DIGBY WELLS ENVIRONMENTAL

Mining Permit Application for the De Groote Boom Project

Surface Water Impact Assessment

Project Number:

UAR2967

Prepared for:

De Groote Boom Minerals (Pty) Ltd

April 2015

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Name	**Responsibility**	**Signature**	**Date**
Andy Pirie	Report Writer		April 2015
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EXECUTIVE SUMMARY

Introduction

Digby Wells Environmental (hereafter Digby Wells) has been requested by De Groote Boom Minerals (Pty) Ltd (hereafter De Groote Boom), to compile and submit an Environmental Management Plan (EMP), pursuant to an application for a mining permit, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) to the Limpopo Department of Mineral Resources (DMR), to mine chromite (chrome ore and all associated minerals) on the farm De Grooteboom 373 KT, near Steelpoort in Limpopo province.

The Mining Permit Application has been accepted by the Regional Manager, Limpopo Region, of the DMR under Reference LP 10656 MP and De Groote Boom has been instructed to prepare an EMP, which will include various specialist investigations, and a Public Participation Process (PPP). The surface water impact assessment report will form one of the specialist investigations, and will be incorporated into the EMP report.

Methodology

The surface water assessment was carried out in three phases namely:

- A desktop study to characterize the site, identify water sampling points and to conduct hydrological characterization, site characterisation, catchment and water use description. The catchment attributes namely Mean Annual Runoff (MAR), Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) were obtained from the WR2005 manual/database. Storm rainfall depths were obtained from the closest rainfall station for the 1:50 and 1:100 year recurrence intervals, using the Design Rainfall programme (Smithers and Schulze, 2003);
- A site visit to assess the site characteristics and collect surface water quality samples. Upstream and downstream surface water quality locations were sampled; and
- Report compilation including the following:
  - Water quality baseline status benchmarked against the South African National Standard (SANS) 241-1:2011 drinking water standards;
  - Potential impacts identification, rating pre- and post-mitigation for a list of anticipated project activities;
  - Recommendation of mitigation measures to minimise or reduce impacts on the surface water quantity and quality;
  - Development of a surface water quality monitoring programme indicating monitoring points, frequency of monitoring, database management and reporting; and

- Documentation of the (SWMP) developed for the study area.

Baseline Hydrology

Baseline hydrology can be summarised as follows:

- The De Groote Boom study area is located within the Olifants Water Management Area (WMA 4) and within quaternary catchments B41G and B41H, with majority of the study area falling within quaternary catchment B41G. Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) for B41G was determined to be 650 mm and 1261 mm respectively, and was adopted to represent the site.
- A number of non-perennial streams drain the mountain where the infrastructure and open cut mining is planned and may potentially be impacted as a result of the project. These non-perennial streams were found to be seasonal and only likely to flow after rainfall.
- The land cover of the site and surrounding area is bushveld, with a number of operational mines located in the Dwars River valley.
- The study area has gentle slopes of between 0° and 8°, with steeper slopes occurring near the top of the mountain.
- Slopes within the study area were dominated by shallow rocky soils of the type Mispah / Glenrosa, while the flatter areas were dominated by the deeper well drained Hutton soils.
- Surface water within quaternary catchments B41G and B41H was mostly used for mining according to the Water Authorisation Registration and Management System (WARMS).
- Surface water quality within the Groot Dwars and Dwars Rivers was found to good, with all analysed parameters within the SANS 241-1:2011 limits.

Environmental Impact Assessment

Significant impacts to surface water include the following:

- Removal of vegetation and topsoil exposes the soil, leaving it prone to soil erosion which may cause siltation of water resources.
- Storage of diesel and other hazardous substances onsite has the potential to spill and contaminate water resources.
- Water management: channels, pipelines and PCD should be appropriately sized and maintained to avoid spills.

- Haul roads used by heavy machinery has the potential to deteriorate causing erosion and subsequent siltation of water resources. Storm water structures need to be implemented and roads regularly maintained.
- Rehabilitation of the site is extremely important, and should rehabilitation not take place, then long term impacts on surface water resources may be the result.

Surface Water Monitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure that monitoring is implemented to cover all mining activity areas. Recommended monitoring sites are shown in Table 7. Water quality parameters that need to be analysed are shown in Table 8.	-Monthly during construction. - Reduce to quarterly on rehabilitated areas. - This can further be reduced to biannually (wet and dry season). -Monitoring needs to carry on three years after the project has ceased, as is standard practice to detect residual impacts.	Specialist Environmental Quality
Water quantity	Flow monitoring should be carried out in channels and pipelines and at facilities on site. Monitoring water levels in dams and channels. Records of Pit dewatering	-Instantaneous where automatic flow meters are in place for real time measurements. -Where there are no automatic flowmeters weekly monitoring needs to be done. -In operational areas, daily records need to be kept	Specialist Environmental Quality
Physical structures and SWMP performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions. Dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.	Continuous process and yearly formal report	Specialist Environmental Quality
Meteorological data	Measure rainfall	Real time system if in place	Sampler
Rehabilitation	Perform and monitor continuous rehabilitation sites	Continuous	Specialist Environmental Quality

Conceptual Storm Water Management Plan (SWMP)

The SWMP is detailed in section 9. It provides a conceptual plan to manage onsite storm water as well as channel and PCD sizing.

Conclusion

Mining is proposed near the top of a mountain and it is extremely important that the SWMP outlined in this report is followed to prevent pollution of water resources. Water quality of the surrounding streams was found to be good and a stringent water monitoring programme should be followed as outlined in this report. The impact assessment showed that most impacts were minor (negative) and that mitigation can reduce these impacts to negligible (negative). Should responsible mining take place, and the SWMP plan and water monitoring programme be thoroughly implemented and mitigation measures followed, then from a surface water perspective, the impacts on the surface water environment are likely to be negligible.

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1 Introduction

Digby Wells Environmental (hereafter Digby Wells) has been appointed by De Groote Boom (Pty) Ltd (hereafter De Groote Boom), to compile and submit an Environmental Management Plan (EMP), pursuant to an application for a mining permit, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) to the Limpopo Department of Mineral Resources (DMR).

The Mining Permit Application has been accepted by the Regional Manager, Limpopo Region, of the DMR under Reference LP 10656 MR and De Groote Boom has been instructed to prepare an EMP, which will include various specialist investigations, and a Public Participation Process (PPP). The surface water impact assessment report will form one of the specialist investigations, and will be incorporated into the EMP report.

This report provides a baseline hydrological description of the study area, monitoring programme, surface water impact assessment and conceptual storm water management plan.

1.1 Project Location

The study area is located in the Greater Tubatse local municipality, within the Sekhukhune district municipality of the Limpopo Province (Plan 1, Appendix A). Steelpoort is the closest recognisable settlement located 22 kilometres (km) north-east of the study area, while Lydenburg being the largest town in the region is located 33 km south-east of the project area.

1.2 Project Background

De Groote Boom currently holds an approved Prospecting Right valid for three years (with the right to take a Bulk Sample) and it now proposes to mine primarily chromite (chrome ore and all associated minerals) on the farm De Grooteboom 373 KT. It is possible that after completing work under the mining permit, De Groote Boom will commence with full scale mining of chromite (chrome ore and all associated minerals) in terms of a mining right that would be applied for at that stage.

Mining will be undertaken by open cut methods and the ore will be transported to a portable plant for crushing and screening. The ore will be stockpiled and then transported off site by truck. The mining permit area and related infrastructure areas are depicted in Plan 2, Appendix A.

2 Legislation

The specialist surface water assessment complies with South African legislation for environmental authorisations, most specifically the National Water Act (NWA), 1998 (Act No. 36 of 1998).

3 Terms of Reference

The surface water assessment detailed in this report is based on the following terms of reference:

- A site visit to assess the site and to collect water samples for determination of the baseline surface water quality. The baseline surface water quality will be benchmarked against the South African National Standard (SANS) 241: 2011 drinking water standards;
- Identification of surface water impacts for the study area for the construction, operational and decommissioning phases of the project, whilst also providing the necessary mitigation measures required;
- A recommended surface water monitoring programme indicating the variables to be analysed, frequency of analyses, data management and reporting; and
- A conceptual Storm Water Management Plan (SWMP) as prescribed by the Best Practice Guideline (BPG) G1: Storm Water Management (DWS, 2006) of the NWA, was prepared for the proposed infrastructure.

4 Methodology

The surface water assessment was carried out in three phases namely:

- A desktop study to characterize the site, identify water sampling points and to conduct hydrological characterization, site characterization, catchment and water use description. The catchment attributes namely Mean Annual Runoff (MAR), Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) were obtained from the WR2005 manual/database. Storm rainfall depths were obtained from the closest rainfall station for the 1:50 and 1:100 year recurrence intervals, using the Design Rainfall programme (Smithers and Schulze, 2003);
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- Report compilation including the following:
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  - Potential impacts identification, rating pre- and post-mitigation for a list of anticipated project activities;
  - Recommendation of mitigation measures to minimise or reduce impacts on the surface water quantity and quality;

- Development of a surface water quality monitoring programme indicating monitoring points, frequency of monitoring, database management and reporting; and
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5 Baseline Hydrology

5.1 Climate

The Water Resources Manual of South Africa (WR2005, 2012) was used to obtain rainfall and evaporation data described in the sections below.

5.1.1 Rainfall

The study area falls primarily within the B41G quaternary catchment (WR2005, 2012). The corresponding monthly rainfall for the mentioned quaternary catchment is summarised in Table 1.

Table 1: Monthly Rainfall for the Study Area

Month	Monthly Rainfall (mm)
January	111.5
February	88.3
March	75.5
April	41.8
May	14.8
June	6.2
July	5.2
August	5.8
September	20.6
October	60.0
November	111.7
December	108.7
TOTAL	**650**

From Table 1, it can be seen that the mean annual precipitation (MAP) for the study area is 650 mm, with the wettest months occurring from November to January, and the driest months from June to August.

5.1.2 Evaporation

The evaporation obtained from the WR2005 manual/database is based on Symons pan evaporation measurements and needs to be converted to Lake evaporation. This is due to the Symons pan being located below the ground surface, and painted black which results in the temperature in the water being higher than of a natural open water body. The Symons pan is then multiplied by a lake evaporation factor to obtain the adopted lake evaporation. Table 2 is a summary of the evaporation figures for the project site.

Table 2: Monthly Evaporation for the Study Area

Month	Symonds Pan Evaporation (mm)	Evaporation Factor	Lake Evaporation (mm)
January	165.0	0.84	138.6
February	137.6	0.88	121.0
March	135.8	0.88	119.5
April	104.4	0.88	91.9
May	87.9	0.87	76.5
June	71.4	0.85	60.7
July	78.2	0.83	64.9
August	103.5	0.81	83.8
September	134.1	0.81	108.6
October	161.7	0.81	131.0
November	152.6	0.82	125.1
December	168.0	0.83	139.4
TOTAL	**1500**	**N/A**	**1261**

From Table 2 it can be seen that the mean annual evaporation (MAE) for the study area is 1261 mm, with the highest monthly evaporation occurring from October to March, whilst during April to September lower monthly evaporation is observed.

5.1.3 Temperature and Wind

Wind and temperature was obtained from the Loclim programme (FAO, 2005). The method selected to obtain the wind and the temperature data is based on the nearest neighbour method for which the user defines the search radius and number of stations selected. Table 3 is the output from the Loclim programme showing the summary of the temperature and wind speed data representative of the project site, which is based on interpolation from a maximum of 10 nearest stations.

Table 3: Temperature and Wind Speed for the Study Area

Month	Average Temperature (ºC)	Minimum Temperature (ºC)	Maximum Temperature (ºC)	Average Wind Speed (km/hour)
January	20	14.3	26.1	6.48
February	19.7	14.3	23.8	6.48
March	18.7	13.3	24.3	6.12
April	16.7	10	24.3	5.4
May	13.5	5.5	22.2	6.12
June	11	2.2	20	7.2
July	10.8	2.7	20	7.2
August	13.1	4.4	22.2	7.92
September	15.6	7.8	24.3	9.72
October	18	10.6	25.5	9.72
November	18.7	12.8	25.5	9.72
December	19.7	13.8	26.1	7.92

5.2 Affected Quaternary Catchments

South Africa is divided into 19 water management areas (WMA) (National Water Resource Strategy, 2004), managed by its separate water board. 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 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) to name a few.

The De Groote Boom study area is located within the Olifants Water Management Area (WMA 4) and within quaternary catchments B41G and B41H, with majority of the study area falling within quaternary catchment B41G (Plan 3, Appendix A).

The quaternary catchment characteristics are summarised in Table 4.

Table 4: Quaternary Catchment Characteristics

Quaternary Catchment	Catchment Area (km^2)	Rainfall Zone	MAP (mm)	MAR $m^3 x 10^6$	Evaporation Zone	MAE (mm)
B41G	442	B4B	650	25.46	4A	1500
B41H	410	B4B	610	6.7	4A	1500

5.3 Drainage Systems

Six non-perennial streams drain the mountain where the infrastructure and open cut mining is planned and may potentially be impacted as a result of the project (Plan 4, Appendix A). All potentially impacted, non-perennial streams were found to be dry during a site visit conducted in April 2015, with the exception of the northern most non-perennial stream which contained stagnant pools of water near its confluence with the Dwars River. This indicated that these non-perennial streams were seasonal and flowed only after a rainfall event.

The southernmost branch of non-perennial streams drains the proposed mining area into the Springkaanspruit, which was found to be flowing at the time of the site visit. The Springkaanspruit then flows into the Groot Dwars River which then in turn flows into the Dwars River. The non-perennial streams to the west and north of the mining area drain into the Dwars River, after the confluence of the Groot Dwars and Klein Dwars Rivers. The Dwars River then flows into the Steelpoort River which then flows into the Olifants River and finally into the Limpopo River in Mozambique where it discharges into the Indian Ocean.

5.4 Vegetation and Land Cover

The study area falls mostly within the Sekhukhune Mountain Bushveld with vegetation characterised as open and closed broad leafed savannah on hills and mountain slopes (Mucina & Rutherford, 2006). Figure 1 provides an indication of this type of vegetation.

According to the Land Cover 2009 (SANBI, 2009) (Plan 5, Appendix A), majority of the affected quaternary catchments are natural, with cultivated and degraded areas occurring to the northwest, where built-up areas also occur. A number of operational mines are located along the Klein and Groot Dwars Rivers, within close proximity to the proposed project. These include the Dwars River Mine, Two Rivers Mine and the Tweefontein Mine, where chrome and platinum are predominantly mined.

Figure 1: A photograph of the vegetation of the study area looking from the mining area downslope towards proposed location of the PCD

5.5 Topography

The topography of the study area and surrounds is undulating with numerous mountain ridges and valleys. The topographical model indicates that the elevation of the study area decreases from 1369 metres above mean sea level (m.a.m.s.l.) in the north-east to 938 m.a.m.s.l. in the south-west. The elevation of the mining area ranges from 1087 m.a.m.s.l. to 1348 m.a.m.s.l.

The majority of the study area has gentle slopes ranging from between 0° and 8°. Slopes of between 9° and 17° occur in some areas. The steepest slopes occur on the ridges and range from 18° to 58°. The mining area is located on a ridge and has isolated slopes of between 0° and 19°. The majority of slopes in the mining area are between 20° and 47°.

The study area and surroundings have an undulating topography. There are ridges which run along the eastern side of the prospecting area. Ridges also occur in the south-west of the prospecting area along the banks of the Groot Dwars River, together with a ridge in the north-eastern part of the study area. The mining permit area is located on this ridge in the north-western part of the prospecting area.

5.6 Soils

The accompanying soil assessment study (Digby Wells, 2015) found that the mining area and adjacent slopes within the study area was dominated by shallow rocky soils of the type Mispah / Glenrosa, while the flatter infrastructure area where the workshop and stockpile are to be located was dominated by the deeper well drained Hutton soils.

5.7 Surface Water Uses

The Water Authorisation Registration and Management System (WARMS) is a national register of water users that assists the DWS with billing and provides valuable information on how much water is being used by different registered water users. Information pertaining to surface water uses for quaternary catchments B41G and B41H was received from DWS on the 2 April 2015 and is summarised in Table 5.

Table 5: Summary of Surface Water Uses for Quaternary Catchments B41G and B41H

Quaternary Catchment	Registered Water Use	No. of Registered Users	Registered Volumes (m^3/year)	Sources of Water Used
B41G	Agriculture: Irrigation	5	2,318,400	River / stream and wetland
B41G	Mining	6	4,202,695	River / stream and dam
B41H	Agriculture: Irrigation	3	811,360	River / stream
B41H	Mining	4	3,074,327	Dam
B41H	Industry (Urban)	1	294,846	River / stream

Table 5 indicates that mining uses almost double the amount of registered surface water in quaternary catchment B41G when compared to agricultural irrigation, whilst in quaternary catchment B41H, mining uses more than three times the amount of registered surface water when compared to agricultural irrigation.

Plan 6, Appendix A indicates that surface water use for mining is concentrated to the west of the study area along the Klein Dwars, Groot Dwars and Dwars Rivers. Agricultural irrigation is concentrated further away from the study area to the west of quaternary catchments B41H and B41G.

5.8 Storm Rainfall Depths

The design storm rainfall depths were obtained from the design rainfall software (Smithers and Schulze, 2003). The programme is able to extract the storm rainfall depths for various recurrence intervals for the six closest rainfall stations. The rainfall stations and storm rainfall depths for the study area are shown under Section 9.3 of this report.

5.9 Surface Water Quality

5.9.1 DWS Surface Water Quality Database

Surface water quality data was obtained from the DWS National Water Management System database on 4 February 2015 (DWS, 2015) and is shown in Table 6. All DWS monitoring points had missing data for the various measured parameters and only B4H9 had data for the year 2014. Water quality parameters exceeding the SANS 241-1:2011 limits for the maximum allowable limit are highlighted in red in Table 6. The locations of DWS monitoring points are indicated in Plan 7, Appendix A.

From Table 6, it can be seen that magnesium exceeded the maximum allowable limit at L32 (exceeded on 6 occasions) and L29 (exceeded on 7 occasions), and fluoride exceeded the limit at L29 (exceeded on 1 occasion).

Table 6: Minimum and Maximum Water Quality Data for the DWS Monitoring Points

Monitoring Point	Years Monitored	Total Dissolved Solids (mg/L)		Chlorides as Cl (mg/L)		Total Alkalinity as $CaCO_3$ (mg/L)		Sulphate as SO_4 (mg/L)		Calcium as Ca (mg/L)		Magnesium as Mg (mg/L)		Sodium as Na (mg/L)		Potassium as K (mg/L)		Conductivity at 25° C (mS/m)		pH-Value at 25° C (pH units)		Fluoride as F (mg/L)	
(Aesthetic water quality - recommended)		<1200		<300		N/S		<250		<150		<70		<200		<50		<170		5-9.5		<1	
(Drinking water quality - maximum allowable limit)		2400		600		N/S		500		300		100		400		100		370		4-5 or 9.5-10		1.5	
Exposure Duration (years)		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs		70yrs	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
L77	1	419	419	8	8	213	213	7	26	35	35	52	52	11	11	1	1	27.9	57.6	7.9	8.7	0.1	0.1
B4H9	37	94	596	2	63	47	357	2	42	6	56	3	64	1	50	0	6	10.6	88.5	6.7	9.0	0.0	0.7
L32	7	166	401	4	85	97.3	222	2	78.3	18.3	94	15.1	167	1	14.3	0.4	1.82	23.7	56	7.48	8.67	0.01	0.2
L29	7	217	497	6	260	122	378	2	495	21.7	91	18.6	194	6.88	231	0.45	19.4	26	216	6.9	8.72	0.01	2.2

5.9.2 April 2015 Surface Water Quality Sampling

Water samples were taken on a site visit conducted on 15 April 2015 at the locations in Table 7 and indicated in Plan 7, Appendix A.

Table 7: Surface Water Quality Sampling Sites

Sampling Site	Latitude*	Longitude*
SW01	-24.955136º	30.127525º
SW02	-24.928317º	30.108428º
SW03	-24.909045º	30.105407º
SW04	-24.899137º	30.108821º
SW05	-24.888259º	30.112105º
SW06	-24.884455º	30.112247º

*All coordinates in geographic (latitude and longitude) coordinate system, WGS 1984 datum

The water samples were collected as grab samples and were submitted to Aquatico Laboratories (Pty) Ltd, a South African National Accreditation System (SANAS) laboratory for analysis. The water quality results were compared to the South African National Standards (SANS) 241-1:2011 for drinking water quality. Table 8 indicates the results.

Results indicated good water quality in terms of SANS 241-1:2011 at all sampling sites with all analysed parameters well within the aesthetic and maximum allowable limits for drinking water quality.

Table 8: Water Quality Results for Samples taken on the 15 April 2015 compared to the SANS 241-1:2011 Drinking Water Standards

Sampling Point	Total Dissolved Solids (mg/L)	Nitrate NO_3 as N (mg/L)	Chlorides as Cl (mg/L)	Total Alkalinity as $CaCO_3$ (mg/L)	Sulphate as SO_4 (mg/L)	Calcium as Ca (mg/L)	Magnesium as Mg (mg/L)	Sodium as Na (mg/L)	Potassium as K (mg/L)	Iron as Fe (mg/L)	Manganese as Mn (mg/L)	Conductivity at 25° C (mS/m)	pH-Value at 25° C (pH units)	Aluminium as Al (mg/L)	Fluoride as F (mg/L)	Total Hardness (mg/L)
(Aesthetic water quality - recommended)	<1200	<10	<300	N/S	<250	<150	<70	<200	<50	<0.3	<0.1	<170	5-9.5	<0.3	<1	200
(Drinking water quality - maximum allowable limit)	2400	11	600	N/S	500	300	100	400	100	2	0.5	370	4-5 or 9.5-10	0.5	1.5	300
Exposure Duration (years)	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs	70yrs
SW01	109	1.14	2.77	98	5.64	17.9	12.6	4.67	0.72	0.004*	0.002*	21.5	8.51	0.002*	0.21*	97
SW02	121	1.90	3.63	103	6.78	18.6	14.6	5.05	0.73	0.004*	0.002*	23.1	8.35	0.002*	0.21*	107
SW03	130	1.71	3.64	114	5.93	21.1	15.1	5.77	0.74	0.004*	0.002*	24.6	8.31	0.002*	0.21*	115
SW04	137	1.89	3.22	122	5.64	22.0	15.9	6.30	0.75	0.004*	0.002*	25.0	8.28	0.002*	0.21*	120
SW05	142	2.46	3.72	123	6.56	21.6	15.8	7.23	0.72	0.004*	0.002*	26.2	8.32	0.002*	0.21*	119
SW06	137	2.35	9.85	104	7.16	21.5	16.0	7.52	0.77	0.004*	0.002*	26.6	8.29	0.002*	0.21*	120

*Less than the specified value

6 Environmental Impact Assessment

6.1 Methodology

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

Significance = Consequence x Probability

Where

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

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

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

The weight assigned to the various parameters for positive and negative surface water impacts is provided for in the formula and is presented in Table 9. The probability consequence matrix for surface water impacts is displayed in Table 10, with the impact significance rating described in Table 11.

Table 9: Surface Water Impact Assessment Parameter Ratings

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

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
5	Very serious, long-term environmental impairment of ecosystem function that may take several years to rehabilitate. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment.	Province/ Region Will affect the entire province or region.	Project Life The impact will cease after the operational life span of the Project.	Likely The impact may occur.
4	Serious medium term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense social benefits to some people. Average to intense environmental enhancements.	Municipal Area Will affect the whole municipal area.	Long term 6-15 years.	Probable Has occurred here or elsewhere and could therefore occur.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts (Type of Impact = -1)	***Positive Impacts (Type of Impact = +1)***			
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements.	Medium term 1-5 years.	Unlikely Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur.
2	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by very few of population.	Limited Limited to the site and its immediate surroundings.	Short term Less than 1 year.	Rare/ improbable Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures.

Rating	Intensity		Spatial scale	Duration	Probability
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
1	Limited damage to minimal area of low significance that will have no impact on the environment. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level social and environmental benefits felt by very few of the population.	Very limited Limited to specific isolated parts of the site.	Immediate Less than 1 month.	Highly unlikely/None Expected never to happen.

Table 10: Probability Consequence Matrix for Social and Heritage Impacts

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

Table 11: Significance Threshold Limits

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

Score	Description	Rating
-109 to -147	A very serious negative impact which may be sufficient by itself to prevent implementation of the Project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects.	Major (negative)

6.2 Project Activities

The project entails a construction phase, operational phase and possibly a decommissioning phase. The decommissioning phase will only be applicable if the project does not prove to be viable in which case a mining right will not be applied for.

Project activities that would trigger a surface water impact are highlighted in red in Table 12 and are grouped in the impact rating tables under section 6.3 according to similar resultant surface water impacts.

Table 12: Project Activities

Activity	Description
Construction phase	
1	Augmenting existing roads.
2	Construction of pollution control dam (PCD).
3	Transport of construction material, mobile plant and equipment to the site; and movement of haul trucks and excavator on haul roads.
4	Storage of material / diesel at site in temporary facilities.
5	Site clearing and topsoil removal for mining operation area; and construction of mining cut.
6	Preparing an area of approximately 2-3 ha for portable plant and infrastructure (crushing, screening, workshops, ablution and offices etc.) and stock piling.
7	Use of existing drilled / new boreholes.
Operational phase	
8	Storage of fuel and lubricants in temporary facilities.
9	Topsoil removal and stockpiling; and extraction and transportation of ore.
10	Vehicular activity on haul roads; and operation of mining equipment.
11	Crushing and screening of ore in mobile plant.
12	Stockpiling material.
13	Water management.
14	Waste generation and disposal (including sewage).

Activity	Description
Decommissioning phase	
15	Demolition / removal of portable and related infrastructure (if applicable).
16	Vehicular activity: removal of mobile plant / equipment and vehicles.
17	Rehabilitation of site (As per surface use agreement roads, buildings etc. need not be rehabilitated).

6.3 Impact Rating

6.3.1 Construction Phase

Activity 1: Augmenting existing roads. **Activity 5: Site clearing and topsoil removal for mining operation area; and construction of mining cut.**					
Criteria	**Details / Discussion**				
Description of impact	■ Augmenting existing roads and the removal of vegetation and/or topsoil during excavation exposes the soil, leaving it prone to erosion which causes siltation of the surrounding surface water resources. Polluted surface water resources have reduced availability for downstream water users.				
Mitigation required	■ Removal of topsoil should be done systematically, only clearing the necessary areas at a time. ■ Clean and dirty surface water channels should be constructed to divert runoff separately to appropriate storage dams (dirty water to the PCD to avoid eroded soils entering the clean water areas).				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-2	5	-40
Post-Mitigation	3	2	-2	4	-28

Activity 2: Construction of pollution control dam (PCD). **Activity 6: Preparing an area of approximately 2-3 ha for portable plant and infrastructure (crushing, screening, workshops, ablution and offices etc.) and stock piling.**					
Criteria	**Details / Discussion**				
Description of impact	■ The construction of infrastructure exposes the surface water to the following impacts: ▪ Poorly designed and constructed pollution control dams and other water management facilities pose a threat to the surface water quality if leakage of contaminated water reports to the surrounding water bodies. ▪ The stockpiles will pose a source of sediment material that can be washed off to the streams and rivers. ▪ Concrete and other impervious surfaces prevent surface water from infiltrating the soil and will increase runoff.				
Mitigation required	■ Dirty water channels that divert the water to the pollution dams should be constructed surrounding the infrastructure area and initial box cut. ■ The topsoil stockpiles should be vegetated as soon as possible to prevent erosion, which might cause siltation of the water resources.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-2	4	-32
Post-Mitigation	3	2	-2	4	-28

Activity 3: Transport of construction material, mobile plant and equipment to the site; and movement of haul trucks and excavator on haul roads. **Activity 4: Storage of material / diesel at site in temporary facilities.**	
Criteria	**Details / Discussion**
Description of impact	■ The potential impact will arise from potential spillages during transport of construction material, hazardous substances and hydrocarbon containing fuels and lubricants to site. These can be mobilised to surface water resources, resulting in water contamination. ■ Storage of hazardous substances and diesel onsite has the potential to spill and contaminate water resources.
Mitigation required	■ Ensure that spillage control kits are available during transport and on storage sites in case of any accidental leakages of spillages, which can then be cleared immediately. ■ The temporary storage facilities of fuel, lubricants and explosives must be a hard

	park, roofed and bunded facility. This will prevent contamination of soils and the possibility of contamination of the surface water resources.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-4	4	-44
Post-Mitigation	3	2	-2	3	-21

6.3.2 Operational Phase

Activity 8: Storage of fuel and lubricants in temporary facilities.					
Criteria	**Details / Discussion**				
Description of impact	■ The potential impact will arise from the mobilization of leaked/spilled contaminants (hazardous and hydrocarbon containing material) from surface to the surrounding surface water resources. The leakages could have arisen from the use of the fuels, lubricants or from the storage facilities. This could have an impact on the quality of water.				
Mitigation required	■ Ensure that spillage control kits to contain the spillages of the contaminants from point of spillage are available on-site. ■ The temporary storage facilities for fuel, lubricants and explosives must be a hard park, roofed and bunded facility. This will prevent contamination of soils and the possibility of contamination of the surface water resources.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-4	4	-44
Post-Mitigation	3	2	-2	3	-21

<table>
<tr><th colspan="6">Activity 9: Topsoil removal and stockpiling; and extraction and transportation of ore.
Activity 12: Stockpiling material.</th></tr>
<tr><th>Criteria</th><th colspan="5">Details / Discussion</th></tr>
<tr><td>Description of impact</td><td colspan="5">▪ Topsoil removal and the extraction of ore expose the soil and rock, leaving it prone to erosion which causes siltation of the surrounding surface water resources. Polluted surface water resources have reduced availability for downstream water users.
▪ Runoff from stockpiled materials has the potential to contaminate water resources.</td></tr>
<tr><td>Mitigation required</td><td colspan="5">▪ Removal of topsoil and ore should be done systematically, only clearing the necessary areas at a time.
▪ Dirty water channels should be constructed around the stockpiled and mining permit area to divert runoff from entering clean water areas (dirty water to the PCD to avoid eroded soils entering the clean water areas).</td></tr>
<tr><td>Parameters</td><td>Duration</td><td>Spatial</td><td>Intensity</td><td>Probability</td><td>Significant rating</td></tr>
<tr><td>Pre-Mitigation</td><td>3</td><td>3</td><td>-3</td><td>5</td><td>-45</td></tr>
<tr><td>Post-Mitigation</td><td>3</td><td>2</td><td>-2</td><td>4</td><td>-28</td></tr>
</table>

Activity 10: Vehicular activity on haul roads; and operation of mining equipment.					
Criteria	**Details / Discussion**				
Description of impact	▪ Heavy vehicle activity is likely to have an impact the topography of the haul roads. If not maintained, roads may deteriorate during the rainy season as a result of water erosion causing siltation of the surrounding surface water resources. ▪ Mining equipment that is not serviced and maintained correctly has the potential leak hydrocarbons and hazardous substances, and may potentially pollute water resources.				
Mitigation required	▪ Haul roads should be regularly contoured. ▪ Appropriate culverts and drains should be implemented and regularly maintained to deal with surface water runoff on haul roads. ▪ Ensure mining equipment is regularly serviced and maintained.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-2	5	-40
Post-Mitigation	3	2	-2	4	-28

Activity 13: Water management.					
Criteria	**Details / Discussion**				
Description of impact	▪ A potential channel spill or pipeline burst could result in dirty pit water contaminating surface water runoff. ▪ PCDs can also have a negative impact if they are not well lined, if they crack and seep water or overflow in the event of extreme rainfall to the surface and underground.				
Mitigation required	▪ Channels and pipelines need to be appropriately sized. ▪ The design, construction, maintenance and operation of the PCD that form part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level and should be able to contain a 1:50 year recurrence, 24-hour storm event. ▪ Maintenance of water structures is essential to ensure efficient operation and identification of potential issues before they arise.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	4	-4	5	-55
Post-Mitigation	3	2	-2	4	-28

Activity 14: Waste generation and disposal (including sewage).	
Criteria	**Details / Discussion**
Description of impact	▪ Temporary storage of waste material before collection for disposal may result in leakages which could potentially contaminate water resource or a wetland. ▪ Sewage treatment plant system failure may result in overflows or leakages into the surface water bodies onsite.
Mitigation required	▪ Ensure that there is no discharge or leakage on the sewage treatment plant, septic tank or French drain system by monitoring and maintenance of the system. ▪ Measures should be in place to reduce system blockages through usage control and educating employees on the best ways to use the system. ▪ The temporary storage facilities waste materials must be a hard park, roofed and bunded facility. This will prevent contamination of soils and the possibility of contamination of the surface water catchment on site when storm water runoff deposits the contaminated soils into the dam.

Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-3	5	-45
Post-Mitigation	3	2	-2	4	-28

6.3.3 Decommissioning Phase

Activity 15: Demolition / removal of portable and related infrastructure (if applicable).					
Criteria	**Details / Discussion**				
Description of impact	▪ The potential impact will arise during demolition of infrastructure, where mobilization of contaminants such as fuels containing hydrocarbons, waste, explosives, PCD material to the surface water resources resulting in the contamination of those resources.				
Mitigation required	▪ Accredited contractors must be used for disposal and transport of demolition material. ▪ Ensure that spillage control kits to contain the contaminants from point of spillage are available on-site.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-3	5	-45
Post-Mitigation	2	2	-2	4	-24

Activity 16: Vehicular activity: removal of mobile plant / equipment and vehicles.					
Criteria	**Details / Discussion**				
Description of impact	■ Heavy vehicle activity used during the decommissioning phase is likely to have an impact on the topography of the roads. If not maintained, roads may deteriorate during the rainy season as a result of water erosion causing siltation of the surrounding surface water resources.				
Mitigation required	■ Roads should be regularly contoured and road infrastructure (e.g. culverts) maintained.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	3	3	-2	5	-40
Post-Mitigation	3	2	-2	4	-28

Activity 17: Rehabilitation of site (As per surface use agreement roads, buildings etc. need not be rehabilitated).					
Criteria	**Details / Discussion**				
Description of impact	■ Rehabilitation will have a positive impact on the water quantity and quality of the disturbed site. However, should rehabilitation not take place, then long term impacts on surface water resources may result.				
Enhancement required	■ Disturbed areas should be contoured and vegetated to allow for good drainage. ■ Where rehabilitation (grass seeding of topsoil cover) is not effective, the associated soil erosion should be mitigated by installing silt traps. ■ To complement the rehabilitation process, water quality monitoring should be implemented until 3 years post closure, so as to capture any negative residual impacts that could surface years later.				
Parameters	*Duration*	*Spatial*	*Intensity*	*Probability*	*Significant rating*
Pre-Mitigation	7	5	-7	6	-114
Post-Mitigation	6	3	+3	6	72

7 Cumulative Impacts

Water quality sampling and DWS monitoring data indicated that water quality is good along the Groot Dwars and Dwars Rivers with most parameters within the SANS 241-1:2011 drinking water quality standards except for elevated magnesium and fluoride levels at two of the DWS monitoring sites. This is attributed to the undeveloped natural land cover that is still present in many areas in the upper catchments of the Klein and Groot Dwars Rivers, and that many of the mines in the catchment are underground mines with few impacts directly to the surface water. However, it is likely that in the future mining will increase within the Dwars River valley which may impact not only the Dwars River, but the Steelpoort River and ultimately the highly impacted Olifants River. The increasing mines are also likely to have an impact on the surface water quantity (flow and volume) of the aforementioned rivers.

This however can be controlled to an extent through the implementation of mitigation measures presented in this report, and ensuring zero discharge for dirty water.

8 Surface Water Monitoring Programme

A monitoring programme is essential as a management tool to detect negative impacts as they arise and to ensure that the necessary mitigation measures are implemented. It also ensures that storm water management structures are in working order. Monitoring should be implemented throughout the life of the mine. The impacts on water quality will be determined by comparing the monitoring data against the SANS 241-1:2011 drinking water quality standards. Water quality monitoring is recommended at the locations provided in Table 7 and indicated in Plan 7, Appendix A.

The surface water monitoring plan is detailed in Table 13.

Table 13: Surface Water Monitoring Programme

Monitoring Element	Comment	Frequency	Responsibility
Water quality	Ensure that monitoring is implemented to cover all mining activity areas. Recommended monitoring sites are shown in Table 7. Water quality parameters that need to be analysed are shown in Table 8.	-Monthly during construction. - Reduce to quarterly on rehabilitated areas. - This can further be reduced to biannually (wet and dry season). -Monitoring needs to carry on three years after the project has ceased, as is standard practice to detect residual impacts.	Specialist Environmental Quality
Water quantity	Flow monitoring should be carried out in channels and pipelines and at facilities on site.	-Instantaneous where automatic flow meters are in place for real time measurements.	Specialist Environmental Quality

Monitoring Element	Comment	Frequency	Responsibility
	Monitoring water levels in dams and channels. Records of Pit dewatering	-Where there are no automatic flowmeters weekly monitoring needs to be done. -In operational areas, daily records need to be kept	
Physical structures and SWMP performance	Personnel should have a walk around facilities to determine the facilities conditions and pick out any anomalies such as leaks or overflows and system malfunctions.	Continuous process and yearly formal report	Specialist Environmental Quality
	Dams are inspected for silting and blockages of inflows, pipelines for hydraulic integrity; monitor the overall SWMP performance.		
Meteorological data	Measure rainfall	Real time system if in place	Sampler
Rehabilitation	Perform and monitor continuous rehabilitation sites	Continuous	Specialist Environmental Quality

9 Conceptual Storm Water Management Plan (SWMP)

9.1 Introduction

Mining operations have the potential to impact upon the baseline condition of an area in the following ways:

- Bulk earthworks which will strip vegetation and expose top soils and sub-soils to erosion by storm water thereby increasing levels of suspended solids within local watercourses and water features; and
- Discharge of polluted or improperly treated storm water into local watercourses or water features.

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

The aim of this conceptual storm water management plan is to mitigate the above impacts by fulfilling the requirements of the National Water Act (Act 36 of 1998) and more particularly GN 704.

The following definitions from GN 704 are appropriate to the classification of catchments and design of storm water management measures at the De Groote Boom study area:

- **Clean water system:** includes any dam, other forms of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted (clean) water;
- **Dam:** includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. dirty water);
- **Dirty area:** means any area at a mine or ***activity*** which causes, has caused or is likely to cause pollution of a water resource;
- **Dirty water system:** This includes any dirty water diversions bunds, channels, pipelines, dirty water dams or other forms of impoundment, and any other structure or facility constructed for the retention or conveyance of water containing waste (i.e. dirty water); and
- **Activity:** means any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported.

9.2 Overview of the Conceptual Storm Water Management Plan

Based on the current mine infrastructure layout a series of measures relating to clean water diversion and dirty water containment is proposed. A summary of these findings are listed below:

- Three clean water diversion channels are required to capture and convey runoff from the upstream clean water environment to either the nearest watercourse/drainage path or the downstream environment.
- A single pollution control dam (PCD) is required to capture any dirty water runoff emanating from the proposed plant area.

9.3 Storm Rainfall Depths

The design storm rainfall depths were obtained from the design rainfall software (Smithers and Schulze, 2003). The programme is able to extract the storm rainfall depths for various recurrence intervals for the six closest rainfall stations as shown in Table 14.

Table 14: Summary of the Six Closest Rainfall Stations

Station Name	SAWS Number	Distance (km)	Record Length (Years)	Mean Annual Precipitation (mm)	Altitude (mamsl)
MARTENSHOOP (POL)	0593419 W	13	90	689	1365
GA-SEKHUKHUNELAND	0593015 W	22	78	552	1260
BEETGESKRAAL	0554516 W	23.1	44	749	1689
DE GROOTBOOM	0593586 W	28.5	52	551	834
KLIPFONTEIN	0593778 W	32.6	63	674	1231
DERDEGELID (POL)	0593306 W	32.8	44	582	845

The adopted storm rainfall depth to be used in the peak flow calculations is based on the storm rainfall depths for the above closest station to the project site (Martenshoop (POL) – 0593419 W). The summary of the rainfall depths for the 1 day storm duration for various recurrence intervals are shown in Table 15.

Table 15: Adopted Storm Rainfall Depths for the Study area

Duration	Rainfall Depth (mm)						
(day)	1:2 year	1:5 year	1:10 year	1:20 year	1:50 year	1:100 year	1:200 year
1 day	53	72.7	86.9	101.4	121.5	137.7	154.8

9.3.1 Hydraulic Design Standards

9.3.1.1 PCD

GN 704 requires that dirty water containment facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. GN 704 also requires that as a minimum, the 1:50 year design volume and a 0.8 m freeboard allowance should always be available. The 1:50 year design rainfall event was used to size the PCD capacity.

9.3.1.2 Clean Water Channels

GN 704 requires that the clean water systems are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more than once in 50 years. Therefore proposed clean water channels where sized to accommodate the 1:50 year peak flows.

9.4 Methodology

9.4.1 Channel Sizing

Peak flows used to size the clean water channels were calculated using the Rational method, whilst the actual sizing of the channels to obtain the conceptual design were undertaken based on the Manning's Equation. Both of these methods are built in within the Utilities Program for Drainage (UPD) software which was utilized. A summary of the two methods are described below.

9.4.1.1 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); and

A = Area (km^2).

The Rational formula has the following assumptions:

- The rainfall has a uniform area distribution across the total contributing catchment;
- The 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 hence 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); and

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

9.4.1.2 Mannings Equation

The Manning's equation is:

$$Q = A\frac{1}{n}R^{2/3}S^{1/2}$$

Where:

A = Area of Channel;

R = Hydraulic Radius (area / wetted perimeter);

S = Longitudinal Slope of Channel; and

n = Mannings Roughness Coefficient.

9.4.2 PCD Sizing

The sizing of the PCD was based on the Soil Conservation (SCS) method described below.

9.4.2.1 SCS Method

The SCS method, described fully in Schmidt and Schulze (1987), is particularly suited to small catchments (less than 30 km^2) and takes into account most of the factors that affect runoff, such as quantity, time distribution and duration of rainfall, land use, soil type and size and characteristics of the generating catchment. It is based on the principle that runoff is caused by the rainfall that exceeds the cumulative infiltration of the soil. Soil types are divided into four hydrological groups, ranging from soils with low runoff potential (well-drained with high infiltration ability and permeability such as sand and gravel) to soils with high runoff potential (very low infiltration rates and permeability such as shallow soils with clay, peat or rock).

The method used a curve number (CN) which can be determined from observation of the characteristics of the catchment. The curve number expresses a catchments storm flow response to a rainfall event (Schulze et al. 1992). This response is dependent on the catchment characteristics such as hydrological soil properties, catchment slope and land use.

The SCS storm flow depth equation is given below:

$$Q = \frac{(P - I_a)^2}{P - I_a + S} \quad \text{for } P > I_a$$

Where:

Q = storm flow depth (mm);

P = daily rainfall depth (mm), usually input as a one-day design rainfall for a given return period;

S = potential maximum soil water retention (mm), index of the wetness of the catchments soil prior to a rainfall event; and

I_a = Initial losses (abstractions) prior to the commencement of storm flow, comprising of depression storage, interception and initial infiltration (mm), which equals 0.1S.

9.5 Summary of Catchment Characteristics and Peak Flow Estimates

A summary of the catchment characteristics used to calculate the peak flows at the respective catchment outlets are shown in Table 16, whilst the calculated peak flows are shown in Table 17.

Table 16: Summary of catchment characteristics

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (10-85) (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Catchment 1	0.304	1212.5	176.52	139.3	0.15	0.283
Catchment 2	0.112	809.5	25.82	166.1	0.19	0.254
Catchment 3	0.063	388.9	175.08	107.5	0.04	0.326

Table 17: Summary of Peak Flows

Name	50 year	100 year
Catchment 1	3.16	4.09
Catchment 2	1.25	1.61
Catchment 3	0.59	0.76

9.6 Summary of Channel and PCD Sizing

The clean water channels conceptual design described in Table 18 is based on a trapezoidal unlined channel as indicated in Figure 2, such that the channel fill material is removed and placed on the downstream side to create a bund which will form one of the channel side slopes.

Table 18: Summary of Channel Sizing

Name	Channel Length (m)	Slope (m/m)	Calculated depth (m)	Design depth (m)	Side slopes (1V:XH)*	Velocity (m/s)	Channel type
Channel 1	261	0.005	0.793	1	3	1.178	Trapezoidal (unlined)
Channel 2	389	0.005	0.522	1	3	0.929	Trapezoidal (unlined)
Channel 3	330	0.005	0.366	1	3	0.762	Trapezoidal (unlined)

*1V : XH, relates to 1 vertical is to X horizontal, such that for a channel depth of 1 m, there will be a horizontal distance for the respective channel side slope of X m. For this storm water management plan the side slopes are 1V : 3H.

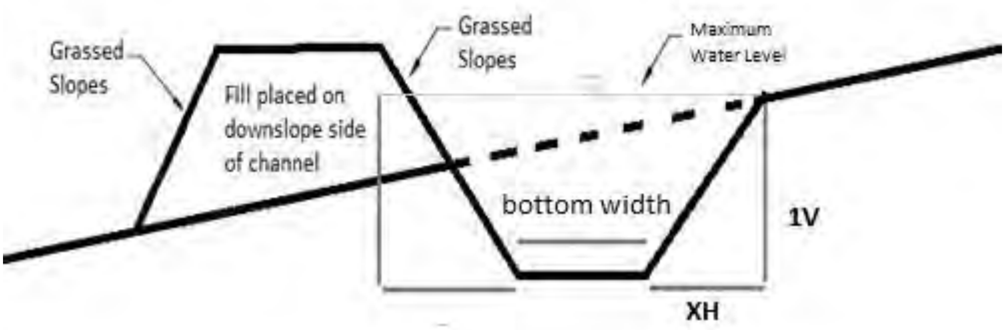

Figure 2: Typical Storm Water Channel Design

The approximate plant area used to size the PCD was estimated at 60 000 m^2, this was based on current infrastructure footprint. A CN of 85 was used based on the mixture of hardstanding (paved, concrete covered) areas together with grassed and compacted surface areas. Using the SCS method described in section 9.4.2, the estimated PCD size obtained is 5077 m^3. The summary of results is shown in Table 19 and the conceptual storm water management plan layout is shown in Plan 8, Appendix A.

Table 19: Summary of PCD sizing

Name	Area (km^2)	CN	PCD Volume (m^3)
Plant Area	0.06	85	5077

9.7 Recommendations

The following should be noted:

- As part of the detailed design of the containment facilities, the PCD volumes proposed within this report will need to be assessed by daily time-step water balance model to ensure compliance with GN 704. Modelling should be undertaken using daily rainfall and evaporation data from nearby weather stations in addition to the predicted inflows to and outflows from the respective containment facility.

10 Conclusions

Mining is proposed near the top of a mountain and it is extremely important that the SWMP outlined in this report is followed to prevent pollution of water resources. Water quality of the surrounding streams was found to be good and a stringent water monitoring programme should be followed as outlined in this report. The impact assessment showed that most impacts were minor (negative) and that mitigation can reduce these impacts to negligible (negative). Should responsible mining take place, and the SWMP plan and water monitoring programme be thoroughly implemented and mitigation measures followed, then from a surface water perspective, the impacts on the surface water environment are likely to be negligible.

11 References

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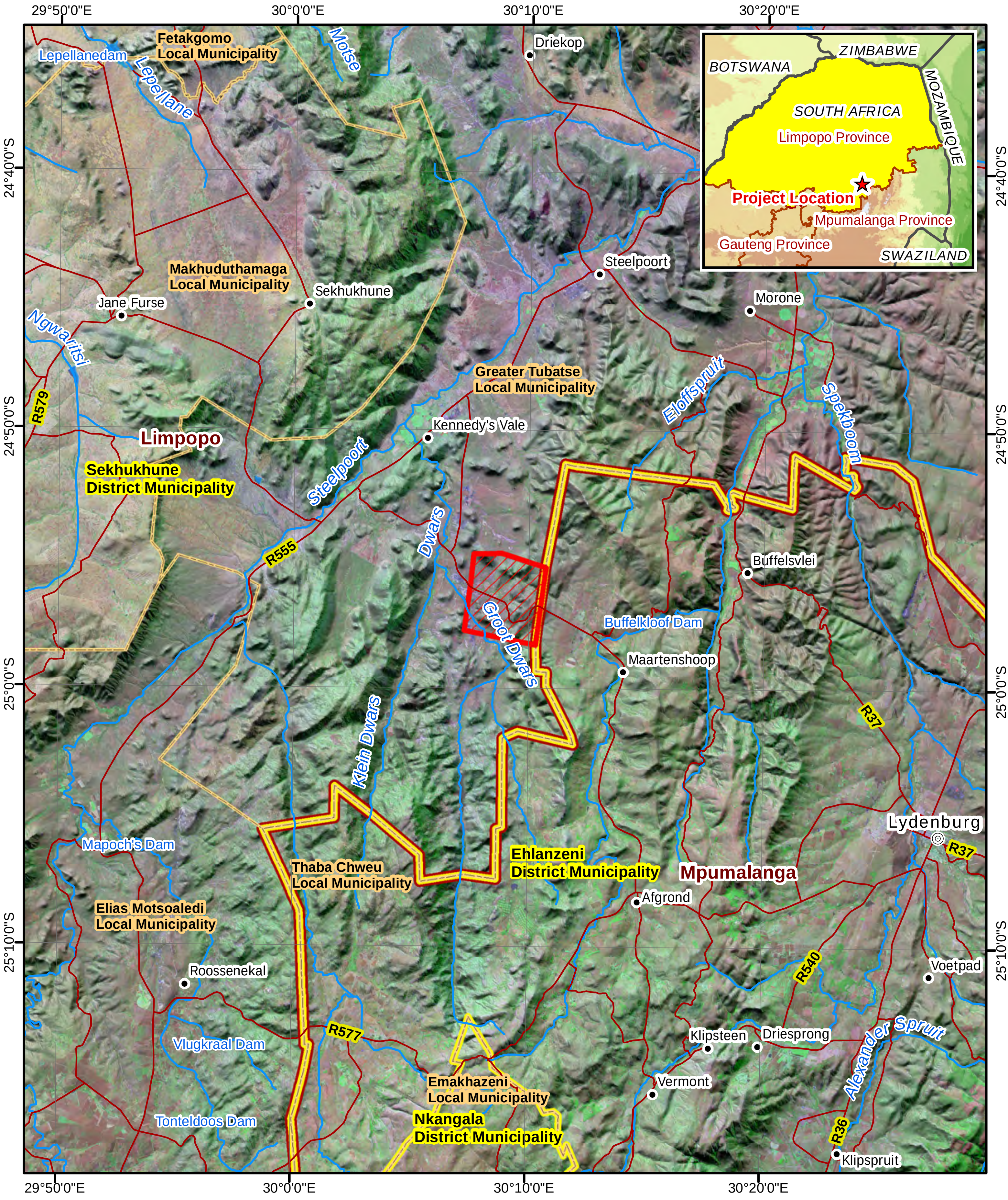
Appendix A: Plans



Plan 1: De Groote Boom Mining Permit Regional Setting

Legend

- Prospecting Area
- Secondary Town
- Settlement
- Main Road
- National Road
- River
- Dam
- Provincial Boundary
- District Municipal Boundary
- Local Municipal Boundary

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.005

N

0 2.5 5 10 15
Kilometres

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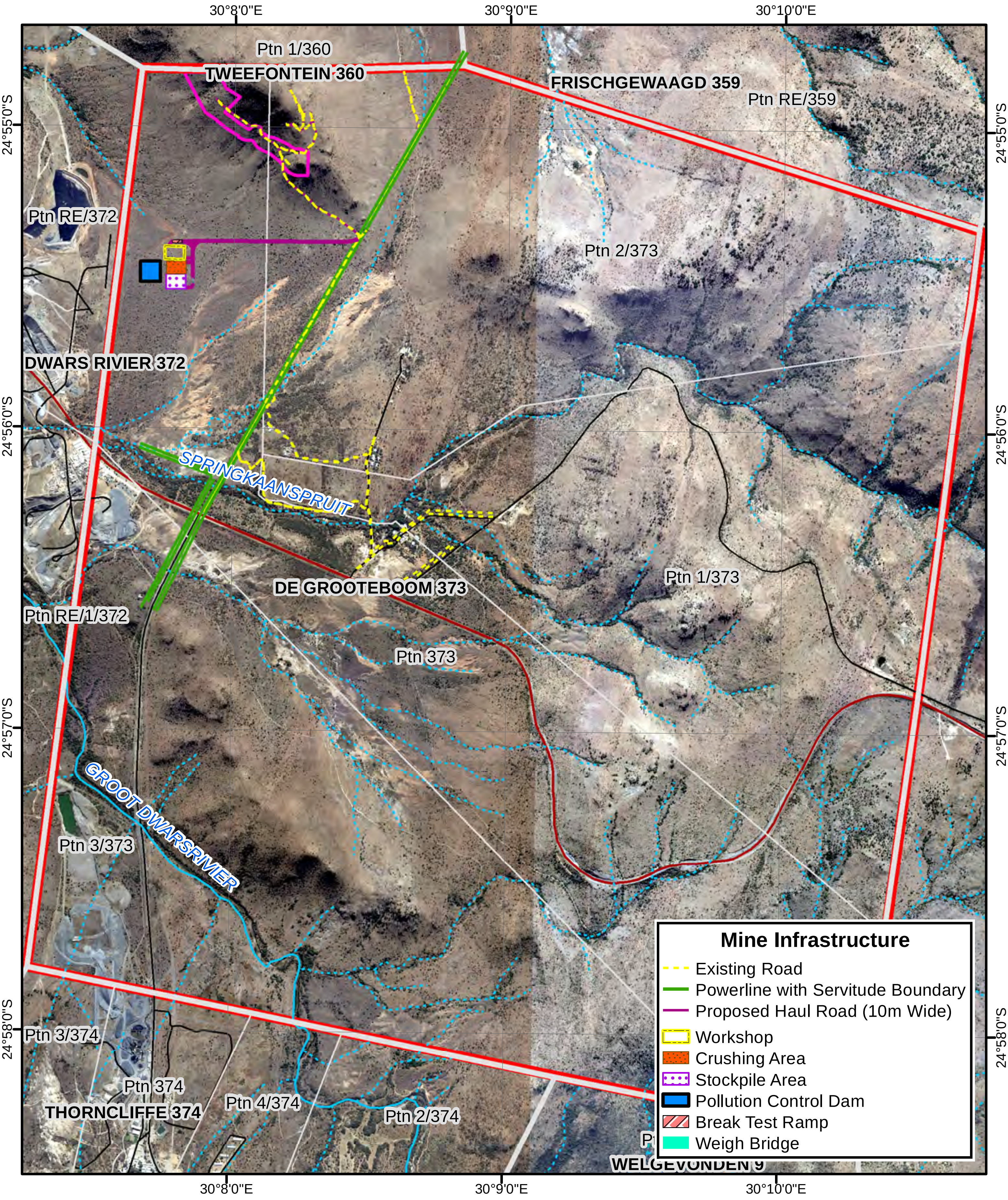

Plan 2: De Groote Boom Mining Permit Local Setting & Proposed Infrastructure

Legend

- Prospecting Area
- Study Area
- Non-Perennial Stream
- Perennial River
- Main / Secondary Road
- Minor Road
- Farm Boundary
- Farm Portion

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.003

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DIGBY WELLS ENVIRONMENTAL

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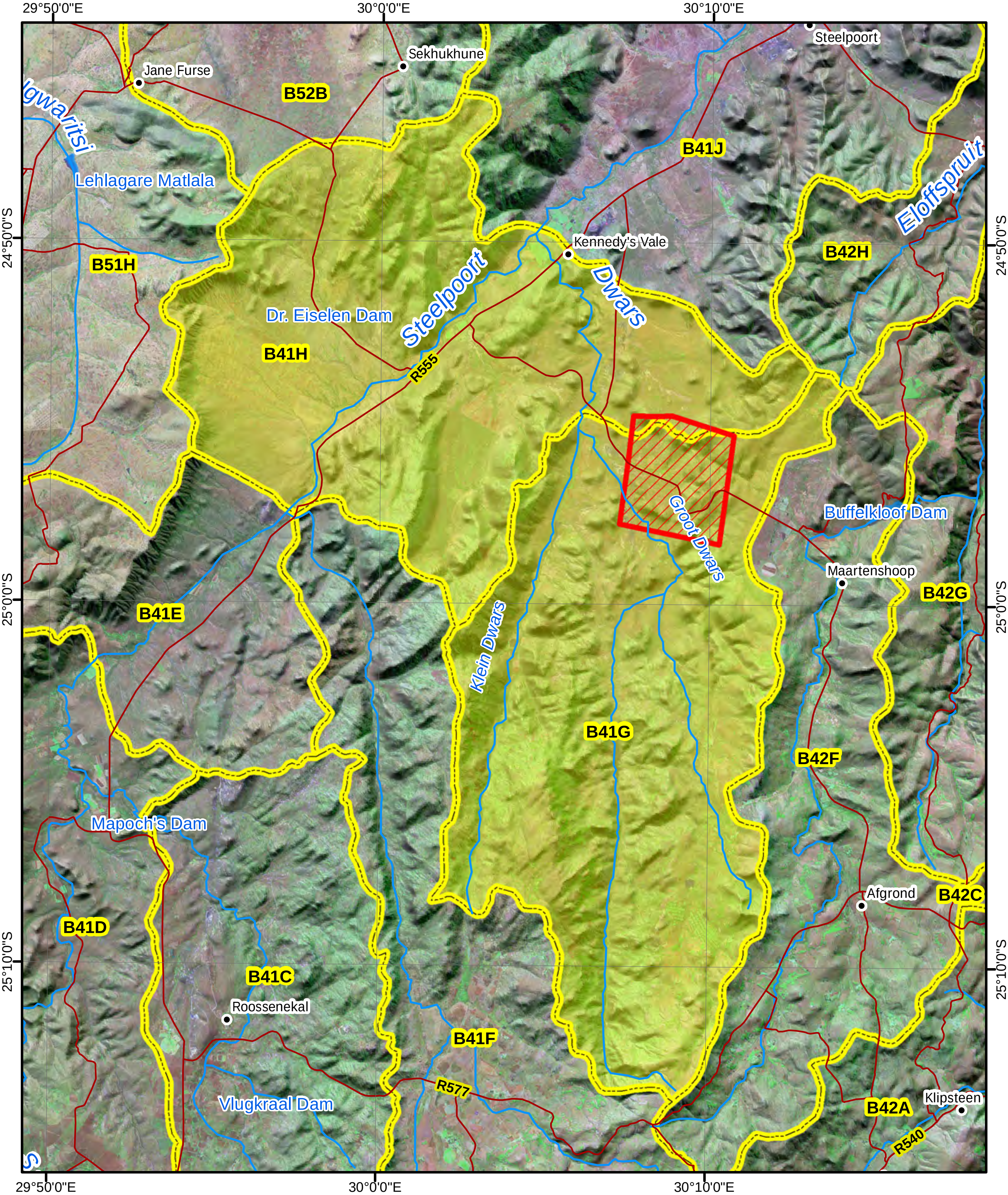

Plan 3: De Groote Boom Mining Permit Quaternary Catchments

Legend

- Prospecting Area
- Secondary Town
- Settlement
- Main Road
- National Road
- River
- Dam
- Quaternary Catchments
- Affected Catchments

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.004

N

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Kilometres

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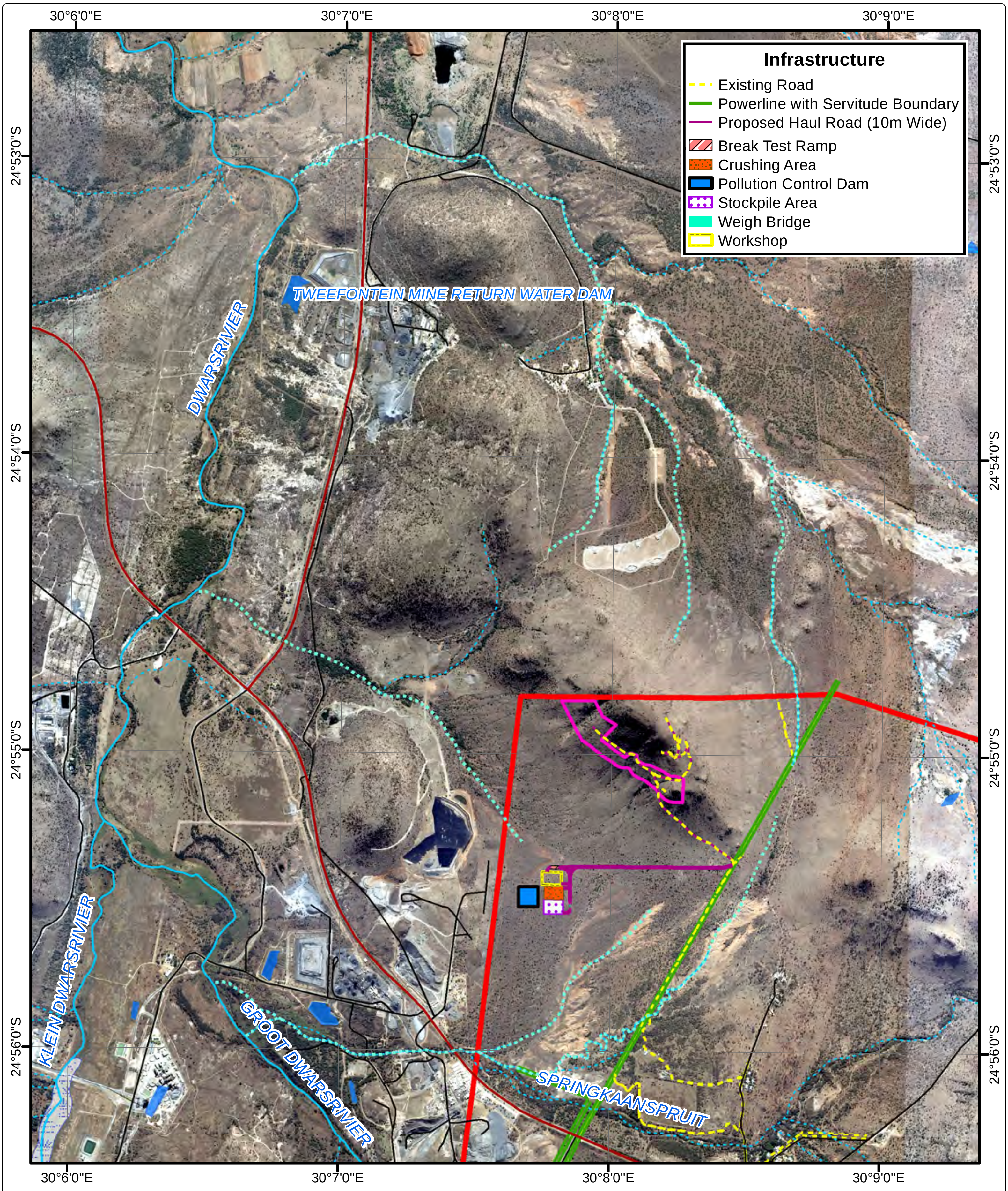

Plan 4: De Groote Boom Mining Permit Drainage Systems

Legend

- Prospecting Area
- Study Area
- Main / Secondary Road
- Minor Road
- Non-Perennial Stream
- Perennial River
- Potentially Affected Non-Perennial Stream
- Dam
- Wetland

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.002

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Kilometres

DIGBY WELLS ENVIRONMENTAL

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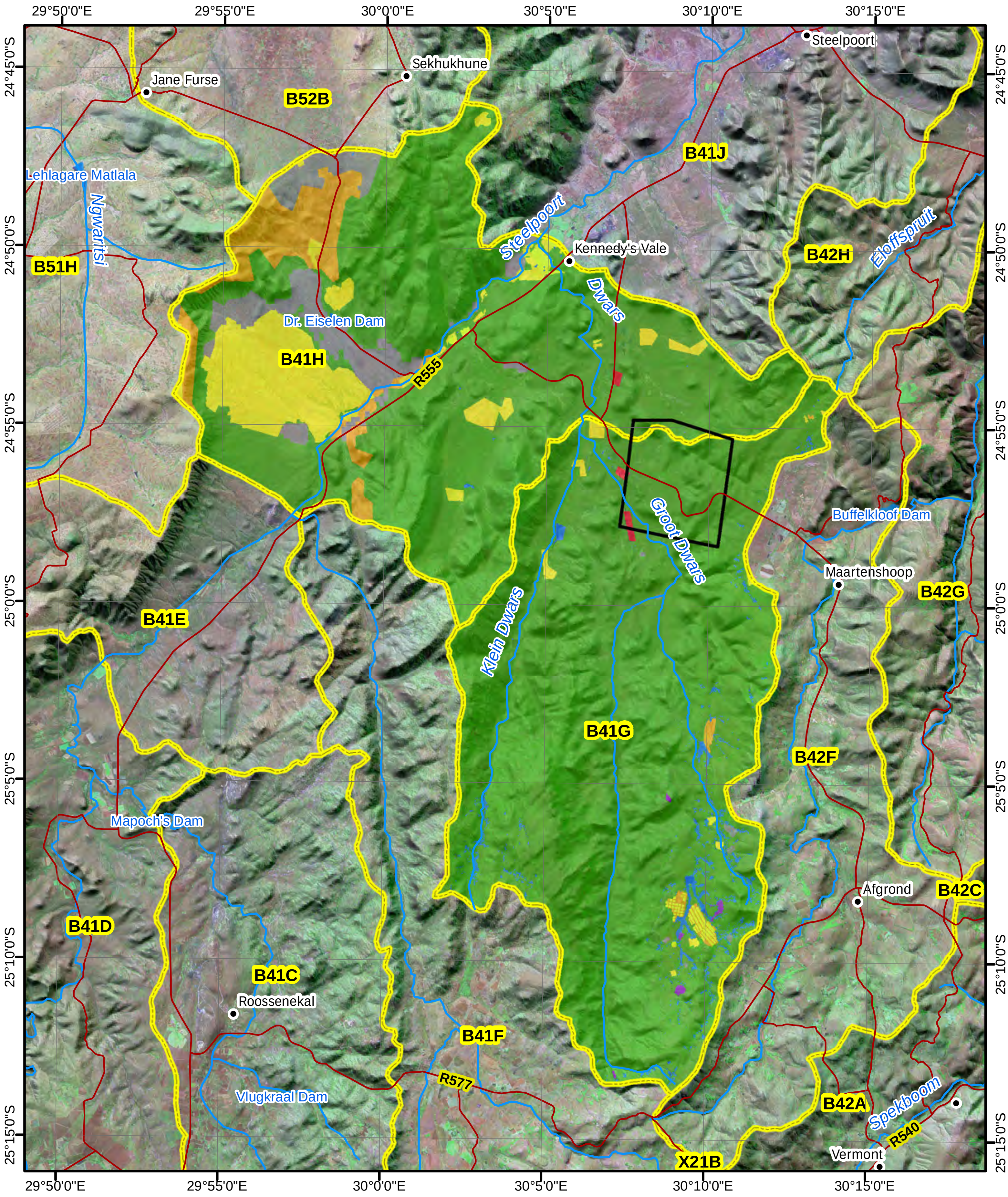

Plan 5: De Groote Boom Mining Permit Land Cover (2009)

Legend

- Prospecting Area
- Settlement
- Main Road
- National Road
- River
- Dam
- Quaternary Catchments

Land Cover (2009)

- Cultivation
- Degraded
- Mines
- Natural
- Plantations
- Urban Built-up
- Waterbodies

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.001

N

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Kilometres

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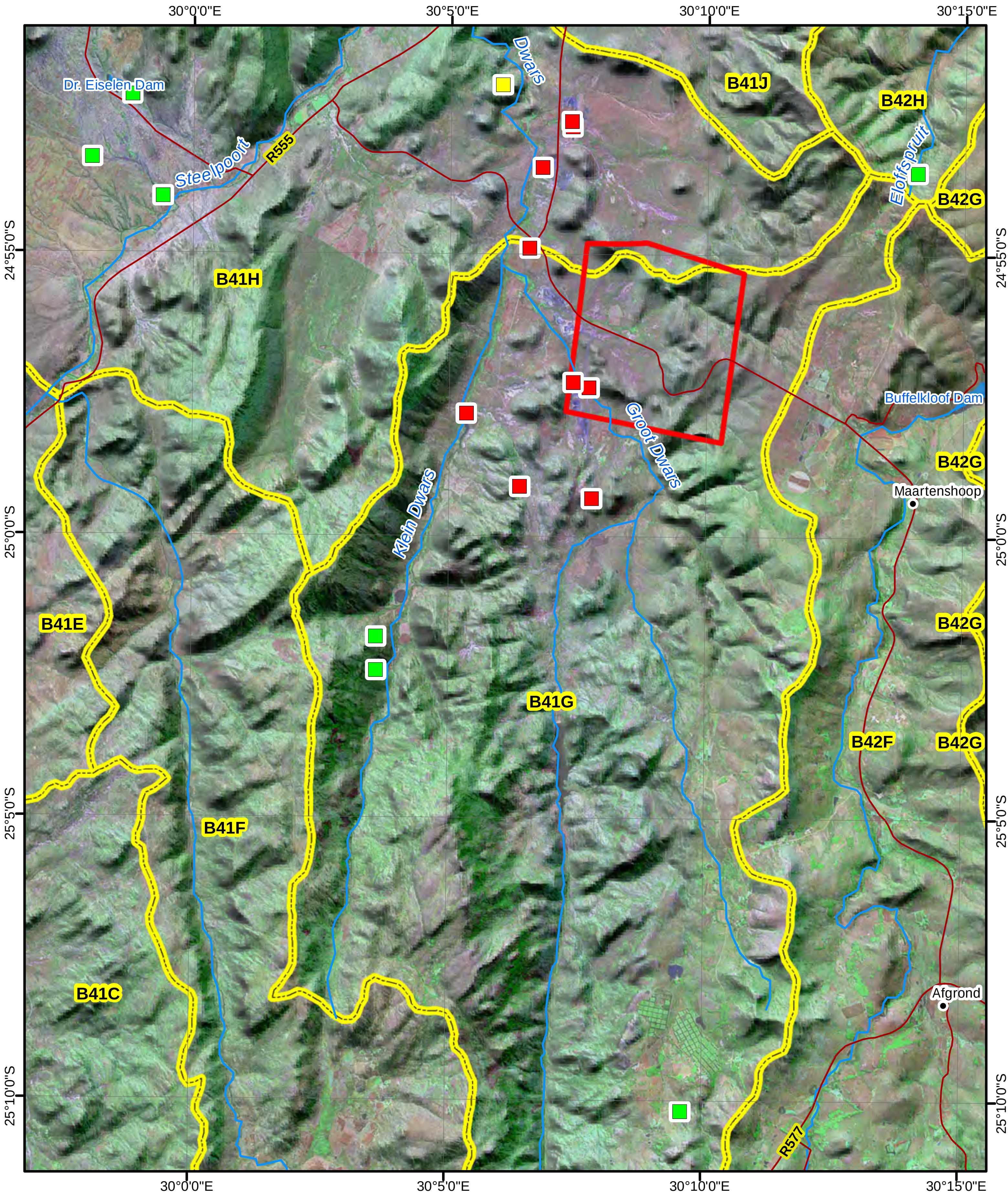

Plan 6: De Groote Boom Mining Permit Surface Water Uses

Legend

- Prospecting Area
- Quaternary Catchments
- Settlement
- Main Road
- National Road
- River
- Dam

Surface Water Uses

- Agriculture: Irrigation
- Mining
- Industry (Urban)

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.006

N

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Kilometres

DIGBY WELLS ENVIRONMENTAL

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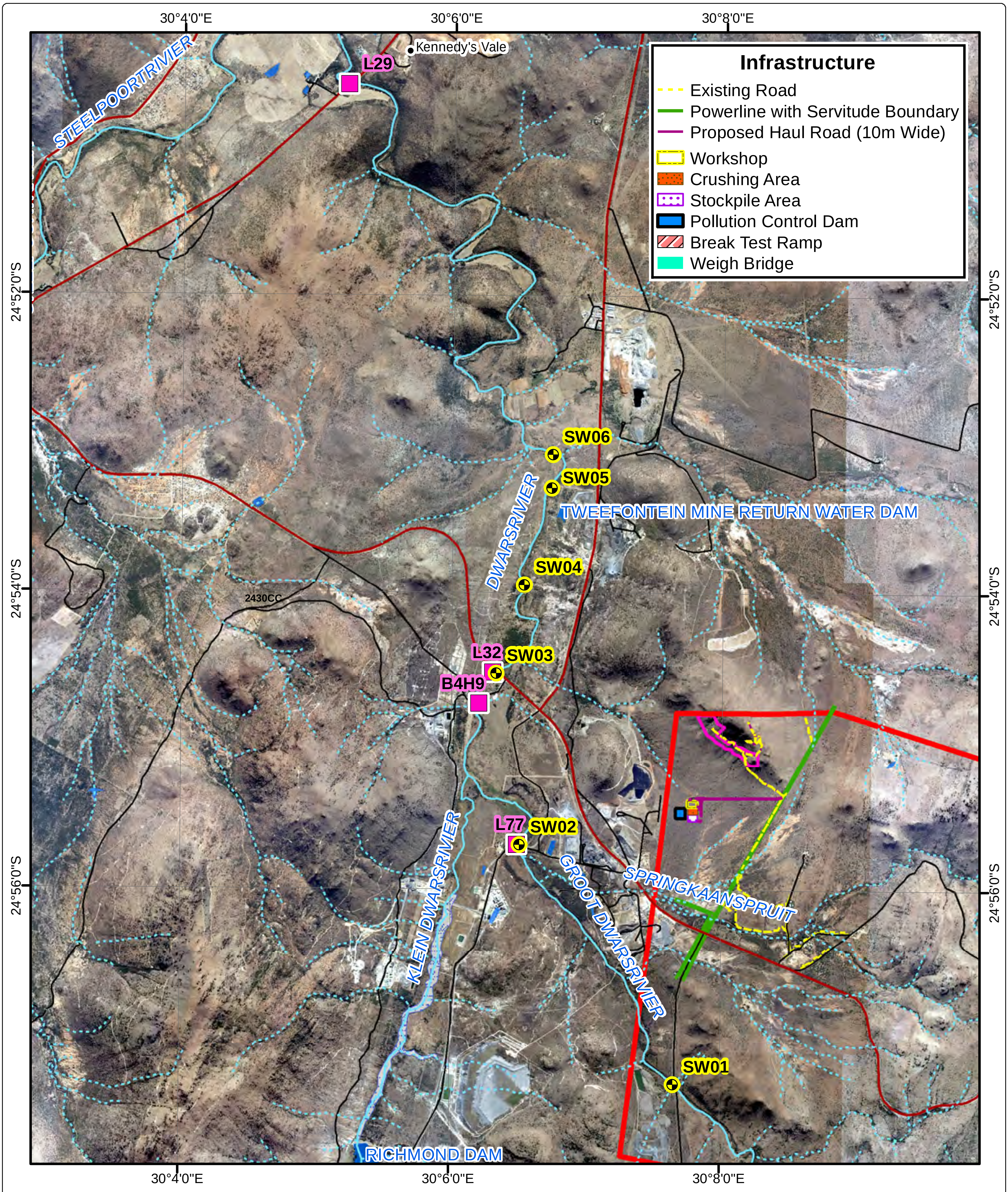

Plan 7: De Groote Boom Mining Permit Surface Water Sampling & Monitoring Points

Legend

- Prospecting Area
- Study Area
- April 2015 Surface Water Sampling Points
- DWS Water Monitoring Points
- Settlement
- Main / Secondary Road
- Minor Road
- Non-Perennial Stream
- Perennial River
- Dam
- Wetland

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.007

N

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Kilometres

DIGBY WELLS ENVIRONMENTAL

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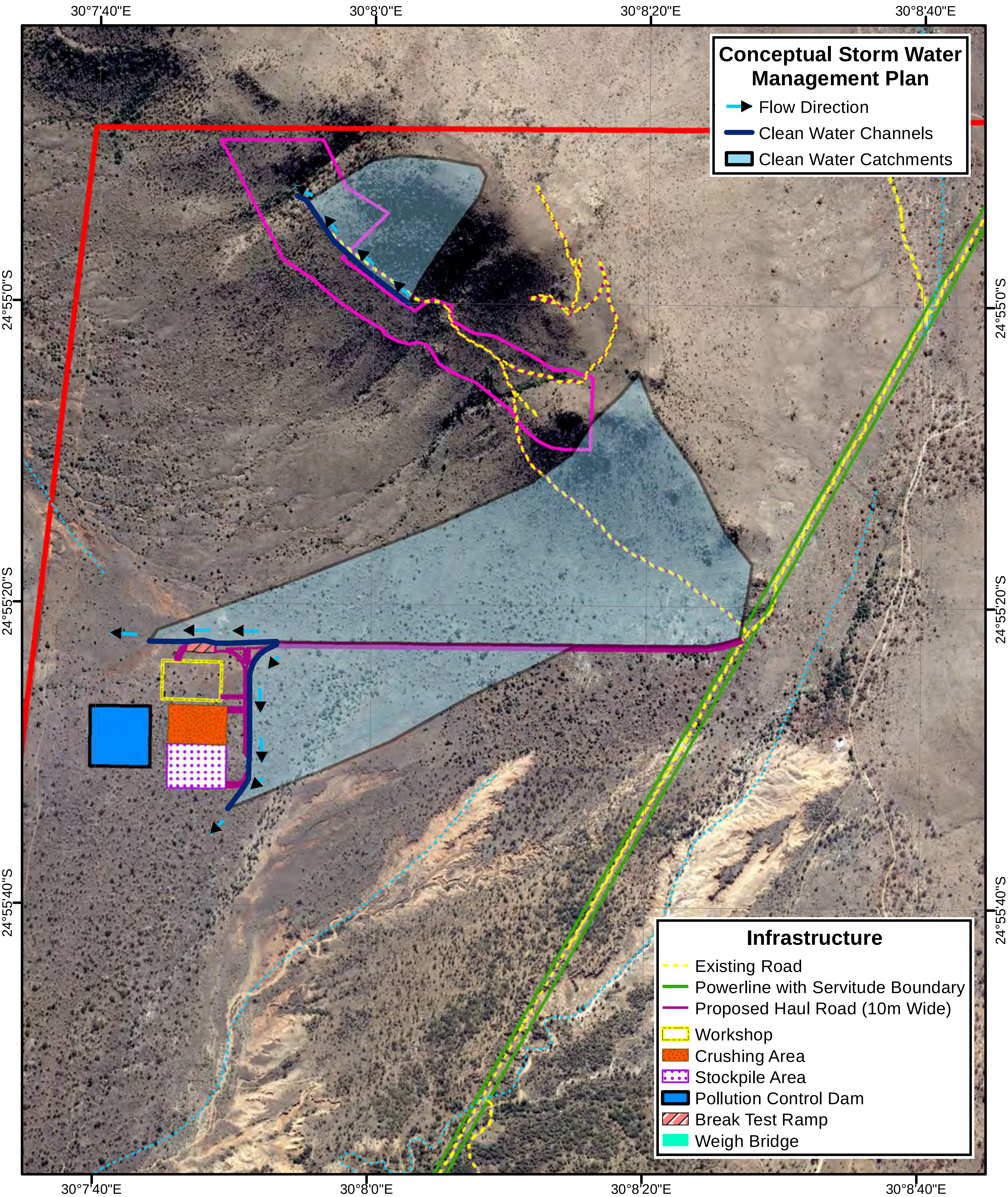

Plan 8: De Groote Boom Mining Permit Conceptual Storm Water Management Plan

Legend

- Prospecting Area
- Study Area
- Non-Perennial Stream

Projection: Transverse Mercator
Central Meridian: 31°E
Datum: WGS 1984
Date: 04/05/2015
Ref #: anp.UAR2967.201505.008

N

0 100 200 400
Metres

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Appendix B: Water Quality Laboratory Results

aquatico Laboratories (Pty). Ltd.

T0685

Test Report

Client: Digby Wells & Associates
Address: 359 Pretoria Ave, Fern Isle, Section 5, Ferndale, Randburg
Report no: 24044
Project: Digby Wells & Associates

Date of certificate: 24 April 2015
Date accepted: 17 April 2015
Date completed: 24 April 2015
Revision: 0

Lab no:				210127	210128	210129	210130	210131	210132
Date sampled:				15-Apr-15	15-Apr-15	15-Apr-15	15-Apr-15	15-Apr-15	15-Apr-15
Sample type:				Water	Water	Water	Water	Water	Water
Locality description:				SW01	SW02	SW03	SW04	SW05	SW6
	Analyses	**Unit**	**Method**						
A	pH @ 25°C	pH	ALM 20	8.51	8.35	8.31	8.28	8.32	8.29
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	21.5	23.1	24.6	25.0	26.2	26.6
A	Total dissolved solids (TDS)	mg/l	ALM 26	109	121	130	137	142	137
A	Total alkalinity	mg $CaCO_3$/l	ALM 01	97.7	103	114	122	123	104
A	Chloride (Cl)	mg/l	ALM 02	2.77	3.63	3.64	3.22	3.72	9.85
A	Sulphate (SO_4)	mg/l	ALM 03	5.64	6.78	5.93	5.64	6.56	7.16
A	Nitrate (NO_3) as N	mg/l	ALM 06	1.14	1.90	1.71	1.89	2.46	2.35
A	Ammonium (NH_4) as N	mg/l	ALM 05	0.032	0.045	0.044	0.060	0.049	0.041
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.058	0.057	0.058	0.059	0.065	0.061
A	Fluoride (F)	mg/l	ALM 08	<0.213	<0.213	<0.213	<0.213	<0.213	<0.213
A	Calcium (Ca)	mg/l	ALM 30	17.9	18.6	21.1	22.0	21.6	21.5
A	Magnesium (Mg)	mg/l	ALM 30	12.6	14.6	15.1	15.9	15.8	16.0
A	Sodium (Na)	mg/l	ALM 30	4.67	5.05	5.77	6.30	7.23	7.52
A	Potassium (K)	mg/l	ALM 30	0.716	0.727	0.744	0.752	0.723	0.766
A	Aluminium (Al)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
A	Manganese (Mn)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Total chromium (Cr)	mg/l	ALM 31	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
A	Copper (Cu)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Nickel (Ni)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Zinc (Zn)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Cobalt (Co)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Cadmium (Cd)	mg/l	ALM 31	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
A	Lead (Pb)	mg/l	ALM 31	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
A	Turbidity	NTU	ALM 21	4.95	3.98	11.4	10.2	10.2	9.08
A	Total hardness	mg $CaCO_3$/l	ALM 26	97	107	115	120	119	120
N	Suspended solids (SS)	mg/l	ALM 25	<1	1	9	15	8	<1

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

Appendix C: Declaration of Independence

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ENVIRONMENTAL

SPECIALIST DECLARATION OF INDEPENDENCE

I, **Andy Pirie**, declare that I –

- Act as the independent specialist for the undertaking of a specialist section for the proposed project: **Surface Water Impact Assessment for the Mining Permit Application for the Proposed De Groote Boom Project**;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- Do no have nor will have a vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2006;

Andy Pirie

Name of specialist

Signature of the specialist

Digby Wells Environmental

Name of company

4 May 2015

Date