing flood risk, while trapping sediment being washed from the surrounds.	GN704 NWA BPG: G1

Activities	Potential impacts	Aspects affected	Phase	Mitigation	Standard to be achieved/objective
	Positive impact of dilution due to treated water being added to the current Leeuspruit flows.	Water quality	Operational	Compliance with closure plan	Discharge water quality specifications of the AWTF

Table 17-4: Prescribed environmental management standards, practice, guideline, policy or law

Specialist field	Applicable standard, practice, guideline, policy or law	
Surface water	National Water Act no 36 of 1998.	Department of Water Affairs and Forestry, 2006, "*Best Practice Guideline No. G1: Storm Water Management*".

18 Conclusions and Recommendations

The following is a summary of the conclusions reached:

- The four primary rivers draining the project area are the Leeuspruit, Klein Wes Rietspruit, Loopspruit and the Wonderfonteinspruit.
  - The Leeuspruit drains surface water runoff emanating from the Ezulwini (Cooke 4) mining areas, and the Kloof mining areas in a south easterly direction towards the Rietspruit, which is a tributary of the Vaal River and into the Vaal Barrage. The main water users and potential impacts are the West Rand towns in the upper reaches, mining and agriculture;

    Flows on the Leeuspruit can range from no flows during the dry season to a max of 24 593 m^3/day during the wet season. Flows on the Leeuspruit will increase from no flows been observed during the dry season to a constant 15 000 m^3/day flowing down the section of the Leeuspruit when re-mining commences. During the wet season peak flows can be as much as 39 593 m^3/day;
  - The Klein Wes Rietspruit surface water runoff emanates from the Ezulwini (Cooke 4) mining areas, and flows in a south easterly direction towards the Rietspruit. Sebokeng is located in the upper reaches, with agriculture and Agricultural Holdings dominating in the area;

    Average (actual) flows in the Klein Wes Rietspruit is estimated to be 69 612 m^3/day. Decrease in flows in the Klein Wes Rietspruit is expected to range between 27 to 33% downstream of the Peter Wright Dam. Estimated water use is estimated conservatively at 5000 m^3/day. The water usage from the Klein Wes Rietspruit in comparison to what is actually available during re-mining is still sufficient to cater for the demand;
  - The Wonderfonteinspruit is divided into the Upper and the Lower Wonderfonteinspruit and is responsible for draining surface water runoff emanating from the Driefontein and Kloof mining areas. The source of the Upper Wonderfonteinspruit is the Tudor Dam, located north, and upstream of the Donaldson Dam, the Luipaards Vlei Dam and the Lancaster Dam. The Upper Wonderfonteinspruit ends at the outflow of the Donaldson Dam, where a 1 m pipeline signifies the beginning of the Lower Wonderfonteinspruit. The Lower Wonderfonteinspruit is made up of the 1 m pipeline which extends approximately 30 km down the natural drainage path of the Wonderfonteinspruit.

    Agriculture, mining, Carletonville and surrounding towns and residential areas, and Agricultural Holdings dominate the catchment.

Approximately 33 Ml/day (33 000 m^3/day) is being discharged into the Wonderfonteinspruit from the K10 Shaft together with additional discharges of 20 Ml/d (20 000 m^3/day) from Cooke 1 Shaft.

It must be noted that over and above the 53 Ml/day entering the 1 m pipeline, on the Upper Wonderfonteinspruit there are discharges into the Wonderfonteinspruit of approximately 15 - 20 Ml/d from the Flip Human Waste Water Treatment Works, and on the Lower Wonderfonteinspruit, approximately 10 Ml/d is discharged directly into the 1 m pipeline from the Hannes van Niekerk WWTW. Therefore, total flows discharged to the Wonderfonteinspruit via the 1 m pipeline currently, amounts to 78 Ml/day (78 000 m^3/day).

During re-mining approximately 20 Ml/d (20 000 m^3/day) from K10 Shaft will be used within the RTSF process, together with 12 Ml/d from Cooke 1 Shaft, resulting in total discharges to the 1 m pipeline decreasing from 53 Ml/day (53 000 m^3/day) as a result of mine discharges to 21 Ml/d (21 000 m^3/day) as a result of an estimated 32 Ml/day (32 000 m^3/day) being used for the reclamation process.

Downstream flow gauging station C2H080 is used to record the current flows at the exit of the 1 m pipeline. The mentioned gauging station has a record length of over a year (January 2014 to February 2015). Current flows are measured to be 72 123 m^3/day on average. Decrease in flows in the Wonderfonteinspruit is expected to range between 37 to 55% at the outlet of the 1 m pipeline; and

- The Loopspruit also drains a small portion of surface water runoff from the Kloof mining area, eventually flowing westward into the Vaal River. Mining in upper reaches, agriculture and Potchefstroom located in the lower reaches dominate.

  Average flows in the Loopspruit is estimated to be around 5 463 m^3/day. There are no planned discharges or abstraction from the Loopspruit currently being considered.

- The Water quality parameters measured were compared against the following standards:
  - In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment;
  - South African National Standards (SANS) 241: 2015 drinking water standards; and
  - South African Water Quality Guidelines for Agricultural Use: Irrigation (DWAF, 1996.
- The In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment is the most stringent guideline and is used to compare the various water quality parameters.

The majority of the samples analysed for the baseline exceeded the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment.

The In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment are more stringent than the SANS 241:2015 drinking water quality standards. The surface water quality assessment thus represents a worst case scenario (use of strict Barrage WQO) as in-stream guidelines for smaller more impacted streams could potentially be less stringent for example, the new proposed RQOs for the Mooirivier allow for an EC of 110 mS/m (compared to Barrage value of 70 mS/m and sulfate values of 500 mg/L compared to the 200 mg/L for the Barrage. The in-stream guidelines for the Rietspruit in fact allows for an EC of 120 mS/m and sulfate of 500 mg/L.

- In general, Sulfate, Nitrate, Electrical Conductivity, Ammonia and Fluoride indicate high concentrations that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment at most sampling points as indicated in Table 7-9 and described below:
  - Sulfate displays high concentrations, above the mentioned In-Stream Guideline Limit (200 mg/L). Nitrate concentrations measured in the Driefontein and Kloof mining areas exceed 230 mg/L, with the In-Stream Guideline Limit listed as 6 mg/L;
  - High pH levels that exceed the In-Stream Water Quality Guidelines for the Vaal Barrage sub-catchment (<6.5 and > 8.5) were observed at sampling sites DSW9 and SW12;
  - Surface water runoff draining from the Ezulwini, Cooke 4 and the Kloof mining complexes ultimately report to sampling points SW03, L2, L3 and SW05. Monitoring point SW03 located downstream of the RTSF and associated infrastructure, on the Leeuspruit, indicated a high Sulfate concentration (417 mg/L), with existing mine sampling points L2 and L3 located on the upstream tributary of the Leeuspruit measuring Sulfate concentrations of 387 mg/L and 415 mg/L respectively. Sampling point SW05, located within the Kloof mining complex, on a tributary of the Leeuspruit, indicate a Sulfate concentration of 494 mg/L;
  - At the Driefontein mining complex, most of the water quality monitoring points was dry, however sampling sites SW08 and SW09, taken on the upstream and downstream tributary of the Wonderfonteinspruit indicate Sulfate concentrations of 362 mg/L and 372 mg/L respectively;
  - Water quality monitoring points LP004, LP005, LP006, LU014 and W12 indicate high concentrations of Nitrate, with the latter four exceeding 230 mg/L. Sampling points LP004, LP005 and LP006 drain a portion of the Kloof

and Driefontein mining areas, whilst LU014 and W12 drain a portion of the Kloof and Cooke mining areas; and

- When compared against the South African Water Quality Guidelines for Agricultural Use: Irrigation (Table 7-11), Manganese is the only chemical of concern with isolated exceedances of pH and Sodium also measured.

- Estimations of flow for the Leeuspruit, Wonderfonteinspruit, Klein Wes Rietspruit and the Loopspruit were obtained from existing flow data, or estimated based on catchment area and runoff characteristics as in the case of the Leeuspruit;
- Flows on the Leeuspruit can range from no flows during the dry season to a max of 24 593 m^3/day during the wet season. Current flows in the Wonderonteinspruit is estimated to be 72 123 m^3/day on average. Average flows in the Klein Wes Rietspruit is estimated to be 69 612 m^3/day. Average flows in the Loopspruit is estimated to be around 5 463 m^3/day;
- It is anticipated that the average Sulfate loads in the Leeuspruit will increase by approximately 70% due to the discharged water from the AWTF. The additional volume of water discharged from the AWTF will be treated to the design specifications of the treatment plant, which allows for Sulfur to be treated to a concentration of 350 mg/L. The additional flows from the AWTF will result in a decrease in concentration within the Leeuspruit of between 350 mg/L and 417 mg/L;
- Floodline assessment was undertaken for the section of the Leeuspruit located north of the RTSF and associated infrastructure, together with the unnamed tributary located south of the mentioned infrastructures. Flood modelling results show that the current placement of the RTSF and associated infrastructures lays outside of the 1:100 year floodline and the 100 m river buffer;
- The impact of additional flows being discharged into the Leeuspruit will have an overall positive impact on the river. Minor overflows along smaller dams located along the Leeuspruit may occur, due to the constant additional flow which may not necessarily have occurred during normal flow conditions. As a result, minor backing up of water may occur on the upstream side of these dams, this however will not impact the RTSF and associated infrastructures. The additional flows amount to approximately 0.1 m^3/s and is insufficient to impact the delineated floodlines for the section of the Leeuspruit. The treated water being discharged will have a positive impact, due to the additional dilution effect on the Leeuspruit, and because the quality of the treated water discharged is to fall within the discharge water quality specifications of the AWTF;
- Reduction in flows to the Wonderfonteinspruit is not characterised as a major impact as there is currently sufficient flows being discharged in the Wonderfonteinspruit that will cater for the reduction once re-mining has occurred. Due to the reduction in flows

(from 53 Ml/day to 21 Ml/day), there will be a decrease in salt loading on the Wonderfonteinspruit from 37% to 55%; and

- Currently salt loads reporting to the downstream section at the Rietspruit, after the confluence of the Leeuspruit, experiences an increase in salt loading. This is due to the 10 Ml/day being discharged to the Leeuspruit East, and the 60 Ml/day being discharged to the Klein Wes Rietspruit. Salt loads from these watercourses will eventually report to the mentioned monitoring location on the Rietspruit. During re-mining 15 Ml/day will be discharged from the AWTF together; however there will be a decrease in flows into the Klein Wes Rietspruit (20 Ml/day). Therefore in summary, salt loading will show a decrease on the Rietspruit; and
- The groundwater assessment (Digby Wells, 2015) indicated that seepage from the RTSF can negatively influence the groundwater quality in the underlying aquifers during the operational phase, if no mitigation is undertaken and also impact the streams. Once the plume reaches the streams, it can migrate at a faster rate compared to the speed of the groundwater flow and could have Medium to High impact on the down-gradient riverine ecosystem and communities. Mitigation is therefore required.

  Although the proposed blast curtain would be crucial to contain the pollution plume, it has a side effect since it will lower the water table from its natural position in the outer ring of the drain. Thus, the water quality impacts will be reduced, but the area/extent of the impact on the groundwater levels would increase.

  The average seepage rate from the RTSF (which is dependent on the permeability of the TSF material) is estimated to be 3.21×10^{-4} m/d (SRL, 2015). This is expected to last for up to 100 years after closure and it is only then the rate will start to decrease (assuming cover is in place). For the blast curtain to work effectively, it has to intercept at least 120% of the seeped water (i.e. 4,810 m^3/d). This is because the curtain is also draining from the outer periphery. The plume can escape away from the curtain if it is pumped at less than this.

  Dewatering the blast curtain will have a side effect in terms of lowering the water table around the periphery of the RTSF, outside the perimeter of the blast curtain drain. The predicted cone of dewatering at the end of operation extends across the Leeuspruit. Considering the shallow water level within the project area, the drawdown could be more than 25 m in some localities. Dewatering can potentially affect and reduce the flow rate of the Leeuspruit and its tributes, but water in the Leeuspruit flows much faster compared to the seepage rate through the stream floor and subsequently the stream flow won't be impacted significantly by the grout curtain dewatering activities.

The following is a summary of the recommendations

- It is recommended that surface water monitoring be undertaken post closure at the various watercourses so as to check for residual impacts;

- Electronic monitoring of slurry pressure and flow rate to identify burst pipelines as soon as possible should be undertaken;
- There should be an adequate stormwater management plan based on GN 704 requirements such that all clean and dirty water areas are maintained separate; and
- Hydrocarbon storage areas must be bunded and spill kits made available such that any hydrocarbon spillages can be cleaned up.
- Another option of impact mitigation (other than with a blast curtain) would be the use of a liner to minimise the infiltration of contaminants from the RTSF to the groundwater. However, if a liner is implemented without the removal of sulphides (using the acid plant), the runoffs that originate from the RTSF will be more acidic and dissolve heavy metals. This can affect the Leeuspruit negatively, unless the runoff is intercepted with a cut-off drain before it reaches the river. The water can then be treated by the AWTF before being discharged.

19 References

- Amendment of the EMP for COP undertaken by Digby Wells Environmental, April 2013.
- Daily Rainfall Extraction Utility, Version 1.4, Richard Kunz (ICFR), 2004.
- Development of an Integrated Water Quality Management Plan for the Vaal River System, Integration of Resource Water Quality Objectives, September 2009.
- Driefontein Gold Mine EMP, August 2011.
- Environmental Impact Report: Proposed Gold Fields West Wits Project, March 2010.
- Environmental Management Programme for the alignment with the DME requirements, March 2008.
- Food and Agriculture Organisation (FAO) of the United Nations, 2005, *"New LoClim - Local climate estimator"*.
- Golder Associates Africa (Pty) Ltd (Golder) undertook a surface water impact assessment report, 2009.
- IWWMPs, IWULAs and IWULs for Driefontein, August 2011.
- IWWMP for Kloof Gold Mine, April 2010.
- WRC (Water Research Commission) , 2009, "*Water Resources of South Africa, 2005 Study (WR2005)*", Water Research Commission, Pretoria.
- Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition, 1996.
- Integrated Water and Waste Management Plan for South Deep Gold Mine, June 2010.
- Kloof Gold Mine EMP; August 2011.

Appendix A: Curriculum Vitae

SIVAN DHAVER

Mr Sivan Dhaver

Unit Manager - Hydrology

Hydrologist

Digby Wells Environmental

1 EDUCATION

Qualification	:	BSc (Hons) Hydrology
Institution	:	University of Zululand
Date Completed	:	2004

Qualification	:	BSc Hydrology
Institution	:	University of Zululand
Date Completed	:	2003

2 LANGUAGE SKILLS

English : Excellent Speak, Read, Write

Afrikaans : Fair Speak, Read, Write

Zulu : Fair Speak, Read, Write

3 EMPLOYMENT

Period:	March 2015 to Date
Company:	Digby Wells Environmental, Republic of South Africa
Designation	Unit Manager - Hydrology

Period:	September 2013 to March 2015
Company:	SLR Consulting, Republic of South Africa
Designation	Senior Hydrologist

Period:	October 2008 to September 2013
Company:	SRK Consulting, Republic of South Africa/ Wales (UK)
Designation	Hydrologist/Senior Hydrologist
Period:	August 2006 to October 2008
Company:	Department of Water Affairs and Forestry, Republic of South Africa
Designation	Hydrologist
Period:	March 2005 to June 2005
Company:	ENGEOCON
Designation	Hydrologist

4 EXPERIENCE

Carried out BSc (Hons) project successfully which involved investigation of the efficiency of irrigation scheduling techniques by analysing climate and soil data on one of the resident farms located in the university.

Assisted lecturers at **UNIZUL** during my final year of study in 2004. Type of work included, soil texture analysis, borehole siting using Magnetometer, general hydrological field work such as measuring borehole water levels.

Began work in March 2005 and ended on June 2005 for **ENGEOCON** under conditions of temporary employment, my duties included carrying out of Percolation tests, collection of hydrocensus data, and borehole siting using magnetometer and **EM 34 geophysical equipment**.

Began work for **Department of Water Affairs and Forestry** in August 2006 until November 2008, as a **Hydrologist**. I worked in the sub directorate of hydrological information until July 2007. My duties included surface water modelling using programs such as **WRSM2000** and **WRYM**, Patching of rainfall data using **PATCHR** and **CLASSR** programs.

I then moved to the sub directorate of Integrated Water Resource Studies as of July 2007 until October 2008. My duties included assisting in various water resources related research projects.

I was involved in the following project before I left DWAF, "**The Impact of Land use on the Water Resources of the Eastern Cape region of South Africa using the ACRU model**".

Began work for **SRK Consulting** as a **Hydrologist/Senior Hydrologist** in 2008 until 2013. Within this period I spent nine months working in Cardiff in the SRK consulting (UK) office during 2012.

I then moved to **SLR Consulting** as a **Senior Hydrologist** during September 2013 up until March 2015.

Currently work for **Digby Wells Environmental** as of March 2015 – present, as a **Unit Manager** for the hydrological sciences discipline.

My consulting experience is listed below:

- Development of stormwater management plans for mines as per GN 704 of the National Water Act no 36 of 1998 specifically, Best Practice Guideline – G1: Storm Water Management published by DWAF.
- Stormwater management plans for urban developments.
- Conceptual sizing of stormwater infrastructure including sizing of canals, berms, culverts and storage facilities.
- Development of Water and Salt balances for mines as per GN 704 of the National Water Act no 36 of 1998 specifically, Best Practice Guideline – G2: Water and Salt Balance published by DWAF.
- Floodline delineations using the HEC-RAS hydraulic model.
- Surface water hydraulics.
- Baseline surface water specialist studies, including investigating catchment characteristics, estimation of peak flows, and the Mean Annual Runoff (MAR) of the project area, evaluation of climate data specifically the rainfall and evaporation data.
- Surface water impact assessment's regarding the development of mines and the subsequent impacts to the surface water resources by the respective mine.
- Surface water monitoring studies, involving installation of flow monitoring equipment, to determine the long term rainfall/runoff relationship for the respective catchment of concern.
- Surface water flow measurements along a river section using a ADCP (Acoustic Doppler Current Profiler) to validate stage discharge relationships at respective monitoring locations.

5 PROJECT EXPERIENCE

- **Hydrologist: CONGO MINING LIMITED (CML), Mayoko Baseline Study, THE REPUBLIC OF THE CONGO** Development of a surface water baseline study for Mayoko project. The study included the following: climate analysis, setting up of surface water monitoring network around the project area which involved installation of leveloggers for automatic river depth readings, undertaking a hydro census of nearby villages within close proximity to the project area, hydraulic modelling of existing bridges to obtain stage discharge relationship at respective locations along selected river locations. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Elemental Minerals Limited (ELM), Sintoukola Baseline Study, THE REPUBLIC OF THE CONGO** Characterisation of the surface water baseline scenario of the proposed project area. The study included the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points, establishment of surface water monitoring locations along the selected rivers, and analysis of the flow data from the respective sites, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Northlands Mines, Rautuvaara Surface Water Monitoring Site Selection and ADCP River Bed Survey, FINLAND** Obtaining the river bed profile for the Muonio River at respective sites upstream and downstream of the proposed effluent discharge point, whilst also providing appropriate surface water locations along the surrounding rivers. The study involved the following: undertaking of a desktop study to identify possible locations of surface water monitoring locations together with respective sites for the ADCP River Bed survey, undertake a detailed site visit to ground truth the desktop study whilst also making changes where necessary, determine the surface water monitoring locations on site, carry out the ADCP survey along the respective locations along the Muonio River, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Marampe Iron Ore Limited, Marampe Iron Ore Project: Water Baseline and Issue Evaluation Report, SIERRA LEONE** Development of a surface water baseline study for proposed Marampe Iron Ore Project. The study included the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points, surface water monitoring setup along the selected rivers and analysis of the flow data from these sites, flood line delineation, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Oracle Coalfields plc, Stormwater Management Plan for the Thariv Open Pit Mining Operations, PAKISTAN** Undertaking a stormwater management plan for the Thariv Open Pit. The study included the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points, conceptual sizing of upstream stormwater diversions, sizing of pump rate requirements at the various proposed sumps, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Volta Resources Inc, Kiaka Water Management Pre Feasibility Study, BURKINO FASO** Undertaking of a Pre-Feasibility Study for the Kiaka project which is made up of a Tailings Facility with an Open Pit, The project site is located 40 km upstream of the Bagre Dam on the right banks of the Nakambe River and the Koulipele River. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points, construction of draft water balance, flood elevation estimation of the Nakambe and Koulipele River, routing of the upstream peak flow through the Bagre Dam, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Hlohlwane Properties CC, 1 in 100 year Flood line for the Spaarwater Pan, SOUTH AFRICA** Routing of the 1 in 100 year peak flows through the Spaarwater Pan. The study required the following: climate data analysis, characterisation of the catchment hydrology for the Spaarwater Pan catchment, obtaining the peak 1 in 100 year flows, routing of flows through the Spaarwater Pan using the Level Pool Routing spreadsheet model. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: KLM Consulting Services, AK6 Stormwater management plan, SOUTH AFRICA** Undertaking of the stormwater management plan for AK6 mine shaft which include the following: climate data analysis, characterisation of the onsite hydrology, peak flow calculations at respective points of interest, conceptual sizing of stormwater infrastructure, construction of mine water balance which comprise sizing of the silt trap facilities, penstock decant pipeline, and return water dam capacity, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Dr Gary Jones, Laurentia Dam Flood Routing, SOUTH AFRICA D**etermining the maximum water elevation at the Laurentia Dam spillway. The above mentioned study included the following: climate analysis, delineation of the upstream catchment, determining the peak flow entering the Laurentia Dam, routing of the peak flow through the Laurentia Dam to obtain the maximum water elevation at the spillway, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Harmony Gold Mining Company, Evander South Surface Water Baseline Study, SOUTH AFRICA** Development of a surface water baseline study for proposed Evander South Gold mine. The study included the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Flood line delineation, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Eskom Holdings Limited, 1 in 100 year Flood line for the Kendal Ash Dump, SOUTH AFRICA** Routing of the 1 in 100 year peak flows through the adjacent watercourse of the Kendal Ash Dump. The study required the following: climate data analysis, characterisation of the catchment hydrology, obtaining the peak 1 in 100 year flows, routing of flows through the watercourse using the HEC RAS hydraulic program. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: ANGLO AMERICAN PLATINUM, Polokwane Smelter Water and Salt Balance, SOUTH AFRICA** Construction of a water and salt balance based for the Polokwane Smelter. The study includes the following: collection of climate data most specifically rainfall and evaporation, collection of flow data at various monitoring locations within the mine, collection of water quality data at various locations within the mine circuit, construction of the water and salt balance diagram using the process flow diagrams (pfd's) from the mine, development of a monthly time step water and salt balance that can be updated as the monthly climate, flow and water quality data is updated, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Mettle Properties Ltd, SWMP for the Proposed Township Development Olievenhoutbos Ext 42 and 43, SOUTH AFRICA** Development of a stormwater management plan for the proposed Olievenhoutbos urban development. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Conceptual sizing of pipe network, sizing of the attenuation ponds to capture surface water runoff, providing final design layout of the stormwater infrastructure indicating location of pipe network and attenuation ponds, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Consolidated Aone Trade & Invest 8 (Pty) Ltd, Stormwater Management Plan for Proposed Development at Crystal Park X57 and X58, SOUTH AFRICA** Development of a stormwater management plan for the proposed Crystal Park urban development. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Conceptual sizing of pipe network, Sizing of the attenuation ponds to capture surface water runoff, providing final design layout of the stormwater infrastructure indicating location of pipe network and attenuation ponds, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Rio Tinto, Chapudi Surface Water Baseline Study, SOUTH AFRICA** Development of a surface water baseline study for the proposed Chapudi coal mine. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Setting up of a surface water flow monitoring network and analysis of flow data from the respective locations. Flood line delineation, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: ROCKGATE CAPITAL CORP, Surface Water Study, MALI** Development of surface water monitoring network and mapping of road crossings along the mine access roads. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective road crossings. Establishment of a surface water monitoring network, obtain a stage discharge relationship at each of the monitoring sites, Provide recommendations on flood risk study including data required, Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: LTE CONSULTING, SWMP for the Sweetwaters development, SOUTH AFRICA** Development of a stormwater management plan for the proposed Sweetwaters urban development. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Conceptual sizing of pipe network, sizing of the attenuation ponds to capture surface water runoff, providing final design layout of the stormwater infrastructure indicating location of pipe network and attenuation ponds, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: ANGLO AMERICAN PLATINUM, Polokwane Smelter storm water audit, SOUTH AFRICA** Assessment of the existing stormwater infrastructure within the Polokwane smelter and providing conceptual design recommendations to meet regulation 704 of the National Water Act no 36 of 1998. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Calculating the water levels for the existing stormwater network based on the peaks obtained, verifying the required capacity of the mine storage facilities whilst ensuring they meet regulation 704 requirements, flood risk assessment, providing final design layout showing changes to stormwater infrastructure network if required, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: SASOL, Surface water baseline study for the Mafutha project, SOUTH AFRICA** Development of a surface water baseline report for the Sasol Mafutha Project which is a proposed open pit coal mine with a Coal to Liquid (CTL) facility, transport corridor together with a proposed new mine town. The study includes the following: climate analysis, catchment hydrology, mine water balance, flood risk assessment, surface water impact assessment, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: LTE CONSULTING, SWMP for the Lion Park development, SOUTH AFRICA** Development of a stormwater management plan for the proposed Lion Park urban development. The study includes the following: climate analysis, catchment delineation based on anticipated flow paths, calculation of peak flows at respective points. Conceptual sizing of pipe network, Sizing of the attenuation ponds to capture surface water runoff, providing final design layout of the stormwater infrastructure indicating location of pipe network and attenuation ponds, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: CHINA MIN METALS, The Naboom Surface Water Baseline Study, SOUTH AFRICA** Undertaking of a surface water baseline study for the project area which includes the following: analysis of regional and local climate, regional and local surface water hydrology characterisation, stormwater management plan based on the proposed infrastructure layout plan, surface water impact assessment for the project site, flood line delineation, Construction of water balance for the proposed mine, reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: DELF, Hydraulic Modelling of Bridges, MOZAMBIQUE** Routing of the 1 in 100 year peak flows through the proposed 10 bridges to determine if the bridge design is adequate. The study required the following: climate data analysis, characterisation of the catchment hydrology for each of the bridges contributing catchment area, obtaining the peak 1 in 100 year flows, routing of flows through the bridges using the HEC RAS hydraulic program. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: EXXARO, Arnot Colliery Stormwater Audit, SOUTH AFRICA** Undertaking of the stormwater audit for the mine which includes: climate data analysis, characterisation of the onsite hydrology, peak flow calculations at respective points of interest, surface water canal/channel sizing, routing of peak flow through mine storage dams, development of water balance for the mine storage dams, developing a stormwater audit report with the required compliances and non- compliances and providing the required recommendations if necessary.

- **Hydrologist: Taung Gold, Evander Surface Water Study, SOUTH AFRICA** Undertaking of the stormwater management plan for the mine which includes: climate data analysis, characterisation of the onsite hydrology, peak flow calculations at respective points of interest, surface water canal/channel sizing. The project also entailed undertaking a flood line assessment for the proposed location of the TSF and associated infrastructure. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Kudumane Manganese Resources (Pty) Ltd, Kudumane Surface Water Study, SOUTH AFRICA** Undertaking of climate data analysis, characterisation of the onsite hydrology, peak flow calculations at respective points of interest. Construction of a site wide water balance and a flood line assessment for the proposed location of the associated mine infrastructure. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: Taung Gold, Jeanette TSF Water Balance, SOUTH AFRICA** Development of a TSF water balance using Goldsim so as to size the return water dam (RWD) and estimate make up water requirements during the wet and dry periods of the year. Reporting of conclusions, whilst providing the necessary recommendations.

- **Hydrologist: EXXARO, Grootegeluk Surface Water Study, SOUTH AFRICA** Undertaking of the stormwater management plan for the mine which includes: climate data analysis, characterisation of the onsite hydrology, peak flow calculations at respective points of interest, surface water canal/channel sizing. The project also entailed development of a TSF water balance using Goldsim. Reporting of conclusions, whilst providing the necessary recommendations.

6 PROFESSIONAL AFFILIATIONS

None

7 PROFESSIONAL REGISTRATION

South African Council for Natural Scientific Professions (Pr Sci Nat) (400086/10)

8 PROFESSIONAL DEVELOPMENT

Currently registered at the **University of Witwatersrand** (Wits) undertaking the **Graduate Diploma in Engineering** (GDE) programme in Water Engineering.

9 PUBLICATIONS

None

Appendix B: Flood Study Results

RC2				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
2482	50 year	100.38	1572.3	2.21
2482	100 year	128.42	1572.42	2.18
2338	50 year	100.38	1571.75	1.11
2338	100 year	128.42	1571.84	1.25
2160	50 year	100.38	1571.71	0.32
2160	100 year	128.42	1571.79	0.38
2010	50 year	100.38	1571.7	0.19
2010	100 year	128.42	1571.77	0.23
1959	50 year	100.38	1571.7	0.17
1959	100 year	128.42	1571.77	0.21
1942	50 year	100.38	1571.7	0.17
1942	100 year	128.42	1571.77	0.21
1887		Culvert		
1857	50 year	100.38	1571.06	0.24
1857	100 year	128.42	1571.1	0.29
1848	50 year	100.38	1571.06	0.2
1848	100 year	128.42	1571.1	0.24
1841		Inl Struct		
1833	50 year	100.38	1569.28	1.22
1833	100 year	128.42	1569.36	1.32
1821	50 year	100.38	1569.2	1.01
1821	100 year	128.42	1569.28	1.11
1672	50 year	100.38	1568.52	1.04
1672	100 year	128.42	1568.59	1.11
1548	50 year	100.38	1567.99	1.58
1548	100 year	128.42	1568.05	1.65
1474	50 year	100.38	1567.59	1.56
1474	100 year	128.42	1567.65	1.64
1373	50 year	100.38	1566.99	1.39

1373	100 year	128.42	1567.05	1.43
1274	50 year	100.38	1566.4	1.43
1274	100 year	128.42	1566.44	1.5
1167	50 year	100.38	1565.83	1.55
1167	100 year	128.42	1565.89	1.54
1036	50 year	100.38	1564.99	1.89
1036	100 year	128.42	1565.1	2.01
986	50 year	100.38	1564.74	1.46
986	100 year	128.42	1564.83	1.56
828	50 year	100.38	1563.68	1.67
828	100 year	128.42	1563.77	1.77
787	50 year	100.38	1563.36	1.43
787	100 year	128.42	1563.44	1.55
746	50 year	100.38	1563.14	1.03
746	100 year	128.42	1563.21	1.13
676	50 year	100.38	1562.59	1.69
676	100 year	128.42	1562.67	1.73
563	50 year	100.38	1561.67	2.05
563	100 year	128.42	1561.78	2.16
406	50 year	100.38	1560.82	1.79
406	100 year	128.42	1560.95	1.86
266	50 year	100.38	1560.15	1.48
266	100 year	128.42	1560.23	1.67
148	50 year	100.38	1559.52	2.03
148	100 year	128.42	1559.58	2.05
58	50 year	100.38	1558.84	1.78
58	100 year	128.42	1558.9	1.87

RC5				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
876	50 year	354.19	1553.96	3.72
876	100 year	439.16	1554.23	4.07
856	50 year	354.19	1553.6	3.86
856	100 year	439.16	1553.77	4.36
820	50 year	354.19	1552.65	4.62
820	100 year	439.16	1552.98	4.57
802	50 year	354.19	1552.55	3.22
802	100 year	439.16	1552.88	3.36
771	50 year	354.19	1552.2	3.18
771	100 year	439.16	1552.5	3.52
748	50 year	354.19	1551.75	3.97
748	100 year	439.16	1552.1	4.06
715	50 year	354.19	1551.52	3.15
715	100 year	439.16	1551.84	3.4
697	50 year	354.19	1551.22	3.63
697	100 year	439.16	1551.51	4.01
667	50 year	354.19	1550.38	4.87
667	100 year	439.16	1550.65	5.14
636	50 year	354.19	1549.87	3.9
636	100 year	439.16	1550.08	4.26
609	50 year	354.19	1549.27	4.14
609	100 year	439.16	1549.53	4.31
590	50 year	354.19	1549.06	3.38
590	100 year	439.16	1549.34	3.48
540	50 year	354.19	1548.64	2.64
540	100 year	439.16	1548.91	2.88
524	50 year	354.19	1548.37	3.19
524	100 year	439.16	1548.63	3.42
474	50 year	354.19	1548.08	2.02

474	100 year	439.16	1548.32	2.23
454	50 year	354.19	1548	1.77
454	100 year	439.16	1548.24	1.95
427	50 year	354.19	1547.88	1.76
427	100 year	439.16	1548.11	1.95
406	50 year	354.19	1547.74	1.92
406	100 year	439.16	1547.96	2.11
372	50 year	354.19	1547.48	2.03
372	100 year	439.16	1547.67	2.27
342	50 year	354.19	1547.24	1.9
342	100 year	439.16	1547.41	2.1
318	50 year	354.19	1547.05	1.71
318	100 year	439.16	1547.21	1.88
278	50 year	354.19	1546.76	1.44
278	100 year	439.16	1546.91	1.6
251	50 year	354.19	1546.09	3.25
251	100 year	439.16	1546.19	3.41
196	50 year	354.19	1543.8	2.19
196	100 year	439.16	1543.95	2.43
160	50 year	354.19	1543.17	2.66
160	100 year	439.16	1543.32	2.82
124	50 year	354.19	1542.62	2.74
124	100 year	439.16	1542.76	2.88
95	50 year	354.19	1542.13	3.11
95	100 year	439.16	1542.29	3.18
59	50 year	354.19	1541.74	2.35
59	100 year	439.16	1541.91	2.47

RC8, RC9				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
1510	50 Year	22.9	1585.05	1.41
1510	100 Year	29.62	1585.1	1.54
1463	50 Year	22.9	1584.23	1.43
1463	100 Year	29.62	1584.29	1.55
1406	50 Year	22.9	1583.27	1.07
1406	100 Year	29.62	1583.32	1.21
1379	50 Year	22.9	1582.53	0.99
1379	100 Year	29.62	1582.56	1.15
1335	50 Year	22.9	1582	0.36
1335	100 Year	29.62	1582.03	0.42
1285	50 Year	22.9	1582.01	0.07
1285	100 Year	29.62	1582.04	0.09
1261		Culvert		
1228	50 Year	22.9	1579.79	1.41
1228	100 Year	29.62	1579.85	1.54
1166	50 Year	22.9	1578.85	1.37
1166	100 Year	29.62	1578.92	1.49
1105	50 Year	22.9	1577.73	1.95
1105	100 Year	29.62	1577.79	2.1
1062	50 Year	22.9	1577.01	1.34
1062	100 Year	29.62	1577.07	1.49
992	50 Year	22.9	1576.16	1.37
992	100 Year	29.62	1576.26	1.47
890	50 Year	22.9	1574.81	1.61
890	100 Year	29.62	1574.86	1.83
784	50 Year	22.9	1573.51	1.36
784	100 Year	29.62	1573.6	1.4
684	50 Year	22.9	1572.36	1.1
684	100 Year	29.62	1572.38	1.32

609	50 Year	22.9	1571.42	1.28
609	100 Year	29.62	1571.48	1.2
556	50 Year	22.9	1570.42	2.1
556	100 Year	29.62	1570.45	2.53
510	50 Year	22.9	1570.35	0.33
510	100 Year	29.62	1570.54	0.3
478	50 Year	22.9	1570.35	0.17
478	100 Year	29.62	1570.54	0.18
439	50 Year	22.9	1570.35	0.11
439	100 Year	29.62	1570.54	0.12
429	50 Year	22.9	1570.35	0.11
429	100 Year	29.62	1570.54	0.12
392		Culvert		
366	50 Year	22.9	1567.9	0.52
366	100 Year	29.62	1567.94	0.68
349	50 Year	22.9	1567.46	
349	100 Year	29.62	1567.51	0.19
231	50 Year	22.9	1565.37	1.53
231	100 Year	29.62	1565.43	1.66
201	50 Year	22.9	1565.18	1.07
201	100 Year	29.62	1565.24	1.17
171	50 Year	22.9	1564.76	1.64
171	100 Year	29.62	1564.81	1.77
1420	50 Year	114.24	1574.36	2.33
1420	100 Year	146.14	1574.49	2.57
1394	50 Year	114.24	1574.02	2.76
1394	100 Year	146.14	1574.15	2.98
1359	50 Year	114.24	1573.82	0.87
1359	100 Year	146.14	1573.95	1.07
1313	50 Year	114.24	1573.57	1.47
1313	100 Year	146.14	1573.7	1.61

1274	50 Year	114.24	1573.41	1.3
1274	100 Year	146.14	1573.53	1.41
1255	50 Year	114.24	1573.32	0.91
1255	100 Year	146.14	1573.44	0.99
1225	50 Year	114.24	1573.15	
1225	100 Year	146.14	1573.27	
1194	50 Year	114.24	1572.96	0.54
1194	100 Year	146.14	1573.07	0.48
1154	50 Year	114.24	1572.35	1.45
1154	100 Year	146.14	1572.42	1.64
1127	50 Year	114.24	1570.53	4.41
1127	100 Year	146.14	1570.63	4.57
1094	50 Year	114.24	1570.9	0.99
1094	100 Year	146.14	1570.99	1.16
1073	50 Year	114.24	1570.89	0.74
1073	100 Year	146.14	1570.98	0.88
1059	50 Year	114.24	1570.89	0.7
1059	100 Year	146.14	1570.97	0.83
1043	50 Year	114.24	1570.88	0.67
1043	100 Year	146.14	1570.96	0.79
1028		Culvert		
997	50 Year	114.24	1569.4	1.45
997	100 Year	146.14	1569.52	1.59
971	50 Year	132.74	1569.17	1.59
971	100 Year	169.05	1569.28	1.75
935	50 Year	132.74	1568.75	1.56
935	100 Year	169.05	1568.85	1.74
894	50 Year	132.74	1568.34	1.74
894	100 Year	169.05	1568.44	1.87
828	50 Year	132.74	1567.58	2.29
828	100 Year	169.05	1567.69	2.42

799	50 Year	132.74	1567.33	1.66
799	100 Year	169.05	1567.44	1.82
731	50 Year	132.74	1566.53	2.43
731	100 Year	169.05	1566.64	2.54
676	50 Year	132.74	1566.04	1.68
676	100 Year	169.05	1566.15	1.83
617	50 Year	132.74	1565.63	1.27
617	100 Year	169.05	1565.73	1.41
586	50 Year	132.74	1565.44	1.37
586	100 Year	169.05	1565.55	1.48
529	50 Year	132.74	1564.94	1.58
529	100 Year	169.05	1565.06	1.7
300	50 Year	132.74	1563.06	7.04
300	100 Year	169.05	1563.12	7.23
263	50 Year	132.74	1563.58	0.93
263	100 Year	169.05	1563.7	1.03
213	50 Year	132.74	1563.38	1.03
213	100 Year	169.05	1563.49	1.13
179	50 Year	132.74	1563.23	1.03
179	100 Year	169.05	1563.34	1.13
141	50 Year	132.74	1562.99	1.11
141	100 Year	169.05	1563.09	1.25
105	50 Year	132.74	1562.65	1.5
105	100 Year	169.05	1562.74	1.64

RC13, RC14				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
1146	50 year	104.2	1597.53	2.65
1146	100 year	133.39	1597.73	2.88
1095	50 year	104.2	1597	2.96
1095	100 year	133.39	1597.17	3.24
1046	50 year	104.2	1596.82	1.88
1046	100 year	133.39	1596.98	2.12
1007	50 year	104.2	1596.77	1.22
1007	100 year	133.39	1596.91	1.42
974	50 year	104.2	1596.73	1.12
974	100 year	133.39	1596.87	1.3
961	50 year	104.2	1596.68	1.51
961	100 year	133.39	1596.81	1.69
949		Culvert		
928	50 year	104.2	1595.01	2.82
928	100 year	133.39	1595.15	3.03
875	50 year	104.2	1594.57	2.28
875	100 year	133.39	1594.73	2.43
852	50 year	104.2	1594.39	2.2
852	100 year	133.39	1594.55	2.38
815	50 year	104.2	1594.1	1.96
815	100 year	133.39	1594.25	2.14
776	50 year	104.2	1593.76	2.02
776	100 year	133.39	1593.93	2.15
697	50 year	104.2	1593.4	1.48
697	100 year	133.39	1593.57	1.64
634	50 year	104.2	1593.06	1.7
634	100 year	133.39	1593.21	1.87
584	50 year	104.2	1592.83	1.48
584	100 year	133.39	1592.98	1.67

516	50 year	104.2	1592.16	2.3
516	100 year	133.39	1592.28	2.44
432	50 year	104.2	1590.96	2.27
432	100 year	133.39	1591.11	2.48
366	50 year	104.2	1590.01	3.15
366	100 year	133.39	1590.17	3.31
299	50 year	104.2	1588.79	3.38
299	100 year	133.39	1588.94	3.61
239	50 year	104.2	1588.2	2.09
239	100 year	133.39	1588.38	2.3
213	50 year	104.2	1587.98	2.39
213	100 year	133.39	1588.14	2.61
175	50 year	104.2	1587.77	1.77
175	100 year	133.39	1587.93	1.93
133	50 year	104.2	1587.1	3.23
133	100 year	133.39	1587.24	3.44
111	50 year	104.2	1586.51	3.24
111	100 year	133.39	1586.69	3.39
84	50 year	104.2	1586.17	2.54
84	100 year	133.39	1586.39	2.69
62	50 year	104.2	1585.57	3.69
62	100 year	133.39	1585.78	3.93
974	50 year	45.95	1595.13	1.82
974	100 year	59.31	1595.19	1.98
937	50 year	45.95	1594.64	1.62
937	100 year	59.31	1594.73	1.71
896	50 year	45.95	1594.37	1.1
896	100 year	59.31	1594.45	1.22
855	50 year	45.95	1593.82	1.8
855	100 year	59.31	1593.88	1.96
817	50 year	45.95	1593.32	0.89
817	100 year	59.31	1593.44	1

789	50 year	45.95	1593.3	0.74
789	100 year	59.31	1593.41	0.86
764	50 year	45.95	1593.29	0.59
764	100 year	59.31	1593.4	0.7
736	50 year	45.95	1593.28	0.56
736	100 year	59.31	1593.38	0.67
731	50 year	45.95	1593.27	0.6
731	100 year	59.31	1593.38	0.71
708		Culvert		
681	50 year	45.95	1591.44	2.46
681	100 year	59.31	1591.52	2.69
661	50 year	45.95	1591	2
661	100 year	59.31	1591.11	2.18
629	50 year	45.95	1590.52	2.11
629	100 year	59.31	1590.65	2.27
593	50 year	45.95	1590.02	2.29
593	100 year	59.31	1590.14	2.51
551	50 year	45.95	1589.18	2.52
551	100 year	59.31	1589.27	2.75
509	50 year	45.95	1588.29	1.96
509	100 year	59.31	1588.37	2.16
476	50 year	45.95	1587.5	2.42
476	100 year	59.31	1587.58	2.62
442	50 year	45.95	1586.89	2.05
442	100 year	59.31	1587	2.25
406	50 year	45.95	1586.16	2.68
406	100 year	59.31	1586.27	2.85
375	50 year	45.95	1585.28	2.77
375	100 year	59.31	1585.36	3.06
275	50 year	104.2	1583.58	7.8
275	100 year	133.39	1583.67	8.3

233	50 year	104.2	1583.61	3.15
233	100 year	133.39	1583.77	3.54
183	50 year	104.2	1583.21	2.46
183	100 year	133.39	1583.35	2.71
136	50 year	104.2	1582.67	2.66
136	100 year	133.39	1582.81	2.81
90	50 year	104.2	1582.31	1.5
90	100 year	133.39	1582.45	1.68
26	50 year	104.2	1581.76	2.16
26	100 year	133.39	1581.88	2.32

RC15, RC16, RC17				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
1141	50 year	175.68	1557.14	2.82
1141	100 year	223.6	1557.24	3.01
1065	50 year	175.68	1556.02	2.58
1065	100 year	223.6	1556.14	2.72
991	50 year	175.68	1555.37	1.89
991	100 year	223.6	1555.5	2.04
929	50 year	175.68	1554.69	2.08
929	100 year	223.6	1554.82	2.25
758	50 year	175.68	1552.47	9.11
758	100 year	223.6	1552.54	9.2
707	50 year	175.68	1552.83	2
707	100 year	223.6	1552.95	2.23
672	50 year	175.68	1552.26	2.75
672	100 year	223.6	1552.38	2.75
451	50 year	175.68	1550.82	1.36
451	100 year	223.6	1550.06	9.74
335	50 year	175.68	1549.99	2.55
335	100 year	223.6	1550.1	2.66
259	50 year	175.68	1549.31	1.74
259	100 year	223.6	1549.43	1.87
186	50 year	175.68	1548.87	1.61
186	100 year	223.6	1548.99	1.73
52	50 year	175.68	1547.82	1.82
52	100 year	223.6	1547.92	1.97
2096	50 year	40.96	1574.24	2.11
2096	100 year	52.88	1574.29	2.28
2044	50 year	40.96	1573.29	1.38
2044	100 year	52.88	1573.38	1.5
2004	50 year	40.96	1573.07	0.9

2004	100 year	52.88	1573.16	1
1938	50 year	40.96	1572.25	1.38
1938	100 year	52.88	1572.33	1.66
1892	50 year	40.96	1571.86	0.93
1892	100 year	52.88	1571.99	0.93
1881	50 year	40.96	1571.7	1.48
1881	100 year	52.88	1571.93	0.95
1793	50 year	40.96	1571.65	0.2
1793	100 year	52.88	1571.95	0.21
1790	50 year	40.96	1571.65	0.2
1790	100 year	52.88	1571.95	0.21
1785	50 year	40.96	1571.65	0.2
1785	100 year	52.88	1571.95	0.21
1780	50 year	40.96	1571.65	0.19
1780	100 year	52.88	1571.95	0.19
1743	50 year	40.96	1571.64	0.66
1743	100 year	52.88	1571.93	0.73
1694	50 year	40.96	1571.49	0.55
1694	100 year	52.88	1571.77	0.63
1633	50 year	40.96	1571.39	0.45
1633	100 year	52.88	1571.64	0.52
1605		Bridge		
1572	50 year	40.96	1569.01	0.88
1572	100 year	52.88	1569.33	0.96
1510	50 year	40.96	1568.42	0.9
1510	100 year	52.88	1568.73	0.98
1437	50 year	40.96	1567.62	0.93
1437	100 year	52.88	1567.92	1.01
1366	50 year	40.96	1566.95	0.76
1366	100 year	52.88	1567.23	0.85
1256	50 year	40.96	1564.88	1.5

1256	100 year	52.88	1565.03	1.65
1136	50 year	40.96	1562.53	1
1136	100 year	52.88	1562.58	1.11
998	50 year	40.96	1560.85	1.4
998	100 year	52.88	1560.91	1.48
874	50 year	40.96	1559.48	
874	100 year	52.88	1559.57	0.31
779	50 year	40.96	1558.2	1.1
779	100 year	52.88	1558.25	1.27
670	50 year	40.96	1557.05	1.05
670	100 year	52.88	1557.12	1.12
535	50 year	40.96	1555.54	1.91
535	100 year	52.88	1555.58	2.08
357	50 year	40.96	1553.41	0.97
357	100 year	52.88	1553.55	1.16
238	50 year	40.96	1552.58	1.88
238	100 year	52.88	1552.62	2.05
1332	50 year	36.74	1670.74	1.91
1332	100 year	47.46	1670.81	1.98
1252	50 year	36.74	1669.04	1.76
1252	100 year	47.46	1669.1	1.97
1143	50 year	36.74	1666.56	1.59
1143	100 year	47.46	1666.63	1.72
1051	50 year	36.74	1664.71	1.7
1051	100 year	47.46	1664.77	1.89
974	50 year	36.74	1663.08	1.65
974	100 year	47.46	1663.13	1.75
905	50 year	36.74	1661.17	1.38
905	100 year	47.46	1661.2	1.54
824	50 year	36.74	1658.6	1.93
824	100 year	47.46	1658.66	2.04

751	50 year	36.74	1656.65	1.5
751	100 year	47.46	1656.69	1.62
642	50 year	36.74	1654.06	1.32
642	100 year	47.46	1654.11	1.44
543	50 year	36.74	1651.76	1.46
543	100 year	47.46	1651.82	1.62
429	50 year	36.74	1649.89	1.58
429	100 year	47.46	1649.96	1.69
342	50 year	36.74	1648.11	2.33
342	100 year	47.46	1648.19	2.51
256	50 year	36.74	1646.15	2.12
256	100 year	47.46	1646.23	2.29
186	50 year	36.74	1644.57	2.19
186	100 year	47.46	1644.64	2.38
108	50 year	36.74	1642.52	2.15
108	100 year	47.46	1642.58	2.31
6310	50 year	120.51	1649.61	2.73
6310	100 year	154.02	1649.72	2.92
6221	50 year	120.51	1648.15	2.25
6221	100 year	154.02	1648.29	2.44
6105	50 year	120.51	1646.47	2.51
6105	100 year	154.02	1646.6	2.73
6004	50 year	120.51	1644.67	2.84
6004	100 year	154.02	1644.81	3.04
5903	50 year	120.51	1642.89	2.81
5903	100 year	154.02	1643.02	3.08
5801	50 year	120.51	1640.94	2.44
5801	100 year	154.02	1641.07	2.68
5618	50 year	120.51	1637.21	10.76
5618	100 year	154.02	1637.27	10.79
5567	50 year	120.51	1636.81	2.11
5567	100 year	154.02	1636.94	2.3

5486	50 year	120.51	1635.88	2.25
5486	100 year	154.02	1635.99	2.44
5422	50 year	120.51	1634.84	1.84
5422	100 year	154.02	1634.94	2.05
5363	50 year	120.51	1633.84	1.89
5363	100 year	154.02	1633.93	2.07
5260	50 year	120.51	1632.41	2.21
5260	100 year	154.02	1632.53	2.35
5121	50 year	120.51	1630.3	2.6
5121	100 year	154.02	1630.41	2.84
5004	50 year	120.51	1628.77	2.22
5004	100 year	154.02	1628.91	2.33
4893	50 year	120.51	1627.44	2.36
4893	100 year	154.02	1627.56	2.62
4780	50 year	120.51	1625.92	2.3
4780	100 year	154.02	1626.07	2.42
4663	50 year	120.51	1623.9	3.42
4663	100 year	154.02	1624.05	3.71
4579	50 year	120.51	1622.31	2.47
4579	100 year	154.02	1622.54	2.66
4472	50 year	120.51	1620.67	3.28
4472	100 year	154.02	1620.86	3.53
4392	50 year	120.51	1619.22	2.51
4392	100 year	154.02	1619.46	2.69
4332	50 year	120.51	1618.67	2.51
4332	100 year	154.02	1619.02	2.56
4250	50 year	120.51	1618.27	0.16
4250	100 year	154.02	1618.66	0.17
4167	50 year	120.51	1617.74	0.42
4167	100 year	154.02	1618.15	0.46
4088	50 year	120.51	1615.92	0.43

4088	100 year	154.02	1616.26	0.47
4058	50 year	120.51	1614.74	0.63
4058	100 year	154.02	1615.05	0.68
4040		Inl Struct		
4028	50 year	120.51	1614.73	0.45
4028	100 year	154.02	1615.05	0.47
4019	50 year	120.51	1614.48	0.47
4019	100 year	154.02	1614.79	0.5
4013	50 year	120.51	1614.29	0.52
4013	100 year	154.02	1614.61	0.54
4004	50 year	120.51	1614.02	0.44
4004	100 year	154.02	1614.36	0.45
3995	50 year	120.51	1613.8	0.38
3995	100 year	154.02	1614.15	0.4
3983	50 year	120.51	1613.54	0.4
3983	100 year	154.02	1613.9	0.41
3955	50 year	120.51	1612.96	0.45
3955	100 year	154.02	1613.34	0.47
3943	50 year	120.51	1612.74	0.39
3943	100 year	154.02	1613.13	0.41
3924	50 year	120.51	1612.44	0.36
3924	100 year	154.02	1612.84	0.37
3817	50 year	120.51	1610.83	0.42
3817	100 year	154.02	1611.23	0.46
3765	50 year	120.51	1609.99	0.43
3765	100 year	154.02	1610.35	0.46
3652	50 year	120.51	1606.87	0.73
3652	100 year	154.02	1607.16	0.77
3548	50 year	120.51	1603.67	3.32
3548	100 year	154.02	1603.8	3.6
3433	50 year	120.51	1600.65	4.16

3433	100 year	154.02	1600.74	4.19
3343	50 year	120.51	1598.68	2.69
3343	100 year	154.02	1598.83	2.88
3227	50 year	120.51	1596.76	3.44
3227	100 year	154.02	1596.92	3.65
3117	50 year	120.51	1595.15	2.09
3117	100 year	154.02	1595.28	2.28
3019	50 year	120.51	1593.59	2.97
3019	100 year	154.02	1593.69	3.16
2965	50 year	120.51	1592.68	2.08
2965	100 year	154.02	1592.76	2.41
2898	50 year	120.51	1591.47	3.58
2898	100 year	154.02	1591.8	3.38
2771	50 year	120.51	1589.33	1.93
2771	100 year	154.02	1589.47	2.11
2671	50 year	120.51	1587.96	2.5
2671	100 year	154.02	1588.06	2.72
2582	50 year	120.51	1586.32	1.93
2582	100 year	154.02	1586.5	2.18
2488	50 year	120.51	1585.94	1.37
2488	100 year	154.02	1586.09	1.5
2421	50 year	120.51	1585.56	1.81
2421	100 year	154.02	1585.7	1.97
2353	50 year	120.51	1584.79	2.23
2353	100 year	154.02	1584.89	2.47
2308	50 year	120.51	1584.56	1.36
2308	100 year	154.02	1584.68	1.45
2195	50 year	120.51	1583.88	0.77
2195	100 year	154.02	1582.84	2.94
2113	50 year	120.51	1582.75	0.97
2113	100 year	154.02	1582.95	1.02

1935	50 year	120.51	1579.93	0.8
1935	100 year	154.02	1580.18	0.88
1855	50 year	120.51	1578.4	1.27
1855	100 year	154.02	1578.66	1.36
1776	50 year	120.51	1577.24	0.82
1776	100 year	154.02	1577.51	0.89
1731	50 year	120.51	1576.76	0.91
1731	100 year	154.02	1577.02	1
1710	50 year	120.51	1576.5	0.9
1710	100 year	154.02	1576.74	1.01
1669	50 year	120.51	1574.82	2.28
1669	100 year	154.02	1575.01	2.5
1642	50 year	120.51	1574.7	1.29
1642	100 year	154.02	1574.86	1.46
1627	50 year	120.51	1574.66	1.41
1627	100 year	154.02	1574.81	1.6
1568	50 year	120.51	1574.08	1.38
1568	100 year	154.02	1574.19	1.66
1532	50 year	120.51	1573.41	2.31
1532	100 year	154.02	1573.44	2.85
1513	50 year	120.51	1573.46	0.81
1513	100 year	154.02	1573.52	1
1505	50 year	120.51	1573.44	1.23
1505	100 year	154.02	1573.5	1.47
1502	50 year	120.51	1573.43	1.06
1502	100 year	154.02	1573.49	1.28
1499	50 year	120.51	1573.45	0.55
1499	100 year	154.02	1573.52	0.67
1498	50 year	120.51	1573.45	0.52
1498	100 year	154.02	1573.52	0.65
1495	50 year	120.51	1573.46	0.34
1495	100 year	154.02	1573.53	0.44

1482		Bridge		
1458	50 year	120.51	1571.43	4.27
1458	100 year	154.02	1571.52	3.56
1370	50 year	120.51	1570.79	1.26
1370	100 year	154.02	1570.89	1.45
1306	50 year	120.51	1569.71	1.98
1306	100 year	154.02	1569.8	2.19
1239	50 year	120.51	1568.78	0.98
1239	100 year	154.02	1568.86	1.16
1163	50 year	120.51	1567.71	1.05
1163	100 year	154.02	1567.8	1.24
1119	50 year	120.51	1567.18	1.47
1119	100 year	154.02	1567.25	1.64
1048	50 year	120.51	1566.11	0.66
1048	100 year	154.02	1566.18	0.87
924	50 year	120.51	1564.6	1.1
924	100 year	154.02	1564.68	1.17
803	50 year	120.51	1562.67	2.57
803	100 year	154.02	1562.74	2.67
702	50 year	120.51	1560.97	2.03
702	100 year	154.02	1561.1	2.19
624	50 year	120.51	1560.08	2.27
624	100 year	154.02	1560.21	2.46
522	50 year	120.51	1558.97	2.03
522	100 year	154.02	1559.08	2.19
394	50 year	120.51	1557.49	2.18
394	100 year	154.02	1557.6	2.34
265	50 year	120.51	1556.32	1.87
265	100 year	154.02	1556.41	2.01
199	50 year	120.51	1555.3	1.64
199	100 year	154.02	1555.37	1.84

RC19 and RC26				
Cross section	Profile	Q (m^3/s)	Water Elevation (m)	Velocity (m/s)
12996	50 year	149.2	1540.45	1.48
12996	100 year	190.4	1540.53	1.61
12829	50 year	149.2	1539.23	1.44
12829	100 year	190.4	1539.31	1.56
12739	50 year	149.2	1538.38	1.71
12739	100 year	190.4	1538.46	1.85
12573	50 year	149.2	1537.22	1.24
12573	100 year	190.4	1537.34	1.36
12400	50 year	149.2	1536.06	1.59
12400	100 year	190.4	1536.13	1.78
12316	50 year	149.2	1535.3	1.56
12316	100 year	190.4	1535.39	1.62
12139	50 year	149.2	1534.42	1.1
12139	100 year	190.4	1534.5	1.23
11985	50 year	149.2	1533.56	1.39
11985	100 year	190.4	1533.66	1.42
11896	50 year	149.2	1533.37	0.71
11896	100 year	190.4	1533.45	0.82
11775	50 year	149.2	1532.82	1.77
11775	100 year	190.4	1533.02	1.37
11667	50 year	149.2	1532.44	0.75
11667	100 year	190.4	1532.94	0.59
11535	50 year	149.2	1532.41	0.4
11535	100 year	190.4	1532.92	0.4
11342	50 year	149.2	1532.4	0.26
11342	100 year	190.4	1532.91	0.26
11240		Bridge		
11136	50 year	254.38	1528.1	1.95
11136	100 year	333.74	1528.26	2.15

10985	50 year	254.38	1526.91	1.94
10985	100 year	333.74	1527.04	2.16
10836	50 year	254.38	1525.65	1.88
10836	100 year	333.74	1525.78	2.03
10650	50 year	254.38	1524.62	1.48
10650	100 year	333.74	1524.75	1.62
10376	50 year	254.38	1522.91	1.88
10376	100 year	333.74	1523.03	2.01
10130	50 year	254.38	1521.53	1.2
10130	100 year	333.74	1521.64	1.33
9832	50 year	254.38	1519.43	1.54
9832	100 year	333.74	1519.56	1.73
9530	50 year	254.38	1517.76	1.12
9530	100 year	333.74	1517.87	1.26
9248	50 year	254.38	1516.05	1.84
9248	100 year	333.74	1516.17	1.93
9051	50 year	254.38	1515	1.28
9051	100 year	333.74	1515.12	1.41
8384	50 year	254.38	1512.05	1.21
8384	100 year	333.74	1512.16	1.33
7940	50 year	254.38	1510.51	1.02
7940	100 year	333.74	1510.64	1.12
7552	50 year	254.38	1508.64	1.88
7552	100 year	333.74	1508.78	1.98
7254	50 year	254.38	1507.18	0.92
7254	100 year	333.74	1507.33	1.06
6869	50 year	254.38	1506.01	1.38
6869	100 year	333.74	1506.15	1.45
6560	50 year	254.38	1505.03	1.23
6560	100 year	333.74	1505.16	1.35
6376	50 year	254.38	1504.22	1.58
6376	100 year	333.74	1504.32	1.73

6018	50 year	254.38	1502.68	1.34
6018	100 year	333.74	1502.81	1.41
5469	50 year	254.38	1500.9	0.98
5469	100 year	333.74	1501.09	0.97
4907	50 year	254.38	1499.22	1.35
4907	100 year	333.74	1499.37	1.5
4480	50 year	254.38	1497.6	1.65
4480	100 year	333.74	1497.75	1.75
4084	50 year	254.38	1496.19	1.1
4084	100 year	333.74	1496.34	1.19
3451	50 year	254.38	1494.08	1.49
3451	100 year	333.74	1494.22	1.59
3153	50 year	254.38	1492.79	1.3
3153	100 year	333.74	1492.89	1.46
2750	50 year	254.38	1491.38	1.12
2750	100 year	333.74	1491.58	1.16
2482	50 year	254.38	1490.41	1.5
2482	100 year	333.74	1490.39	2.04
2107	50 year	254.38	1489.04	1.31
2107	100 year	333.74	1489.47	1.06
1866	50 year	254.38	1488.95	0.47
1866	100 year	333.74	1489.42	0.45
1599	50 year	254.38	1488.93	0.29
1599	100 year	333.74	1489.41	0.3
1434		Bridge		
1268	50 year	254.38	1486.22	0.96
1268	100 year	333.74	1486.33	1.06
636	50 year	254.38	1483.92	1.11
636	100 year	333.74	1484.06	1.15
414	50 year	254.38	1482.85	1.66
414	100 year	333.74	1482.99	1.8