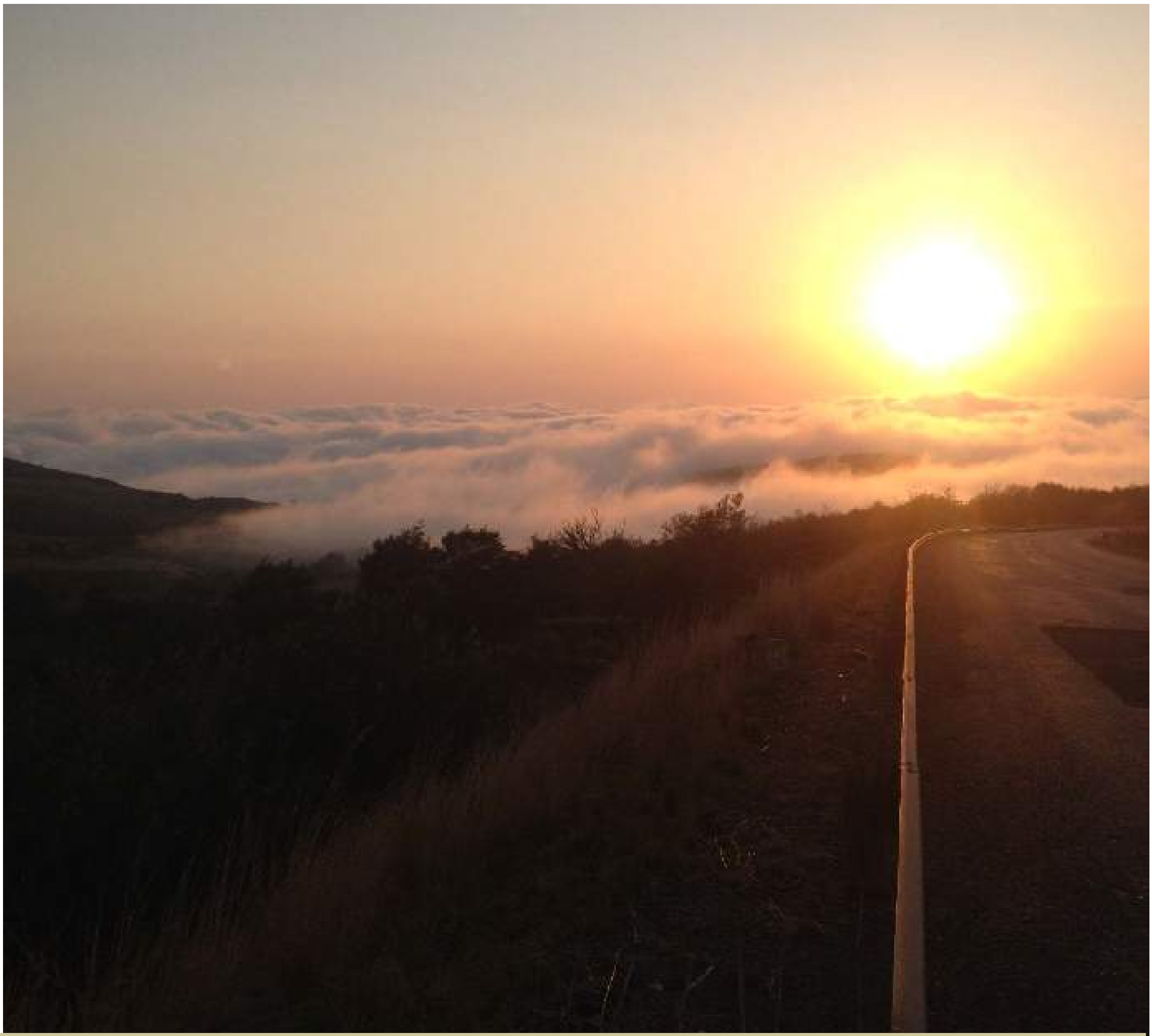
Groundwater Assessment



YZERMYN UNDERGROUND COAL MINE

Specialist Study: Geohydrology Impact Assessment

2013/09/03

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2013/09/03

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1 Introduction

This report presents the results of a geohydrology study and groundwater impact assessment conducted for the proposed Yzermyn Underground Coal Mine. The terms of reference, project background, objectives and scope of work of the assessment are outlined in the following sections.

1.1 Terms of Reference

WSP Environmental (Pty) Ltd (WSP) was appointed by Atha to undertake a comprehensive social and environmental impact assessment (ESIA) for the proposed mine. The ESIA included several specialist studies. This report details the findings of the geohydrological baseline assessment and the geohydrological impact assessment.

1.2 Project Background

Atha Africa Ventures (Pty) Ltd (Atha) acquired the coal prospecting rights[1] to an approximate area of 8,360 hectare (ha) located some 58 kilometres (km) southwest of Piet Retief in the Mpumalanga Province (**Figure 1**). Mindset has completed exploration activities (infill drilling) to adequately identify the proposed coal resource for the Yzermyn Underground Coal Mine.

The mine will apply underground drill and blast/ BORD and PILLAR mining methods with a portal/adit being sunk in the northern section (27°13’14.05”S; 30°18’39.25”E) of the resource area.

It is proposed that the Utrecht Coalfield of the Karoo Supergroup will be mined. The Alfred and Dundas coal seams, which form part of the Utrecht coal field, will be extracted.

1.3 Assessment Objectives

The objectives of the geohydrology study are to characterise the baseline geohydrological conditions in the target area and identify the potential impacts of the underground mining on groundwater. Specific objectives include:

- Confirmation of the underlying geology, fractures and structural features;
- Determination of the occurrence and depths of groundwater beneath the study area;
- Installation of test boreholes at selected sites;
- Assessment of borehole yields in terms of the mine water demand;
- Determination of the prevailing groundwater quality; and
- Evaluation of impacts of the mine on groundwater occurrence and quality.

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[1] The prospecting rights were previously held by BHPBilliton, Ingwe Colliery and transferred to Bunengi Mining in 2011. Subsequent to this, Atha bought the shares from Bunengi Mining thereby becoming the primary holder of the prospecting right.

1.4 Scope of Works

The following scope of work was conducted:

- **Desktop Geohydrological Review**

  This included a desktop assessment of the main aquifer formation in the area, including its characteristics and review of exploration drilling logs.

- **Geohydrological Fieldwork programme**
  - **Hydrocensus**

    Inspection of the target area and surrounding farm land to determine if there are any boreholes in the vicinity of the project area and for what purpose (i.e. domestic or agricultural).

  - **Borehole Siting**

    Borehole sites were selected from exploration drilling data and aquifer targeting.

  - **Borehole Installation**

    Installation works were undertaken by a specialist contractor to advance boreholes at selected locations.

  - **Pump Testing**
    - 24 hour constant discharge;
    - Recovery testing; and
    - Slug testing.

  - **Groundwater Quality Assessment**

    To determine the environmental baseline groundwater quality and suitability of groundwater for use, water samples were collected and analysed.

- **Geohydrological Modelling Programme**
  - Development of a Site Conceptual Model
  - Documenting key assumptions
  - Numerical model inputs from the desktop review and fieldwork results
  - Numerical model calibration against field data

- **Groundwater Impact Assessment**
  - Determined the extent of potential impacts to groundwater quantities and quality from numerical model results,
  - Developed a Groundwater Management Plan
  - Recommended measures for the management of groundwater during construction phase, operational phase and closure of the proposed Yzermyn Underground Coal Mine.

The above scope is described and discussed in the remainder of this report.

2 Site Description

Atha holds the prospecting right for an area of 8,360 ha (comprising 12 farms) located in the Pixley ka Seme Local Municipality in the Mpumalanga Province (**Figure 1**). This includes three farms and a portion of an additional farm: Kromhoek 93, Goedgevonden 95, Yzermyn 96 Portion 1 and a portion of Zoetfontein 94. The identified resource area considered in this assessment is located approximately 30 km northeast of the town of Wakkerstroom and comprises hilly grasslands, containing ridges, plateaus and valleys, with the highest area recording 1,765 metres above mean annual sea level (m amasl).

2.1 Geology

The proposed Yzermyn Underground Coal Mine is located in the Vryheid Formation of the Karoo Supergroup, on the northern boundary of the Utrecht Coalfield (RSA DMEA, 1988). The site consists predominantly of sandstones and shales interbedded with sandstones. As illustrated by the red colour in **Figure 2** numerous dolerite intrusions (dykes and sills) have intruded the Vryheid Formation. Dolerite sills are generally favourable for perched groundwater conditions above the sill. This can result in springs and seep where the water day-lights at surface. There is significant faulting of the surrounding country rock. These could act as potential groundwater flow pathways.

The general stratigraphic profile at the proposed Yzermyn Underground Coal Mine is presented below:

	Jd	Dolerite Sill
Pe		Karoo Supergroup : Escourt Formation – Sandstone and Mudstone
Pvo		Karoo Supergroup : Volksrust Formation – Shale and Siltstone
Pv		Karoo Supergroup : Vryheid Formation – Sandstone and Shale

2.2 Geohydrology

The following sections characterise the groundwater occurrence both regionally and locally in relation to the proposed Yzermyn Underground Coal Mine.

2.2.1 Regional Setting

It has been noted that the rocks of the Karoo Supergroup do not generally generate economic aquifers. High yielding boreholes are known to be located along dyke margins where alteration of the sandstones and shale has resulted in preferential pathways for groundwater.

Groundwater in the Karoo is commonly considered to occur in two distinct aquifers; a shallow intergranular and fractured upper aquifer in the weathering zone; and deep-seated fractured rock aquifers. The latter would include faults in the sandstone and shale.

Groundwater levels in Karoo aquifers are generally found to mimic surface topography. Groundwater tends to flow from elevated areas towards lower lying areas which are often associated with surface drainage and water courses. Surface water and groundwater interaction occurs along the river and stream courses.

A groundwater assessment for a proposed coal mine expansion was conducted on the farm Kransbank, some 30 km north of Yzermyn, in 2012 (ERM 2013). Data from 75 hydrocensus sites (44 boreholes and 31 natural springs), 8 km of geophysical survey and drilling of 10 groundwater exploration/monitoring boreholes was consolidated in a conceptual hydrogeological model. Key features of the model included:

- Five types of groundwater bearing horizons:
    - Perched groundwater
    - Alluvial horizon
    - Weathered horizon
    - Regional fractured horizon
    - Groundwater related to geological structures
- Groundwater flow generally follows surface topography
- Groundwater feeds surface water features including springs, wetlands, streams and rivers
- Dolerite sills can act as barriers to groundwater flow
- Faults and fractures may connect water bearing strata above and below the dolerite sills
- The groundwater bearing horizons are interconnected

These features may also be applicable to Yzermyn.

2.2.2 Local Setting

WSP undertook Phase 1 groundwater drilling during the scoping phase of the ESIA. Five boreholes were drilled in the northern portion of the resource area where the Alfred and Dundas coal seams were expected to be shallow (**Table 1**).

The boreholes were drilled to depths of approximately 70m bgl and intersected both Alfred and Dundas coal seams. All five boreholes proved to be poor sources of groundwater. Only one borehole had an estimated yield greater than 0.5l/s. Water strikes in these boreholes were confined to shallow depths between 10 and 20m bgl in the weathered shallow aquifer.

Based on the drilling results and local topography groundwater is considered to flow in a northeasterly direction.

Table 1: Boreholes installed during the Scoping Phase

Borehole ID	Latitude (WGS 84)	Longitude (WGS 84)	Total Depth (m bgl)	Fractures (m bgl)	Water Level (m bgl)	Estimated Yield (l/s)
ATHA-BH1	-27.216343	30.301979	62	Seepage	23.64	<0.1
ATHA-BH3	-27.223212	30.314948	61	12	4.03	<0.1
ATHA-BH4	-27.222509	30.315511	67	11, 62	4.54	0.13
ATHA-BH5	-27.221349	30.282341	70	Seepage	9.87	<0.1
ATHA-BH6	-27.221882	30.316052	67	16, 33, 39	3.02	0.25

3 Geohydrological Assessment

The geohydrological assessment contains a description of the fieldworks undertaken including hydrocensus, borehole siting, borehole installation and aquifer testing. This assessment provides for a quantitative assessment of groundwater occurrence in the target area to develop inputs into the conceptual site model and the geohydrological model.

3.1 Hydrocensus

It appears that water in the project area is generally not sourced from boreholes. This was suggested by a search of the Department of Water Affairs: National Groundwater Database. No registered boreholes were found within a 30km radius of the target area.

WSP conducted a hydrocensus to identify local boreholes and water sources from 3 to 5 March 2013. Surrounding farmers were approached and asked for information regarding the installation and locations of boreholes on their farms. WSP were informed that water is generally not sourced from boreholes but from springs (locally referred to as "fonteins"). Known locations of springs are listed in **Table 2** and displayed in **Figure 3**. The springs are used for both domestic and livestock watering purposes. Most of the springs occur high up near the sources of water courses and appear to be associated with dolerite geology.

No boreholes were identified in the project area.

Table 2: Springs identified during the 2013 hydrocensus

Spring	Latitude (WGS 84)	Longitude (WGS 84)	Elevation
Fountain 1	-27.23077	30.30374	1582.00
Mawandlane	-27.24912	30.30864	1718.00
Fountain 2	-27.23433	30.30409	1560.00
Fountain 3	-27.21399	30.29832	1475.00
Fountain 4	-27.22309	30.30504	1520.00
Fountain 5	-27.22588	30.29819	1590.00
Fountain 6	-27.24592	30.23894	1679.00
Fountain 7	-27.24136	30.23899	1700.00
Fountain 8	-27.23876	30.2375	1705.00
Fountain 9	-27.22106	30.22846	1695.00
Fountain 10	-27.2499	30.24822	1695.00
Fountain 11	-27.25129	30.25583	1715.00
Fountain 12	-27.28924	30.24068	1854.00
Fountain 13	-27.29062	30.24373	1905.00
Fountain 14	-27.2281	30.27492	1605.00
Fountain 15	-27.25047	30.27026	1730.00
Fountain 16	-27.24958	30.26935	1736.00
Fountain 17	-27.24495	30.27021	1734.00
Fountain 18	-27.24184	30.27103	1727.00
Fountain 19	-27.25528	30.26039	1734.00
Fountain 20	-27.26601	30.26277	1767.00
Fountain 21	-27.2665	30.26087	1757.00
Fountain 22	-27.26722	30.25529	1726.00

Spring	Latitude (WGS 84)	Longitude (WGS 84)	Elevation
Fountain 23	-27.27641	30.25215	1785.00

3.2 Borehole Siting

A Phase 2 drilling programme was conducted from 23 May 2013 to 8 June 2013.

The geological model developed for the Yzermyn coal resource includes inferred faults from significant elevation differences on the coal seam. Drilling records from exploratory boreholes indicated several boreholes had encountered groundwater, generally on geological contacts. This data was used to identify five target locations for drilling of groundwater exploration/monitoring boreholes. Shallow and deep boreholes were recommended for each borehole location to allow separate access to the shallow and deeper aquifers for the purposes of testing and sampling. The five borehole siting locations are shown in **Figure 4**.

3.3 Borehole Installation

Boreholes were advanced by air percussion drill with a diameter of 165mm. Solid steel casing was installed at the top of the deeper boreholes to prevent groundwater from the shallow weathered aquifer impacting on the deeper fractured aquifer. Solid steel casing and slotted steel casing were installed in shallow boreholes to target water strikes observed in the shallow aquifer. Due to site access issues not all of the target locations could be reached by the drill rig. Additional locations and boreholes were added to the initial programme at the request of Atha. Drilled borehole locations are shown in **Table 3** and displayed in **Figure 5**.

Table 3: Final Borehole Installation Locations

Borehole ID	Longitude (WGS 84)	Latitude (WGS 84)
CBH 1	30.31597	27.23156
CBH 2 S	30.28051	27.22868
CBH 2 D	30.28053	27.22878
CBH 3 S	30.30128	27.23360
CBH 3 D	30.30128	27.23360
CBH 4 S	30.30956	27.22252
CBH 4 D	30.30956	27.22253
CBH 5 S	30.29597	27.22661
CBH 5 D	30.29530	27.22608
CBH 6	30.30590	27.21990
CBH 7 S	30.30639	27.22672
CBH 7 D	30.30630	27.22668
CBH8 S	30.29018	27.22597
CBH8 D	30.29016	27.22597

Table 4 displays a drilling summary for each borehole including final depth of borehole, depth of fractures (water strikes), estimated yields and measured groundwater level in the boreholes.

Table 4: Summary of Boreholes Drilled

Borehole ID	Steel Casing Solid (m)	Steel Casing Slotted (m)	Total Depth (m bgl)	Fractures (m bgl)	Water Level (m bgl)	Estimated Yield (l/s)
CBH 1	0-18	0	94	20	2.64	<0.5
CBH 2 S	0	0-24	34	24	15.16	<0.5
CBH 2 D	0-24	0	130	25, 85	15.49	3.5
CBH 3 S	0-12	12-18'	70	10, 18	1.63	2.6
CBH 3 D	0-24	0	208	10, 44, 75	44.75	<0.5
CBH 4 S	0	0-6	36	None	11.75	Seepage
CBH 4 D	0-24	0	214	29, 191	37.95	<0.5

Borehole ID	Steel Casing Solid (m)	Steel Casing Slotted (m)	Total Depth (m bgl)	Fractures (m bgl)	Water Level (m bgl)	Estimated Yield (l/s)
CBH 5 S	0-24	0	49	38	12.7	<0.5
CBH 5 D	0-15	0	214	40	24.99	Seepage
CBH 6	0-18	0	82	19	30.95	<0.5
CBH 7 S	0-6	6-18'	40	10	8.97	3.8
CBH 7 D	0-18	0	202	10, 16	57.77	Seepage
CBH8 S	0-6,12-18	6-12'	49	None	14.6	<0.5
CBH8 D	0-26	0	214	None	38.75	<0.5

Based on observations made during borehole installation groundwater water occurrence appears scarce with only three of the boreholes (CBH2D, CBH3S and CBH7S) providing estimated yields above 0.5l/s. The lack of groundwater encountered in boreholes in the project area suggests that it would be difficult to develop a sustainable groundwater supply.

Geology and drilling observations were recorded for each borehole and are included in the borehole logs in **Appendix B**.

3.4 Aquifer Testing

Aquifer characteristics have been determined from pump test and slug test data. Boreholes with estimated yield greater than 0.5l/s were tested using step drawdown and constant discharge tests from 10 to 15 June 2013. The remaining boreholes were slug tested.

Step tests were conducted on boreholes 2D, 3S and 7S. Three one-hour pumping steps were conducted at progressively increasing pumping rates with recovery measured on conclusion of pumping. This information was then used to determine a sustainable pumping rate for the constant discharge test of the borehole.

Constant discharge tests were conducted over a 24 hour period with recovery recorded immediately thereafter. Aquifer transmissivity was assessed from plots of drawdown versus time. Graphs for the three boreholes tested are provided in **Appendix C.**

Slug tests were undertaken on those boreholes with estimated yield less than 0.5l/s. Slug tests involve displacing the water in the borehole using a slug of known volume and measuring the recovery of the water level. Due to low yields some boreholes contained a slurry of silt and water with insufficient depth to conduct a slug test. These boreholes were reported as “filled with silt”. Slug test field measurements and hydraulic conductivity calculations are provided in **Appendix D**.

The hydraulic properties determined from all tests are tabulated in **Table 5**.

Table 5: Calculate Hydraulic Conductivity Values

Borehole ID	Test Type	Hydraulic Conductivity (m/day)
CBH 1	Slug Test	0.01*
CBH 2 S	Slug Test	1.3
CBH 2 D	Constant Discharge Test	0.02
CBH 3 S	Constant Discharge Test	0.4
CBH 3 D	Unable to test borehole filled with silt	-
CBH 4 S	Unable to test borehole filled with silt	-
CBH 4 D	Slug Test	0.5
CBH 5 S	Slug Test	1.3
CBH 5 D	Unable to test borehole filled with silt	-
CBH 6	Slug Test	0.01*
CBH 7 S	Constant Discharge Test	0.4
CBH 7 D	Slug Test	0.3
CBH8 S	Unable to test borehole filled with silt	-
CBH8 D	Unable to test borehole filled with silt	-

*Very little flow registered during slug test

Generally the hydraulic conductivity of the shallow weathered aquifer is higher than the deeper aquifer. Constant discharge testing indicates the presence of low permeability aquifer boundaries consistent with the presence of water-bearing fracture systems of limited extent.

Based on the test data the geometric average hydraulic conductivity for the shallow boreholes is 0.72 m/d and for the deeper fractured rock aquifer 0.05 m/d. Estimated transmissivities vary between 1 and 5 m^2/d.

3.5 Groundwater Quality Assessment

The groundwater samples were screened against the DWAF Water Quality Guidelines for Domestic Water Use (DWAF 1996). The target water quality ranges associated with domestic water use are considered applicable to the proposed Yzermyn project water use and provide a conservative indicator of suitability for environmental uses.

3.5.1 Sampling Procedure

Prior to sampling, an electronic dip meter was used to determine the groundwater level in each borehole which was measured from the top of the monitoring borehole casing and recorded in meters below ground level.

Dedicated Teflon bailers were used to obtain groundwater samples. Water samples were collected filtered in the field (0.45µm) and preserved using nitric acid solution. Samples were placed in laboratory prepared, sterilised containers specific to the determinants being analysed. Clean, disposable gloves were used during sampling and changed between sampling locations to minimise the potential for cross-contamination. Samples were recorded on a site-specific Chain of Custody sheet and placed in a cooled container (~4^{o}C) for submission to Alcontrol Laboratories (Hawarden, United Kingdom) in 2 working days. Laboratory certificates from Alcontrol Laboratories can be made available upon request.

Groundwater samples were submitted for the following analytical programme:

- **Indicator Parameters:** pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Alkalinity.
- **Inorganic Compounds:** Anions F, Cl, NO_2, NO_3, and Sulphate (SO_4); and cations Na, K, Ca, Mg, including trace metal scan

3.5.2 Water Quality Results

Results are presented in **Table 6** for the shallow boreholes and **Table 7** for the deep boreholes.

Table 6: Water Quality Results for Shallow Boreholes

Parameter	TWQG Domestic Use	CBH2S	CBH3S	CBH4S	CBH5S	CBH7S	CBH8S	Shallow groundwater baseline quality range
Alkalinity,	--	NA	BDL	BDL	BDL	BDL	BDL	BDL
Conductivity	7000	NA	0.326	0.259	0.186	0.245	0.17	0.17 - 0.326
Total Dissolved Solids	45000	NA	257	201	132	196	140	132 - 256
Aluminium (µg/l)	300	BDL	13.4	11.2	9.98	3.21	17.1	3.21 - 17.1
Arsenic (µg/l)	10	0.279	0.355	9.08	0.132	1.2	BDL	BDL - 9.08
Chromium (µg/l)	50	1.5	1.87	1.52	1.43	2.02	2	1.43 - 2.01
Lead (µg/l)	10	BDL	0.509	0.471	0.362	0.8	0.224	BDL - 0.8
Manganese (µg/l)	500	66.4	**776**	37.9	55.6	121	259	37.9 - 776
Nickel (µg/l)	70	1.23	1.63	2.7	0.959	1.34	3.37	1.23 - 3.37
Selenium (µg/l)	10	BDL	BDL	0.522	BDL	0.467	BDL	BDL - 0.522
Vanadium (µg/l)	200	0.314	BDL	1.36	BDL	0.375	0.413	BDL - 1.36
Zinc (µg/l)	5000	0.555	6.47	13.5	2.5	5	7.36	0.555 - 13.5
Nitrite as NO_2 (mg/l)	0.9	0.05	BDL	BDL	BDL	0.119	BDL	BDL - 0.119
Chloride (mg/l)	300	BDL	4.3	6.3	2	BDL	BDL	BDL - 6.3

Parameter	TWQG Domestic Use	CBH2S	CBH3S	CBH4S	CBH5S	CBH7S	CBH8S	Shallow groundwater baseline quality range
Phosphate as PO_4 (mg/l)	--	BDL	BDL	BDL	BDL	0.095	BDL	BDL - 0.095
Nitrate as NO_3 (mg/l)	11	NA	BDL	1	BDL	3.31	BDL	BDL - 3.31
Calcium (mg/l)	--	48.4	34.9	33.4	18.6	39.3	17.7	17.7 - 48.4
Sodium (mg/l)	200	18.9	15	19.3	14.7	7.32	6.36	6.36 - 19.3
Magnesium (mg/l)	70	14.2	20.9	8.92	11.6	10.4	12.3	8.92 - 20.9
Potassium (mg/l	50	1.61	BDL	2.68	1.05	1.13	BDL	BDL - 2.68
Iron (mg/l)	2	BDL	**11.8**	0.0362	0.0782	BDL	**11.4**	BDL - 11.8
pH	6-9	NA	**8.34**	**8.31**	7.98	7.94	7.06	7.06 - 8.34

Table 7: Water Quality Results for Deep Boreholes

Parameter	TWQG Domestic Use	CBH1	CBH6	CBH2D	CBH3D	CBH4D	CBH5D	CBH7D	Deep groundwater baseline quality range
Alkalinity,	--	185	NA	NA	NA	NA	BDL	BDL	NA
Conductivity	7000	2.84	NA	NA	NA	NA	0.172	0.447	NA
Total Dissolved Solids	45000	2220	NA	NA	NA	NA	133	**351**	NA
Aluminium (µg/l)	300	7.75	16.1	3.66	12.8	BDL	4.75	30.2	BDL - 30.2
Arsenic (µg/l)	10	1.8	1.73	0.149	3.56	0.939	0.401	1.84	0.149-3.56
Chromium (µg/l)	50	3.46	1.83	1.37	4.64	1.64	2.67	2.3	1.37-4.64
Lead (µg/l)	10	0.186	0.2	BDL	0.189	0.905	0.313	0.606	BDL-0.905
Manganese (µg/l)	500	13.6	11.9	45.6	13.3	55.1	6.18	12.7	6.18-55.1
Nickel (µg/l)	70	1.28	0.375	0.898	0.566	2.22	1.05	3.47	0.375-3.47
Selenium (µg/l)	10	3.08	BDL	BDL	1.84	BDL	BDL	BDL	BDL-3.08
Vanadium (µg/l)	200	0.625	0.386	0.265	0.887	0.361	13.1	0.342	0.265-13.1
Zinc (µg/l)	5000	2.54	BDL	0.717	BDL	8.04	12.4	12.9	BDL-12.9
Nitrite as NO_2 (mg/l)	0.9	BDL	BDL	BDL	BDL	BDL	BDL	0.356	BDL-0.356
Chloride (mg/l)	300	**367**	22.2	BDL	103	BDL	BDL	BDL	BDL-367
Phosphate PO_4 (mg/l)	--	BDL	0.131	BDL	0.096	0.128	0.109	0.05	BDL-0.131
Nitrate NO_3 (mg/l)	11	BDL	NA	NA	NA	NA	2.03	**28.1**	NA
Calcium (mg/l)	--	10.3	3.19	23.7	2.42	59.2	19	11.4	2.42-59.2
Sodium (mg/l)	200	828	118	41	477	22	7.66	105	7.66-828
Magnesium (mg/l)	70	4.37	0.721	7.3	1.09	10.4	10.2	4.12	0.721-10.2
Potassium (mg/l	50	6.73	2.24	2.14	2.96	2.19	BDL	BDL	BDL-6.73
Iron (mg/l)	2	0.0281	0.091	BDL	BDL	BDL	BDL	0.0716	BDL-0.091
pH	6-9	**8.79**	NA	NA	NA	NA	8.06	7.9	NA

Groundwater quality in both the shallow and deep boreholes largely falls within the drinking water guideline values. The range of results indicates a groundwater quality baseline for the shallow and deeper aquifers that has been captured in **Tables 6 and 7**.

4 Geohydrological Modelling

The development of a numerical simulation model of the groundwater environment at Yzermyn is discussed in the following sections. A conceptual geohydrological model has been developed which combines the results of the drilling (Scoping Phase and Assessment Phase) and testing programmes. The conceptual model was used as the basis for coding of the numerical groundwater flow and mass transport model. The numerical model was then used to indicate the extent and magnitude of groundwater impacts associated with the proposed Yzermyn Underground Coal Mine.

4.1 Conceptual Geohydrological Model

Twenty-three (23) groundwater strikes were recorded during the Scoping Phase and the Assessment Phase fieldwork:

- Six (6) at the base of weathered zone (18m – 29m bgl);
- Six (6) perched in colluvium or weathered siltstone (10m bgl);
- Six (6) in fractured rock (16m – 40m bgl); and
- Five (5) on geological contacts (44m – 191m bgl).

This suggests that three groundwater bodies exist in the project area:

- Perched on low permeability material in the weathered zone or in colluvium;
- Perched on hard rock at the base of the weathered zone; and
- Held in fractures and geological contacts;

These groundwater occurrences are similar to those identified at other sites in the general vicinity of Yzermyn. The occurrences are presented schematically in **Figure 7**.

Groundwater perched on low permeability material in the weathered zone or in colluvium may be a source of water to hillside seeps and springs. It is not clear what the source of water is for the wetlands identified at the proposed adit and plant site. The wetlands appear to be perched on low permeability material in the weathered zone and may also be fed from springs and shallow groundwater from the higher topography to the south of the adit and plant site (**Figure 7**). These groundwater bodies are likely to be directly recharged from rainfall.

Groundwater perched on hard unweathered rock at the base of the weathered zone may also be a source of water for wetlands. This water body would also be recharged from rainfall and the water level would be sensitive to seasonal variations in rainfall recharge.

Groundwater on horizontal and semi-horizontal contacts between different rock types may also be a source for springs. Springs appear to be associated with the dolerite sill that is present at higher altitudes in the project area. Hard rock dolerite is expected to have a significantly lower permeability compared to the Karoo-type rocks. Therefore dolerite sills may act as a barrier to vertical groundwater flow from shallow to deeper levels. The springs are considered to be fed by water bodies perched on the dolerite.

Groundwater in the deep aquifer is confined to fractures, faults and geological contacts at depth. Not all these features are expected to contain groundwater (**Figure 7**). Recharge of this groundwater body is expected to occur along those few fracture systems which connect the deeper aquifer to shallower groundwater bodies or directly to surface.

As a result of the limited connectivity between the deeper and shallower groundwater bodies drawdown in the deeper aquifer is expected to have a limited impact on the shallow perched aquifers. Faults and fractures may provide preferred pathways for groundwater flow and could result in locally significant inflows where intersected by underground workings. Dolerite contact zones are expected to act as preferential pathways to groundwater flow, similarly to faults and fractures.

4.2 Numerical Model Parameters

Based on available information, the aquifer parameters assigned to the conceptual model for the Karoo aquifers present in the project area are presented in **Table 8** below. These were used in the development of the numerical groundwater model.

Table 8: Conceptual Model (iLEH, 2013)

Aquifer Unit	Aquifer parameter	Value/Comment	Source
Shallow Weathered Karoo Aquifer	Thickness (m)	30	Exploration and monitoring borehole logs
	Depth of groundwater level (mbgl)	10	Average from 2013 shallow monitoring boreholes
	Saturated thickness	20	Based on available information
	Hydraulic conductivity (K) (m/d)	0.72	Average from 2013 shallow monitoring boreholes
	Storage coefficient	1E-3	Assumption, based on similar experience
	Rate of recharge (% of MAP)	2%	Assumption, based on similar experience
Deeper Fractured Rock Karoo Aquifer	Thickness (m)	300	Exploration and monitoring borehole logs
	Depth of groundwater level (mbgl)	20	Average from 2013 deep monitoring boreholes
	Saturated thickness	280	Based on available information
	Hydraulic conductivity (K) (m/d)	0.05	Average from 2013 deep monitoring boreholes
	Storage coefficient	1E-4	Assumption, based on similar experience
	Rate of recharge (% of MAP)	Not applicable	Not applicable to this layer
Dolerite intrusions	Thickness (m)	Discrete zones	Exploration and monitoring borehole logs
	Depth of groundwater level (mbgl)	Not available	Interpolated from DTM
	Saturated thickness	Varying	Based on DTM and zones in which dolerite occurs
	Hydraulic conductivity (K) (m/d)	0.001	Assumption, based on similar experience
	Storage coefficient	1E-5	Assumption, based on similar experience
	Rate of recharge (% of MAP)	1%	Assumption, based on similar experience, where dolerite outcrops

The fractured rock aquifer was simulated as two layers to enable the incorporation of the Alfred and Dundas underground workings. The parameters used for both layers remains the same as the fractured rock aquifer in Error! Reference source not found..

Groundwater receptors in the project area include the Assegaai and Mawandlane Rivers, both of which originate in the upland areas of the project area (see **Figure** 18 and **Figure 9**).

4.3 Numerical Modelling

The numerical model for the project was constructed using Processing MODFLOW Pro, a pre- and post-processing package for MODFLOW and MT3D. MODFLOW and MT3D is a widely used simulation code, which is well documented.

The following were included as inputs for the numerical model:

- The parameter information for the Karoo aquifers and dolerite intrusions presented above;
- The Digital Terrain Model (DTM) for the area was incorporated into the model as the topographical surface, and;
- Water levels used in the model were statistically calculated from site measurements and the DTM (by assuming a relationship between topography and groundwater level).

The model was calibrated in both steady state and transient state to quantify aquifer parameters.

Calibration for transmissivity, specific storage (or storativity) and recharge for the Karoo aquifer was undertaken, as these parameters are key to the simulations. These parameters were systematically varied to improve the match between simulated and measured groundwater levels. Due to the fact that the aquifer is heterogeneous and that values for these parameters were assigned regionally, it was not possible to match simulated and measured water levels exactly. A good match was however achieved with the available information (**Figure 10**).

4.4 Assessment of Uncertainties

The accuracy of the modelling project depends on the quality of the input data and the available information.

Future predictions were calculated with the calibrated groundwater flow model, which is a simplified version of reality. The model cannot be viewed as a precise simulation of reality and all models have inherent error in them. Numerical models are however good groundwater management tools that can be used in combination with other tools to develop management plans to minimise the impact of mining on aquifers.

Uncertainties are approached conservatively, based on the precautionary principle, to ensure that the predictions and impact assessment in this report addresses the maximum potential impact of the proposed mine. Uncertainty in this model relate to:

- **Assumption and estimation uncertainties:** The geohydrological characteristics of the aquifers. Quantification of the aquifer characteristics of the faults and dolerite intrusions specifically need to be confirmed through additional fieldwork. Both of these could influence groundwater flow patterns and the rate of the spread of contamination and must therefore be confirmed.
- **Mathematical modelling uncertainties:** It is not possible with the available information, timeframe and budget to quantify every fault zone to quantify the heterogeneity present in the aquifer. For this reason, there are inherent uncertainties in the model. The calibration results however indicate that these uncertainties are in acceptable limits in the project area and that the model can be used to estimate the impact of the Yzermyn Underground Coal Mine operations. It is however important to update the model on a regular basis, as more information becomes available.
- **Assumption on the timing of mining:** It is recommended that the mine schedule is included during simulations to refine the anticipated groundwater seepage rates to the underground workings.

5 Groundwater Impact Assessment

The geohydrological model was used to quantify the extent and magnitude of groundwater impacts. Those project components expected to result in significant groundwater risk were identified. Numerical model simulations were then run based on the inputs derived from previous sections. The resulting modelled impacts are discussed in this section.

The conceptual surface layout map used during this assessment, is presented in **Figure 6**. The following components of the proposed mining project are expected to impact on groundwater quantity and/or quality:

- **Discard facility:** To minimise discard quantity, the coal will be washed in two stages at the washing plant. This will maximise the recovery of saleable product from the Run-of-Mine (ROM) coal. For modelling of worst case scenario it has been assumed that the discard facility will not be lined. The base of the discard facility will however be compacted and sloped towards cut-off drains or toe paddocks to manage seepage.
- **Pollution control dams (PCD):** it is assumed that these dams will be lined with HDPE. Under this assumption, the PCDs are not considered a source to groundwater pollution, provided that they do not overtop and spill.
- **Coal stockpiles (ROM, Primary and Secondary):** the washed coal will be stockpiled on site before being transported offsite. It is assumed that the stockpile area will ~~not~~ be lined and will be placed directly on soil.
- **Underground workings:** conventional board and pillar underground mining methods will be used. This will involve drill and blast and continuous miner operations. The pillars will be 6m wide and to the mining height. No high extraction is planned. The dolerite sill intruded into the area is expected to increase the strength of the overburden material. ~~The risk of subsidence is therefore considered to be low~~. The estimated life of mine (LOM) is 15 years. It is estimated that 40% of the coal will remain as pillars. The underground void space is therefore 60% of the area disturbed.

Impact significance was determined using the WSP standard methodology adopted for the Yzermyn Underground Coal Mine ESIA. This considered the consequence and likelihood of potential impacts, based on:

- The modelled/anticipated deterioration of the baseline conditions;
- The duration of the impact;
- The modelled/anticipated extent of the impact;
- The frequency of the impact; and
- The probability of occurrence of the impact.

The significance of each assessed impact is presented in **Appendix E**.

There are three periods during the life of the mine that are expected to generate impacts; Construction Phase, Operational Phase and After Mine Closure. These impacts may be related to groundwater availability, groundwater quality, or both.

5.1 Construction Phase

List of activities that may have an impact on groundwater during the construction phase:

- Construction of the adit.

5.1.1 Groundwater Availability

The impact significance on groundwater levels during the construction of the adit phase will be limited since:

- The construction phase will be of short duration; and
- The adit is a small structure (7m wide, 3m high) relative to the aquifer extent.

Local dewatering of the aquifer is expected to occur around the adit when the excavation depth exceeds 10 m bgl. The modelled cone of depression is steep around the adit and will not extend more than 500m away (iLEH, 2013). Water level drawdown is expected to be limited to the weathered aquifer. Shallow groundwater beneath wetlands in the vicinity of the adit may be affected if perched water bodies are dewatered into the adit excavation.

Groundwater will seep into the adit and decline shaft but this flow is likely to be sealed off during lining of the adit walls. The volume of groundwater expected to seep into the adit during the construction phase is estimated to be 35 to 80 m^3/d (iLEH, 2013). However, this may increase depending on whether significant water-bearing fractures and faults are intersected.

This impact is assessed to be of low to medium environmental significance (**Appendix E**).

5.1.2 Groundwater Quality

Adit construction is not expected to have an impact on surrounding groundwater quality as groundwater flow will be towards the adit due to dewatering. Groundwater flowing into the adit may be contaminated by:

- Occasional hydrocarbon spills or leaks from construction machinery; and
- Sulphide oxidation in the exposed coal seam, interburden and overburden.

To keep the operations dry excess water will be removed to the surface by pumping. This will be considered dirty water and will be dealt with in the mine's water management system.

This impact is assessed to be of low environmental significance (**Appendix E**).

5.2 Operational Phase

List of activities that may have an impact on groundwater during the operational phase:

- Inflow of groundwater into the underground workings;
- Dewatering of aquifers above the underground workings;
- Abstraction of groundwater for water supply;
- Development of acid mine drainage; and
- Seepage of contaminated groundwater from the discard facility.

5.2.1 Groundwater Availability

The availability of groundwater during the operational phase of the mine is anticipated to be affected by inflow of groundwater to the underground mine workings subsequent dewatering of the underground workings and potential abstraction of groundwater for water supply.

5.2.1.1 Inflow of groundwater to underground workings

Groundwater inflow is expected to occur when mining intersects water-bearing geological features such as water bearing faults, fractures and dyke contact zones. The numerical groundwater model was used to estimate the volume of groundwater flowing into the underground workings considering the range of permeabilities assigned to the deeper aquifer (**Table 9**).

Table 9: Simulated groundwater seepage rates (iLEH, 2013)

Groundwater seepage rate	Alfred Seam Workings	Dundas Seam Workings
Expected minimum (m^3/d)	327	549
Expected maximum (m^3/d)	917	1277
Expected average (m^3/d)	536	842

Modelling results indicate that inflow may vary between 330 and 1280 m^3/d (iLEH, 2013) over the life of the operation. Measured inflow during mining may differ significantly from the model results. This is because the model is not able to account for specific water-bearing features with characteristics that vary from the average considered in the model simulations.

This impact is assessed to be of medium environmental significance (**Appendix E**).

5.2.1.2 Aquifer dewatering

Groundwater inflow to the Yzermyn underground workings will result in reduced groundwater levels in aquifers above the workings. This creates a cone of depression above and around the mining area. The extent of the cone of depression depends on the depth of mining and the permeability of the aquifers that are dewatered.

Cones of depression in the deep aquifer were simulated in the numerical model and are presented in **Figure** 13**11, Figure 12** and **Figure 143**. These figures show the expected drawdown cone at five year intervals during the mining operations. The expected life of mine is 15 years.

Vertical hydraulic conductivity in the project area is expected to be lower than horizontal conductivity due to the horizontal layering of the sedimentary geology. Model results indicate groundwater levels in the deep aquifer may be affected up to 3.5km from the mine workings by the end of mining (**Figure 13**) (iLEH, 2013). Boundary conditions along the southwest model boundary have distorted the simulated drawdown cone. However, this is not expected to significantly impact on the validity of the simulations. The simulated drawdown cone provides a first order assessment of the impact of mining on the fractured rock aquifer.

The conceptual geological model suggests that the position and permeability of faults intersected by the underground workings will play a role in the extent and shape of the dewatering cone. However, it is uncertain whether the inferred faults in the geological model exist or would be water-bearing and act as preferential groundwater flow paths. Therefore two scenarios were tested in the numerical model:

- Water-bearing faults included as discrete zones in the fractured rock aquifer with hydraulic conductivities double that of the host rock (3m^2/d).
- Water-bearing faults with hydraulic conductivities equal to that of the host rock

Including the faults as transmissive features in the model resulted in similar simulated drawdowns to excluding the faults from the model. Highly transmissive water-bearing features may be present at Yzermyn even though there is no data to confirm this.

The shallow and deep aquifers are hydraulically connected. According to the conceptual geohydrological model flow from the shallow aquifer is considered to recharge the deep aquifer. Therefore, drawdown in the deep aquifer will also draw down water level in the shallow aquifer. The impact on water level in the shallow aquifer will depend on the connectivity between the two aquifers. This could not be quantified from the fieldwork programme or other geohydrology studies.

As indicated in the conceptual model, connectivity is likely to be localised and driven by geological structures which intersect both the shallow and deep aquifers. The numerical groundwater model assumed a uniform connectivity between the shallow and deep aquifers. The connectivity was assumed to be related to the transmissivity of the aquifers as determined from the fieldwork programme.

The modelled drawdown in the shallow aquifer as a result of mine dewatering is presented in **Figure 14**. Drawdown in the shallow aquifer after 15 years of mining is generally limited to a zone approximately 1 500m around the mine workings. The simulated shallow groundwater level declines up to 2m south of the adit and plant (**Figure 14**). This area includes several wetlands delineated by Natural Scientific Services (NSS, 2013). These have been indicated on **Figure 15**.

Geological exploration borehole results indicate no dolerite sills in the vicinity of the adit entrance. Therefore, the identified wetlands are not perched on dolerite. Based on the conceptual geohydrological model, wetlands near the base of slopes may obtain water from one or all of the following sources: the shallow aquifer, perched water and springs at higher altitude. The numerical simulations do not apply to water bodies perched on low permeability horizons in the weathered zone or colluvium deposits which are likely to be unaffected by lower water levels in the shallow weathered aquifer. The simulation results are considered to indicate that the volume of water available to the wetlands may be reduced by the decline in water level in the shallow aquifer.

The worst case impact would be experienced in those wetlands where the single source of water is the shallow weathered aquifer. There is no information indicating which of the wetlands this condition applies to, if any.

The proposed bord and pillar mining method is not expected to result in surface subsidence. Therefore, the low vertical permeability of the dolerite sill is not expected to increase due to fracturing induced by mining. As such, no significant impact on springs perched on dolerite is expected.

Based on the model simulation results, the boreholes and springs that may be affected by mine dewatering are listed in **Table 10**.

Table 10: Simulated drawdown in boreholes (iLEH, 2013)

BH ID	Simulated drawdown (m)	Comment
ATHA-BH4	0 – 5m	Scoping Phase Boreholes – not considered a significant impact. Borehole may continue to perform under pre-mining conditions.
ATHA-BH6		
ATHA-BH3	5 – 10m	Scoping Phase Boreholes – not considered a significant impact. Borehole may continue to perform under pre-mining conditions.
ATHA-BH1		
CBH4D	10 – 15m	Assessment Boreholes - may be a significant impact. Borehole may not continue to perform under pre-mining conditions.
CBH6		
BH116	15 – 20m	Assessment and Exploration Boreholes will probably be significant impacted on. Boreholes will not perform under pre-mining conditions. Reduced yields are expected to occur
CBH1		
BH056	20 – 25m	Assessment and Exploration Boreholes will probably be significantly impacted on. Boreholes will not perform under pre-mining conditions. Reduced yields/drying-up are expected to occur
CBH7D		
BH073	25 – 30m	Scoping Phase and Exploration Boreholes will probably be significantly impacted on. Boreholes will not perform under pre-mining conditions. Drying-up are expected to occur
BH084		
BH106		
ATHA-BH5		
CBH2D	>30m	Assessment and Exploration Boreholes will be significantly impacted on. Borehole will not perform under pre-mining conditions. Drying-up is expected to occur.
CBH3D		
CBH5D		
CBH8		
BH057		
BH092		
BH102		

The extent to which the boreholes will be impacted will depend on whether the borehole is located in the shallow or deep aquifer. It will also depend on the specific transmissivity characteristics of the water bearing feature(s) intersected.

This impact is assessed to be of high environmental significance (**Appendix E**).

5.2.1.3 Abstraction of Groundwater for use in Wash Plant and Mine Supply

The groundwater model was used to simulate abstraction from boreholes CBH2D and CBH3S. Based on aquifer test data it is unlikely that these boreholes could be continuously pumped at the rates provided in **Aquifer** characteristics have been determined from pump test and slug test data. Boreholes with estimated yield greater than 0.5l/s were tested using step drawdown and constant discharge tests from 10 to 15 June 2013. The remaining boreholes were slug tested.

Step tests were conducted on boreholes 2D, 3S and 7S. Three one-hour pumping steps were conducted at progressively increasing pumping rates with recovery measured on conclusion of pumping. This information was then used to determine a sustainable pumping rate for the constant discharge test of the borehole.

Constant discharge tests were conducted over a 24 hour period with recovery recorded immediately thereafter. Aquifer transmissivity was assessed from plots of drawdown versus time. Graphs for the three boreholes tested are provided in **Appendix C.**

Slug tests were undertaken on those boreholes with estimated yield less than 0.5l/s. Slug tests involve displacing the water in the borehole using a slug of known volume and measuring the recovery of the water level. Due to low yields some boreholes contained a slurry of silt and water with insufficient depth to conduct a slug test. These boreholes were reported as "filled with silt". Slug test field measurements and hydraulic conductivity calculations are provided in **Appendix D**.

The hydraulic properties determined from all tests are tabulated in **Table 5.**

Table 5**5**. It was therefore assumed that the boreholes will be pumped for 12 hours per day.

The model results are presented in **Figure 15**. The impact of mine dewatering is not included in the assessment. It is shown that groundwater levels may be drawn down to 36m in CBH2D and to 20m in CBH3S (iLEH, 2013). The resultant cone of depression in both the shallow and deeper aquifers is not expected to extend more than 1km from the boreholes.

Under the assumed pumping regime, some 430 m^3/d (12 900 m^3/month) of groundwater could be abstracted, which is equivalent to a third of the monthly water demand at the plant (iLEH, 2013). It is however noted that these two boreholes are between 2 and 3.5km from the plant which may limit their use as a convenient source of water supply.

Based on the field programme and model results the potential of the aquifer to provide bulk water supply appears to be limited. Bulk water abstraction therefore results in a significant drawdown of groundwater levels.

This impact is assessed to be of low to medium environmental significance (**Appendix E**).

5.2.2 Groundwater Quality

During the operational phase shallow groundwater quality could be impacted by the storage of concentrated discard material on the site at the proposed co-disposal discard facility seeping out into the receiving environment.

5.2.2.1 Seepage of contaminated water from discard facility

A source term presents the mass released from a contaminant source over time. It is generally developed using the results of geochemical characterisation of mine materials such as discard, overburden and coal. Source terms were estimated from published sources by Solution[H^+] (2013a) and supported by limited geochemical testing results (Solution[H+] 2013b).

Sulphate, a product of acid mine drainage, was used as an indicator of impact on groundwater quality. At moderate concentrations sulphate has limited chemical interaction in the aquifer. Sulphate is relatively mobile when compared to other dissolved constituents in groundwater. Therefore, sulphate mobility is a conservative indicator of the movement of dissolved groundwater contamination.

The discard facility source term was included in the groundwater model and is summarised in **Table 11**.

Table 11: Discard source term used during numerical modelling simulations

Source identified	Comment	Avg pH	Avg SO_4 at source (mg/l)	Avg SO_4 downstream in aquifer (mg/l)	Seepage rate
Discard facility	■ Consistent with site specific geochemical data ■ Infiltration to groundwater limited by the permeability of material underlying the discard ■ Infiltration rate could be similar to background rates, if discard slopes towards drains to capture excess seepage.	6.51	7400	862 – 2329*	Uncovered discard: 15 – 40% of MAP

Two scenarios were simulated:

- **High permeability:** The discard facility footprint was conservatively assigned the same permeability as the shallow aquifer; and

- **Low permeability:** The discard facility footprint was assigned a permeability of 10^{-7} cm/s, as specified for H:H waste facilities in the DWAF Minimum Requirements guidelines (DWAF 1998).

Model results indicate that the plume from the discard facility will move to the north and northeast with a smaller component to the south and west due to dispersion and the effect of increased recharge from the discard facility.

The high permeability scenario indicates sulphate concentrations of up to 650 mg/l (iLEH, 2013) in the shallow weathered aquifer adjacent to the discard facility. The contaminated groundwater plume is expected to extend up to 500m to the north of the facility and 500m west to the Mawandlane River after 15 years of operation (**Figure 16**). Groundwater sulphate concentrations at the plume front are expected to be more than 60 mg/l.

Under the low permeability scenario the extent of the sulphate plume does not change significantly. However, sulphate concentrations at the plume front are significantly lower with the modelled concentration at the Mawandlane River about 10 mg/l (**Figure 17**).

This impact is assessed to be of high environmental significance (**Appendix E**).

5.3 After Mine Closure

List of post-closure impacts on groundwater:

- Possible decant of contaminated water from the underground workings;
- Development of acid mine drainage (AMD) and contamination of water in the mine workings; and
- Contamination of the aquifer from surface and underground sources after mining ceases.

5.3.1 Groundwater Availability

Mining activities and mine dewatering will cease on mine closure. However, groundwater will continue to seep into the workings and the workings will eventually fill. Groundwater levels are expected to recover after mine closure. The recovery will not be immediate and the residual effects of the mine will still impact the surrounding environment.

5.3.1.1 Decant of water from the abandoned underground workings.

This impact relates to the addition of a water source where none existed before mining. This is likely to change ecological conditions around and downstream of the water source.

Numerical modelling indicates that groundwater levels will recover between 20 and 50 years after mining (iLEH, 2013). Since no ground subsidence is expected from mining recharge to the underground workings is expected to take place at natural (pre-mining) rates.

The proposed adit entrance is above the pre-mining groundwater level. Modelled post-mining groundwater levels are not significantly different to pre-mining levels. Therefore, it is considered unlikely that excess water from the underground workings will decant from the adit. Other access points to the underground workings (such as ventilation boreholes) may be a source of decant if located at a lower elevation than the adit.

If faults with high permeabilities are intersected in the workings, the hydraulic head at potential decant points may be higher than the pre-mining head. This could result in decant unless the decant points are sealed. A decant scenario was simulated in the numerical model considering a mining height of 1.2m and underground void space 60% of the total area mined. The assumptions and results are presented in **Table 12**.

Table 12: Summary of modelled decant scenario

Mining area	Recharge rate (% MAP)	Decant Elevation (mamsl)*	Average groundwater seepage rate (m^3/a)	Maximum groundwater seepage rate (m^3/a)	Estimated volume to decant level (m^3)	Time to flood (Years)	Decant Rate under maximum seepage conditions (m^3/d)

Alfred UG	2	1480	195 640	334 705	10 500 000	31 - 53	< 100
Dundas UG	2	1480	307 330	466 105	10 500 000	23 - 34	< 100

This impact is assessed to be of medium environmental significance (**Appendix E**).

5.3.2 Groundwater Quality

In the long-term oxidation of sulphide minerals exposed in the walls, roof and floor of the mine workings may lead to acid mine drainage (AMD). This will affect the quality of water accumulating in the mine workings. Lasting groundwater quality impacts may result, both at the level of the workings, and from surface decant. These impacts are discussed in the following sections.

5.3.2.1 Potential for acid mine drainage

The potential for acid mine drainage from the proposed mining activities was assessed by Solution[H+] (2013b). Fifteen samples were obtained from geological exploration boreholes drilled at the proposed Yzermyn Underground Coal Mine. The samples included:

- Five coal samples;
- Five samples of sandstone/siltstone from the roof and floor of the Alfred Seam; and
- Five samples of sandstone/siltstone from the roof and floor of the Dundas Seam.

The samples were submitted for acid-base accounting (ABA) testing at Waterlab laboratory in Pretoria.

- All samples from the Dundas Seam roof and floor are non-potentially acid generating (non-PAG). This is due to low sulphur concentrations in the samples and significant neutralisation potential.
- All samples but one from the Alfred Seam roof and floor are potentially acid generating (PAG). This is due to higher sulphur concentrations than the Dundas samples although neutralistion potential (NP) values are similar.
- Two of five coal samples are PAG and the remainder uncertain. This arises since the coal samples generally have the highest sulphur concentrations. The coal samples also have significant NP. High paste pH values suggest that the coal seams may be associated with veins of calcite which is a source of NP.

Based on the ABA results, it appears that there may be distinct differences in drainage quality between the Dundas workings and discard, and the Alfred workings and discard.

A source term presents the mass released from a contaminant source over time. It is generally developed using the results of geochemical characterisation of mine materials such as discard, overburden and coal. Source terms were estimated from published sources by Solution[H^+] (2013a) and supported by limited geochemical characterisation (Solution[H+] 2013b). These are summarised in **Table 113** and subsequently used in numerical modelling of post-closure groundwater contamination.

Table 13: Summary of expected decant quality (Solution [H+], 2013)

Parameter	Most likely long-term scenario	Worst case long-term scenario
SO_4	< 450 mg/l	< 2500 mg/l
pH	>7	6 - 7

Acid mine drainage is not an environmental impact itself. AMD gives rise to impacts on surface and groundwater quality. Therefore, the impact significance of AMD has not been assessed. However, specific impacts from AMD contaminated water have been assessed individually in this report.

5.3.2.2 Contamination of aquifers from surface and underground sources after mining ceases

Water filling the workings after closure is a source of contamination. However, the hydraulic gradient and groundwater flow is generally towards the underground workings until groundwater levels recover after mine dewatering. As indicated in Section 5.3.1.1 it is expected to take 30 to 50 years before groundwater levels recover. Therefore, significant movement of contamination from the mining areas is unlikely to occur until a considerable time after closure. Migration of contamination from the workings and discard facility was simulated in the numerical model.

Two scenarios of groundwater contamination from the discard facility were modelled:

- **High permeability:** The discard facility footprint was conservatively assigned the same permeability as the shallow aquifer; and
- **Low permeability:** The discard facility footprint was assigned a permeability of 10^{-7} cm/s, as specified for H:H waste facilities in the DWAF Minimum Requirements guidelines (DWAF 1998).

The high permeability scenario indicates groundwater contamination will have extended approximately 1 600m north of the facility 100 years after closure (**Figure 198**). Modelled sulphate concentrations up to 500mg/l may be present at the head of the plume. The plume also extends northeast along the Mawandle River.

The low permeability scenario indicates a significantly reduce plume extent and concentration. The plume is modelled to extend approximately 1 000m north of the facility with sulphate concentrations of 10 to 20mg/l at the head of the plume (**Figure 19**). The low permeability sulphate plume also extends a shorter distance along the Mawandlane River (**Figure 19**).

Both model scenarios show potentially contaminated groundwater from the discard facility flowing into the Mawandlane River and the tributary of the Assegaai River. Normally the groundwater component of stream base flow is comparatively low. However, during the dry season, the groundwater base flow component may become more pronounced when surface runoff is reduced or absent.

Preliminary groundwater base flow calculations based on model results suggest groundwater flow of 27 m^3/d into the Mawandlane River. The associated salt load will depend on the contaminant concentrations in the inflowing groundwater. Base flow to the Assegaai River tributary is estimated to be 19 m^3/d.

Model simulations indicate that groundwater contamination will move from the mine workings in a north and northeast direction in the deeper fractured rock aquifer. The plume may extend more than 2km down gradient of the mining operations (**Figure** 20**20**). Simulations considered the inferred faults to act as preferential paths of groundwater flow.

This impact is assessed to be of medium environmental significance (**Appendix E**).

5.4 Key Assumptions

The groundwater study is based on the following assumptions and statements:

- The hydrogeological conceptual model and parameters for the project are based on available information and were inferred where necessary. Should additional information become available, it is recommended that the hydrogeological parameters presented in this report be re-evaluated. The values assumed during conceptualisation are discussed in **Section 4.2** above.
- The groundwater impact assessment is based on the information available at the time of compilation of this report. The results of this study and specifically the modelled impact assessment should be confirmed once additional information is available.
- Some aquifer parameters could not be obtained from the fieldwork programme results. Therefore, storativity for the two aquifers simulated and the characteristics of the dolerite intrusions, were inferred from experience with similar Karoo aquifers elsewhere.
- It was assumed that groundwater flow mimics the topography. Groundwater levels were statistically estimated from the DTM generated for the sub-catchment in which the project is situated.
- It was assumed that pollution control dams at the wash plant and discard facility will be lined and the plant area will be paved. These will limit seepage to the underlying aquifers. Therefore, the discard facility and underground workings are the only significant source of groundwater contamination considered in the numerical model.

- The contaminant source terms for the discard facility and underground workings should be revised once more specific information is available. This information may include geochemical analysis of discard samples once the wash plant is in operation, and samples of underground water during mining operations.

6 Groundwater Environmental Management Plan

Based on the impact assessment, the groundwater impacts of medium to high significance include:

- Aquifer dewatering;
- Groundwater contamination from the discard facility;
- Groundwater inflow to the underground workings; and
- Groundwater contamination from the flooded underground workings after closure.

Mitigation measures for the above impacts and general groundwater management measures are discussed in detail in this section under the headings of groundwater management and groundwater monitoring. For clarity Groundwater Management Programme has been tabulated in **Appendix F**. Initial estimates of management and monitoring costs are presented under the heading Financial Provision.

6.1 Groundwater Management

Specific mitigations to address identified significant groundwater impacts are presented by project phase in the following sections.

6.1.1 Construction Phase

Minimise the impact of aquifer dewatering during adit construction by ensuring that sufficient infrastructure is in place to manage underground water seepage. The following items are to be actioned:

- Water that is required for underground mining must be kept in a dedicated sump.
- Ensure that pollution control dams on surface are adequately sized to accommodate excess underground water. The pollution control dams must be lined to prevent seepage to the underlying aquifers.
- If the adit and underground workings need to be dewatered, an application for a water use license must be made to the Department of Water Affairs (DWA).
- Prevent dirty water runoff from leaving the general mining area. The surface water management plan must allow for the volumes of dirty water removed from the adit and mine workings.
- The plant area must be paved to prevent contaminated seepage from the stockpiles and coal washing areas to the underlying aquifers.
- All dirty water from the plant area must be contained in the plant pollution control dams and re-used in the mining process.
- Compact the base of the discard facility to minimize infiltration of poor quality water to the underlying aquifers during the operational phase. Toe drains should be installed to remove discard seepage and reduce the volume available for infiltration to the aquifers.
- The water balance of the operations should consider the potential underground water make so that the additional volume can be managed in the dirty water management system.
- Seal the adit walls to reduce groundwater seepage into the excavations.
- Commence groundwater monitoring to establish a groundwater quality and level baseline against which future mining impacts can be measured.

6.1.1.1 Discard facility alternatives

Based on the results of this assessment, several alternatives to discard placement and the design of the discard facility have been identified. These include separation of Alfred and Dundas seam discards, changing the location and orientation of the proposed facility, and assessment of discard as a saleable product.

Since Yzermyn is a proposed mine, no samples of discard from the beneficiation plant were available for geochemical characterisation. However, the ABA results from coal seam and roof/floor samples collectively provide an indicator of the potential quality of coal discard material.

Four of 15 samples were found to be non-potentially acid generating (non-PAG). The remainder are either PAG or uncertain. The results are not definitive but suggest that NP could be strongly related to the occurrence of calcite veining and matrix cement in coal and sandstone samples. Therefore, the potential acid drainage risk is likely to be linked to the amount of calcite that persists in the discard after the washing process.

Given that the Dundas roof/floor rock samples are generally non-PAG, the discard from the Dundas workings may also have a lower acid rock drainage risk than discard from the Alfred workings. An alternative discard placement strategy would be to encapsulate high acid potential Alfred discard within lower acid potential Dundas discard. This could potentially reduce oxygen and moisture and therefore AMD generation in the Alfred discard. However, this would require separate washing of ROM from the Alfred and Dundas workings.

The numerically modelled plume of contaminated groundwater from the discard depends on the location of the facility. The proposed east-west orientation of the facility results in a wide front for release of contaminated seepage into two catchments (Mawandlane River and Assegai River tributary). Rotating the footprint so that the longer axis lies north-south could limite the potential impact to the Mawandlane River catchment.

Additional geochemical characterisation and numerical groundwater modelling of these alternatives is required to confirm the potential reduction in environmental impact.

Finally, the potential markets for coal fines and discard as low-quality coal should be assessed. If a saleable use for these materials can be found, the need for a co-disposal facility is largely removed and the potential groundwater contamination impact can be considerably reduced.

6.1.2 Operational Phase

The aim of groundwater management during the operational phase should be to restrict impact of polluted groundwater to the mining area and mitigate the loss of groundwater from the catchment. This will require implementation of the following:

- Implement and maintain a groundwater-monitoring programme as described in **Section 6.2**. Boreholes in the zone of impact, as listed in **Table** 34, should be included in the monitoring programme. The borehole distribution, monitoring frequency and parameters to be measured should be reviewed by a registered groundwater professional on an annual basis. The review should include recommendations for additional boreholes and/or modifications to the monitoring programme as required.
- It is important to measure the flow of all springs in the potential zone of impact before mining commences. This will establish a baseline against which future impacts can be measured.
- Should the groundwater-monitoring programme indicate that private boreholes/springs are impacted by mining activities; the provision of an alternative source of water supply should be negotiated with the affected party.
- Seal water bearing geological structures (faults, fractures, dykes) as they are intersected in the underground workings. This will reduce groundwater seepage into the workings and limit dewatering of surrounding aquifers.
- Re-use groundwater seepage collected in the underground workings in the mining process.
- Should the mine water balance become positive and underground safety is affected by wet underground conditions, an application to DWA must be made for a water use license to pump excess mine water.
- If subsidence above the workings is noted or anticipated, the groundwater impact assessment must be re-evaluated. Additional mitigation measures may be required to manage resulting groundwater impacts.

6.1.3 Mine Closure

The results of monitoring data obtained during the Construction and Operational Phases of the project will be required to obtain approval of mine closure from the Government. In any event, groundwater quality and groundwater level monitoring should continue for at least five years after mining ceases. The monitoring information will be used to update, verify and recalibrate the predictive tools to meet legal requirements.

The following actions are to be implemented during closure:

- The adit and other identified decant points (such as ventilation shafts) must be sealed with a low permeability barrier that will be chemically and geotechnically stable for an extended period.
- Use the results of the monitoring programme to confirm/validate the predicted impacts on groundwater availability and quality after closure.
- Update existing predictive tools to verify long-term impacts on groundwater. It is of specific importance that site specific geochemical information is used to update the contaminant transport modelling presented in this report.

Water in the underground workings will be affected by the coal seam roof and floor rocks. Based on the ABA results, water in the Dundas workings is not likely to be significantly affected by acid generation. However, water in the Alfred workings will be affected. Nevertheless, Dundas workings water is unlikely to be suitable for discharge.

Should significant post-closure decant be expected, it may be possible to blend Alfred and Dundas waters to achieve a consistent feed to a water treatment plant. Therefore, the post-closure mine water management strategy should consider the potential difference in Dundas and Alfred water quality and keep the waters separate as far as possible.

6.2 Groundwater Monitoring

Groundwater monitoring should include;

- Monitoring of groundwater levels in the monitoring and hydrocensus boreholes. This will indicate the impact of mine dewatering on the surrounding aquifers.
- Groundwater inflow into the underground workings by daily measuring volumes of water contained in underground sumps and the volume of water used for drilling, dust suppression or other mining activities.
- Specific measurement of discharge rates from water bearing geological structures intercepted in the workings.
- Sampling and laboratory analysis of groundwater from underground workings and the monitoring and hydrocensus boreholes.
- The monitoring programme, including borehole distribution, monitoring locations, monitoring frequency and parameters to be measured should be reviewed by a registered groundwater professional on an annual basis. The review should include recommendations for additional boreholes and/or modifications to the monitoring programme as required.

Table 14 presents the initial monitoring programme recommended for the proposed Yzermyn Underground Coal Mine.

Table 14: Recommended groundwater monitoring programme

Monitoring position	Sampling interval	Analysis	Water Quality Standards
Construction, Operational and Decommissioning Phases			
Monitoring boreholes	Quarterly (April, July, Oct, Jan)	Full chemical analysis Groundwater level	SANS: Class 1
Rainfall	Daily at the mine	No analysis	Not Applicable
Post-closure phase for 5 years after mining ceases *			
Monitoring boreholes	Quarterly (April, July, Oct, Jan)	Full chemical analysis Groundwater level	SANS: Class 1

Monitoring position	Sampling interval	Analysis	Water Quality Standards
Rainfall	Daily at the mine	No analysis	Not Applicable

*If the results of the screening elements show an increase in concentrations above 10%, the borehole must be resampled and a full chemical analysis be performed.

Laboratory analysis should be conducted by a SANAS accredited laboratory. The mine environmental officer should develop a groundwater-monitoring database to systematically store all relevant groundwater data. The database should be stored in multiple copies to ensure that data is preserved.

An annual compliance report should be compiled by a SACNASP registered groundwater professional. The compliance report should be submitted to the authorities for evaluation and comment. The mine is responsible for developing a monitoring response protocol after the completion of the Construction Phase of the project. This protocol should describe procedures in the event that groundwater-monitoring information indicates that action may be required.

6.3 Financial Provision

The financial provision that should be provided to comply with the commitments made with respect to groundwater includes:

- Groundwater monitoring during mining operations, according to the schedule presented in Table 14 above.
- The cost for mine dewatering is not included, as it is assumed that this cost will be absorbed in the mining operational budget for the project.
- Groundwater monitoring after mining ceases, for an initial period of five years. The length of this monitoring period must be negotiated with Government authorities during the Decommissioning Phase of the project.

References

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Irene Lea Environmental and Hydrogeology (iLEH). 2013. Yzermyn Underground Coal Mine: Numerical Groundwater Model. Draft Report. July 2013.

Mindset Mining Consultants (Pty) Ltd. 2013. Mining Works Programme submitted for a Mining Right Application. Dated January 2013.

Solution[H+], 2013a, PMM12-050.06-D1 Memo Yzermyn Source Term. Dated July 2013

Solution[H+], 2013b, PMM12-050.06-D3 Memo Yzermyn Source Term. Dated 22 August 2013

Republic of South Africa: Department of Mineral and Energy Affairs, 1988, 1:250000 Geological Map Series: 2730 Vryhied,

National Scientific Serves, 2013, Wetland Delineation for Yzermyn Underground Coal Mine, Dated August 2013

Appendix A: Figures

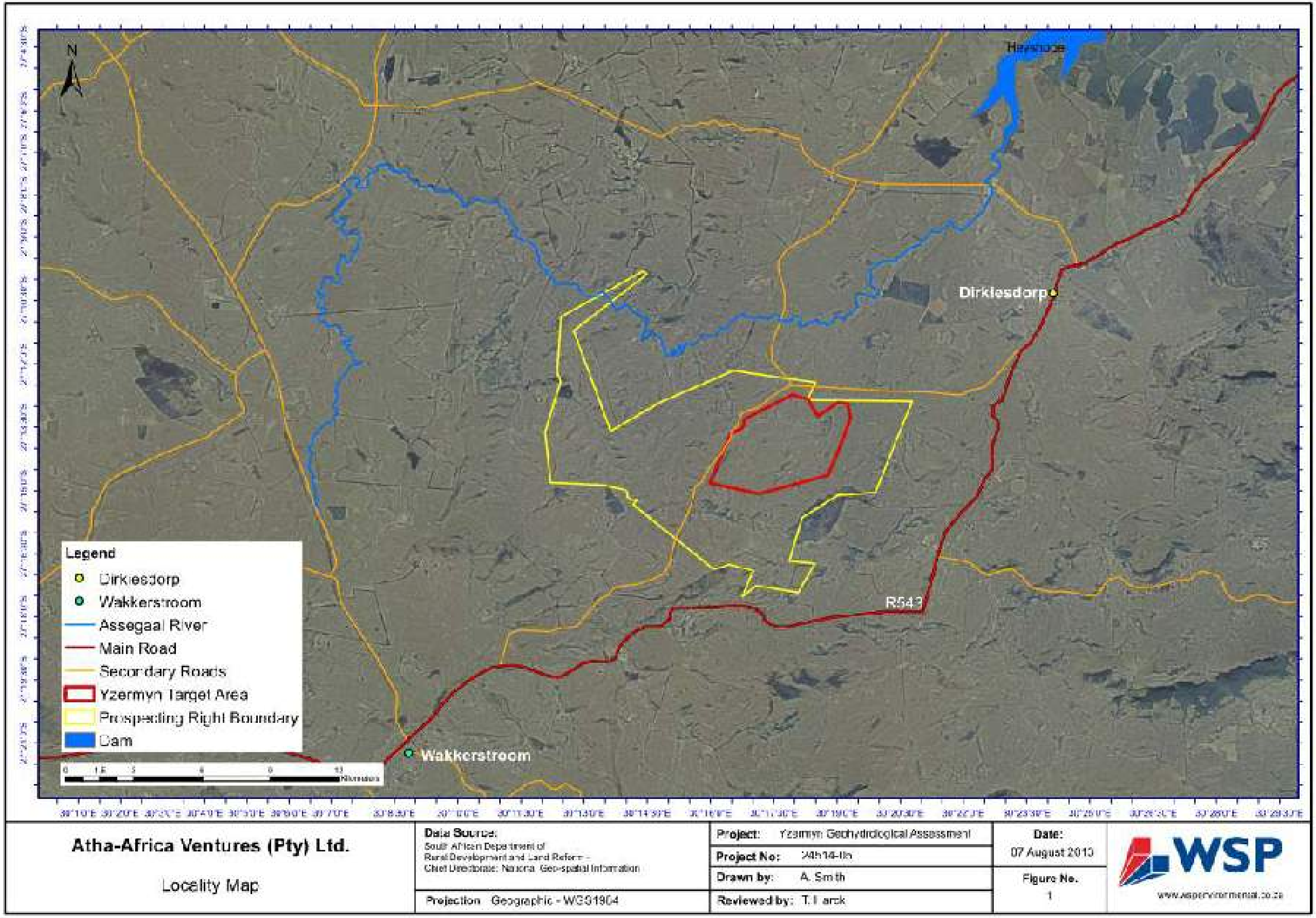


Figure 1: Locality Map of proposed Yzermyn Underground Coal Mine

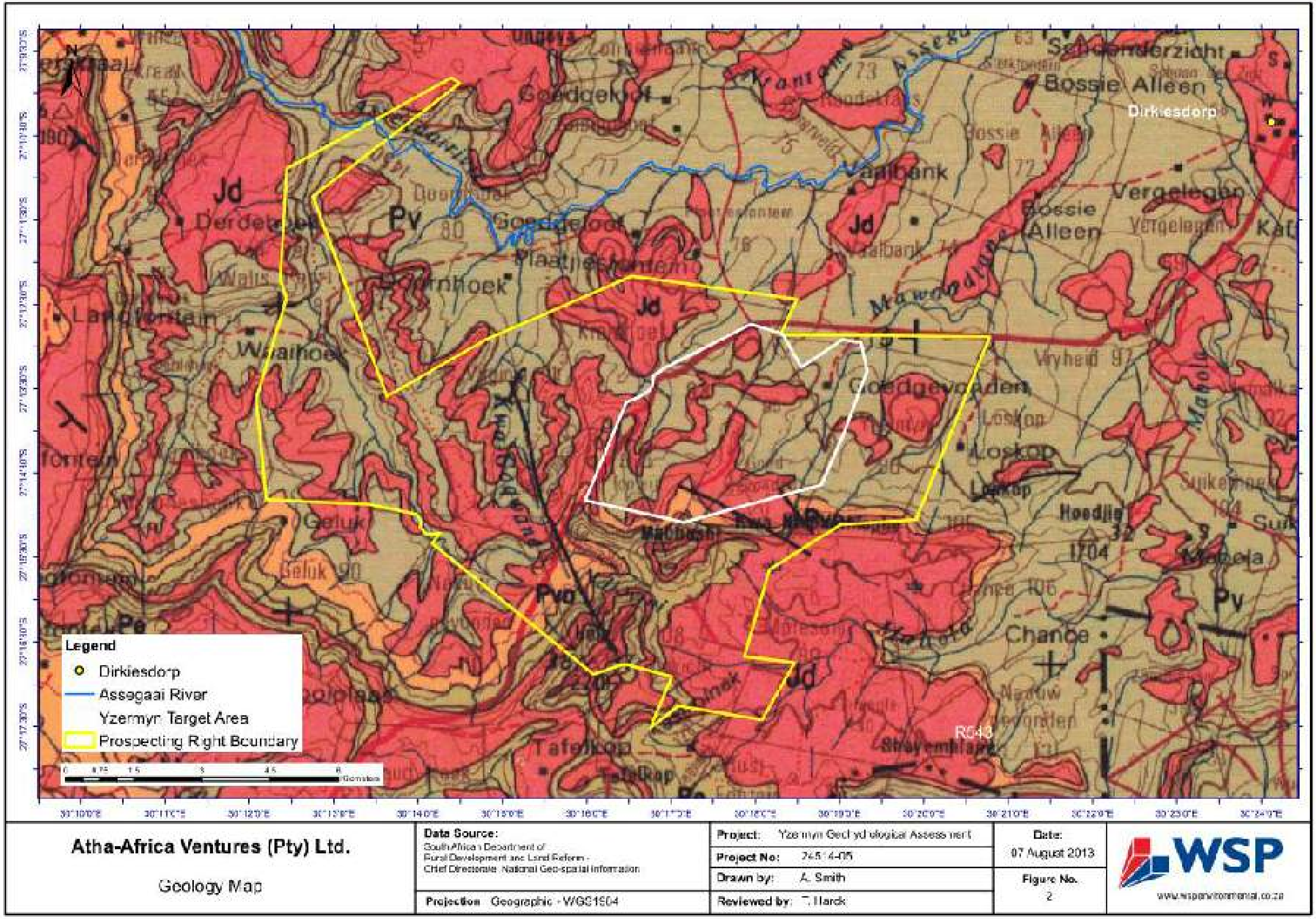


Figure 2: Geology Map of Mine Prospecting Area and Target Area (RSA:DMEA, 1988)

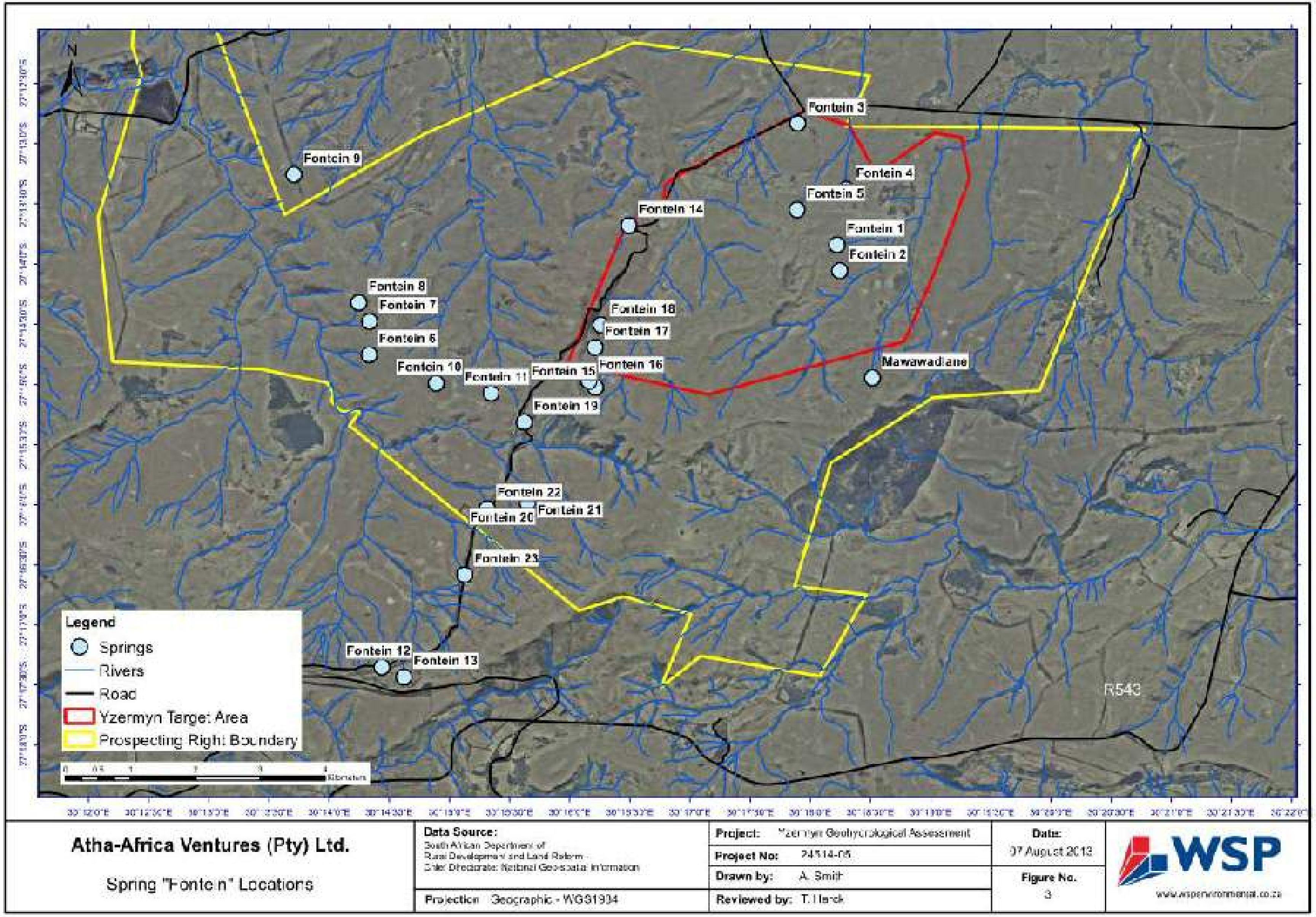


Figure 3: Locations of Springs Identified during Hydrocensus

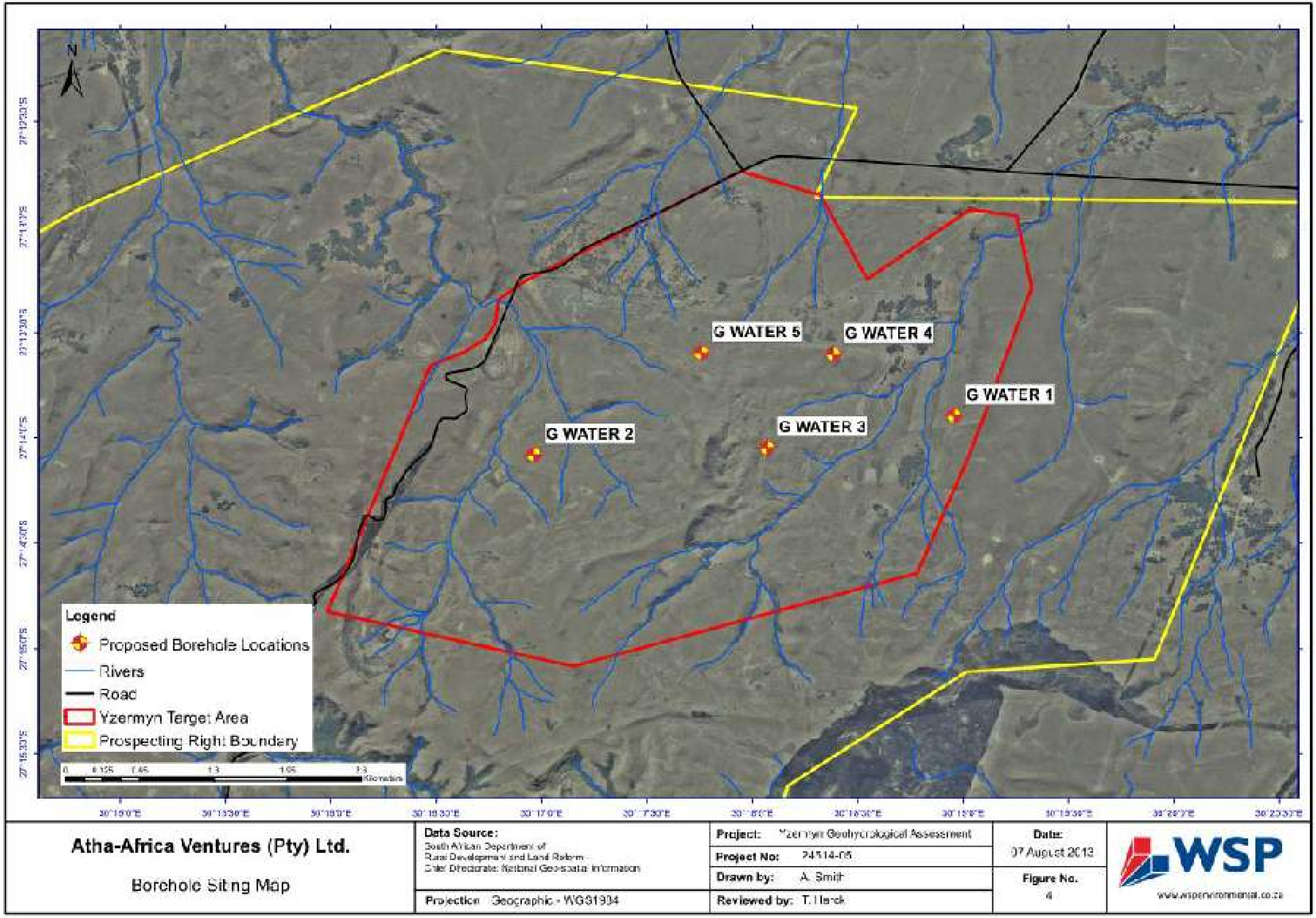


Figure 4: Borehole Siting Locations

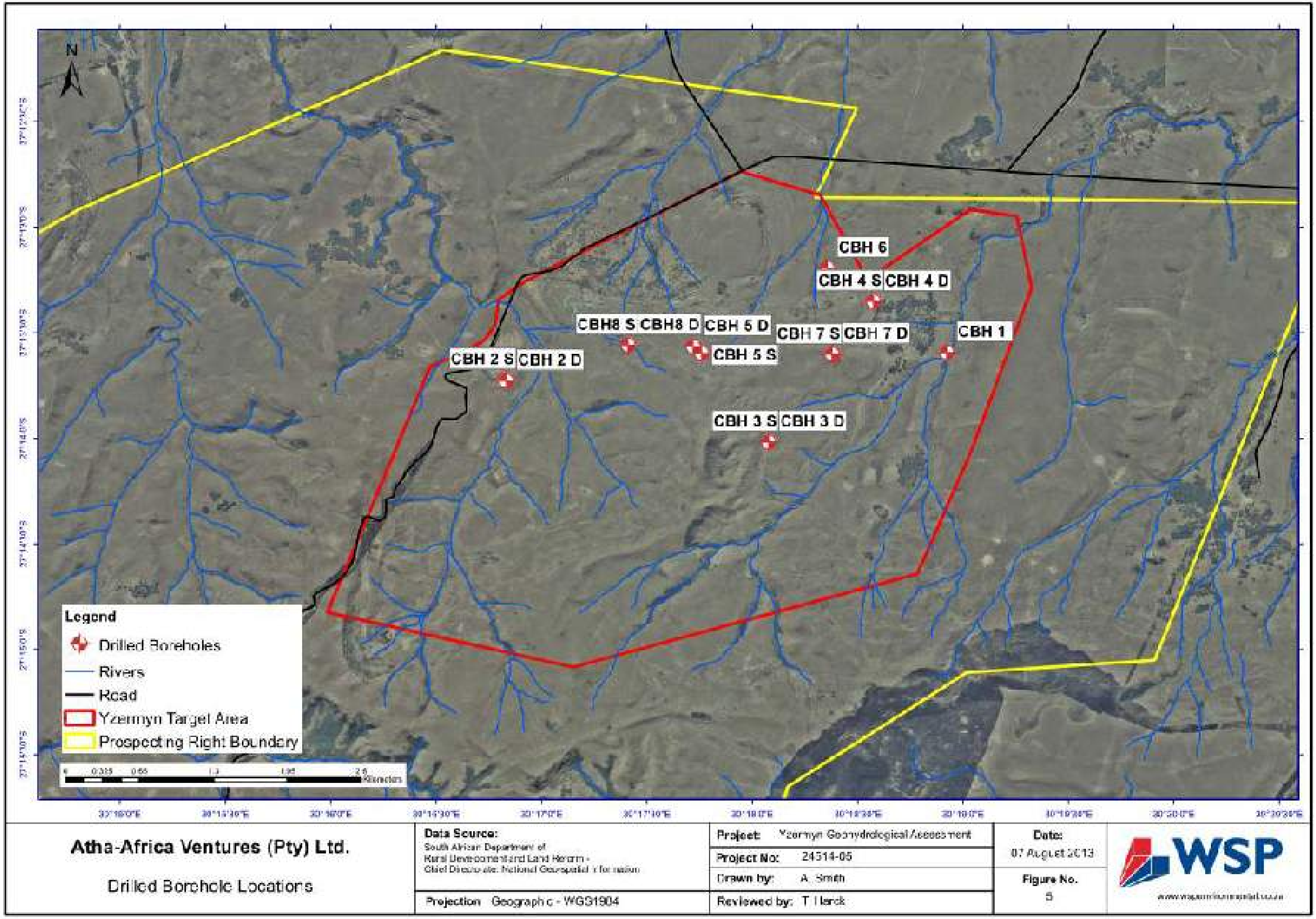


Figure 5: Drilled Borehole Locations

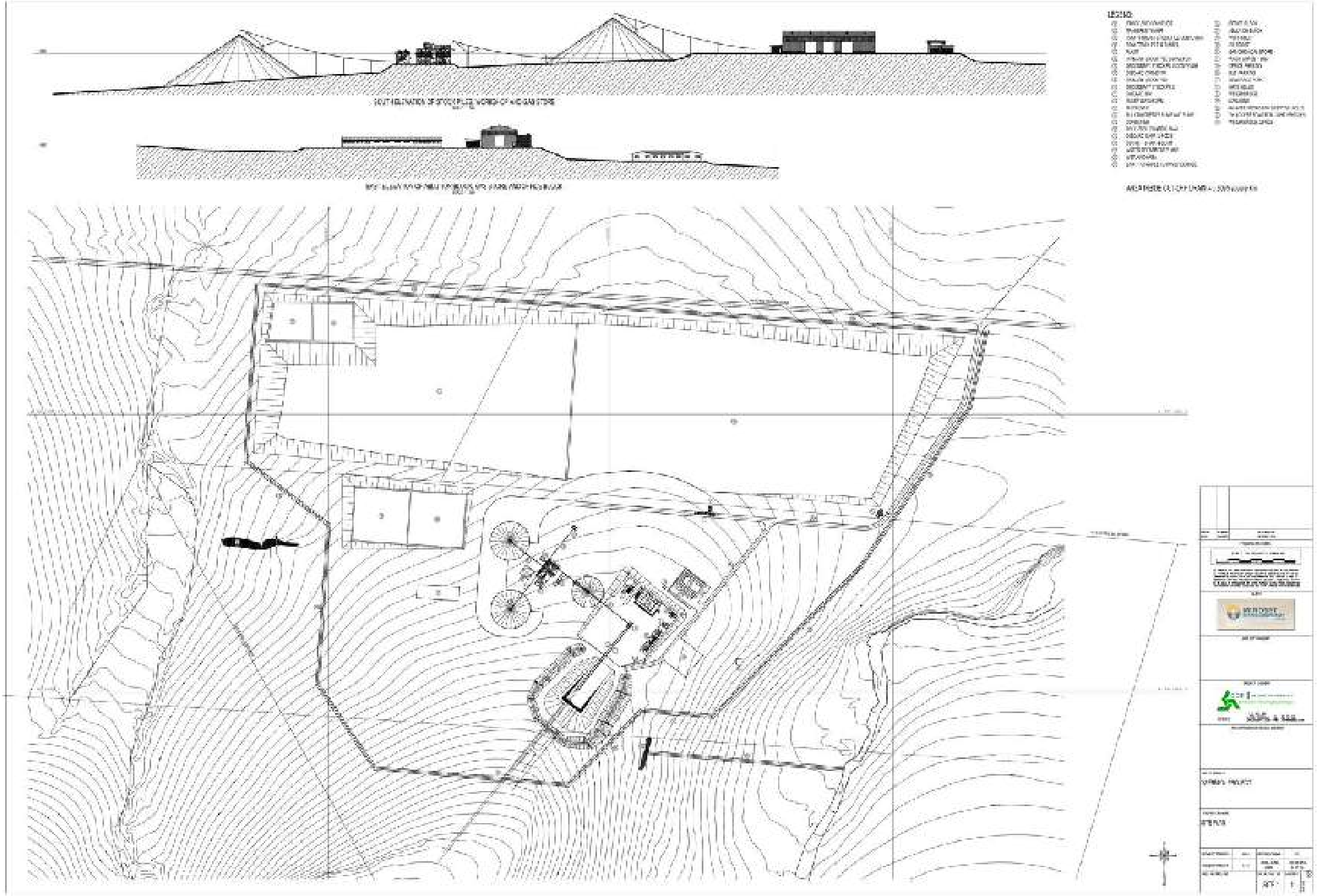


Figure 6: Surface Infrastructure Conceptual Layout (Mindset, 2013)

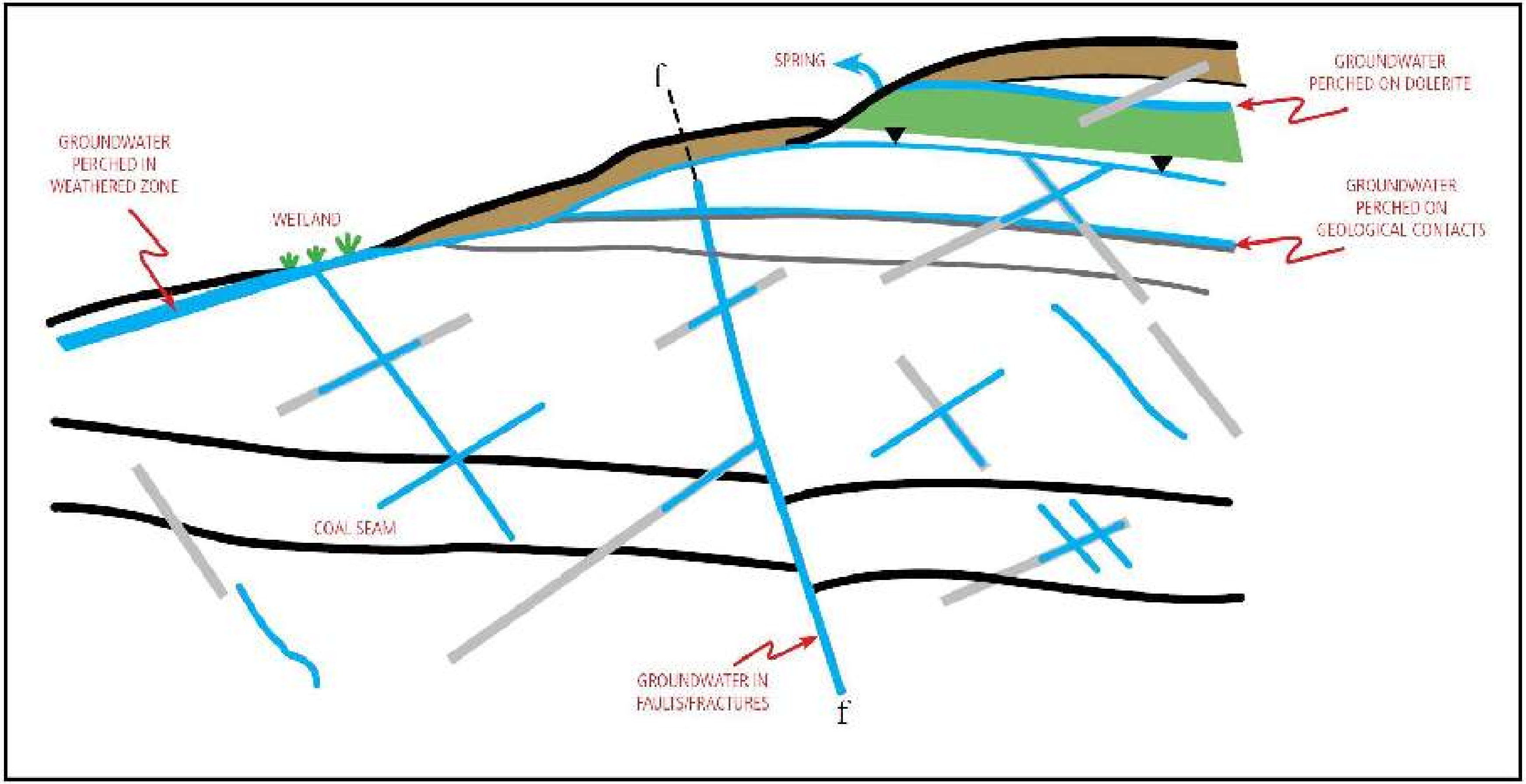


Figure 7: Conceptual Groundwater Model

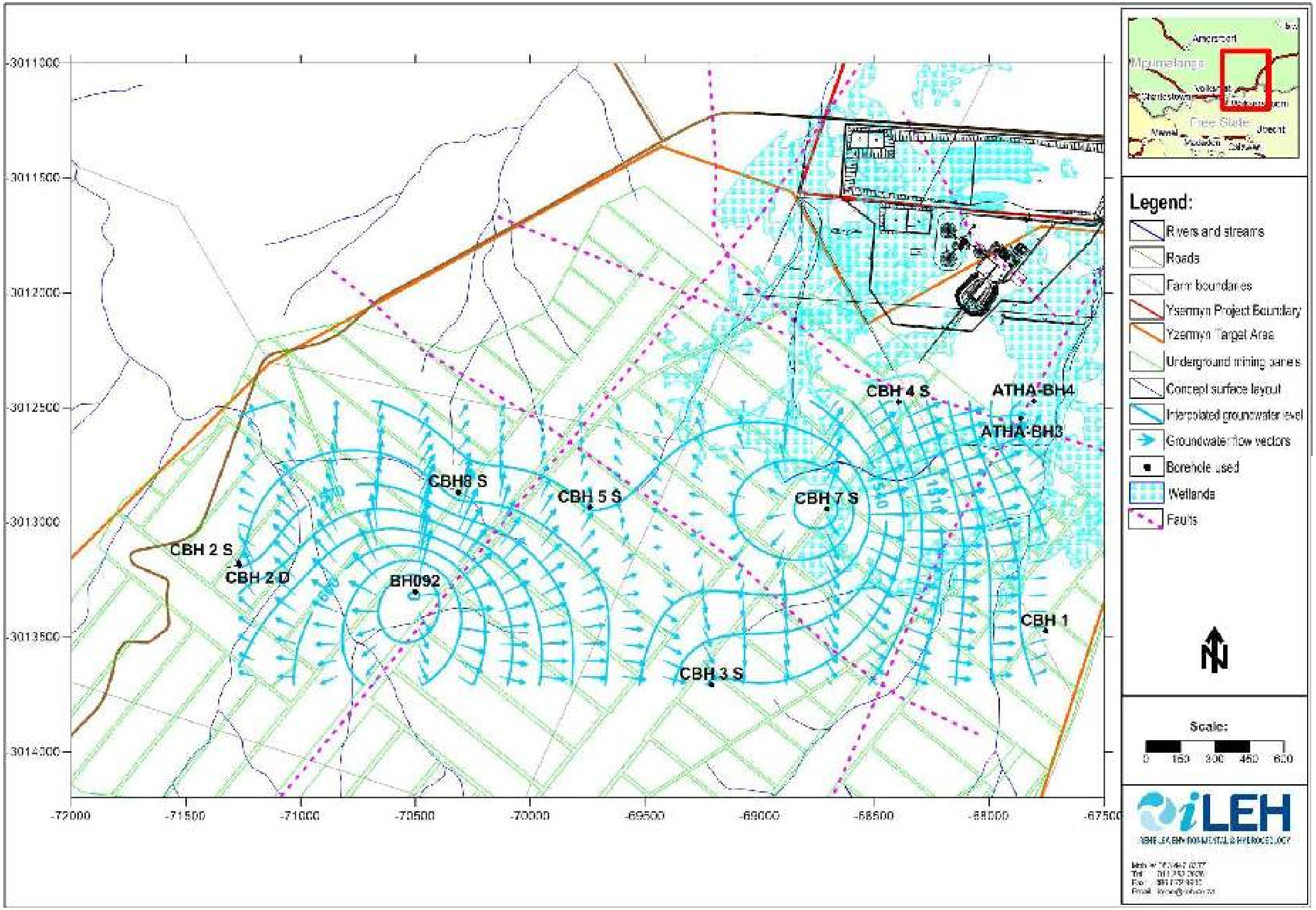


Figure 8: Groundwater flow patterns based on available field measurements for Shallow Aquifer (iLEH, 2013)

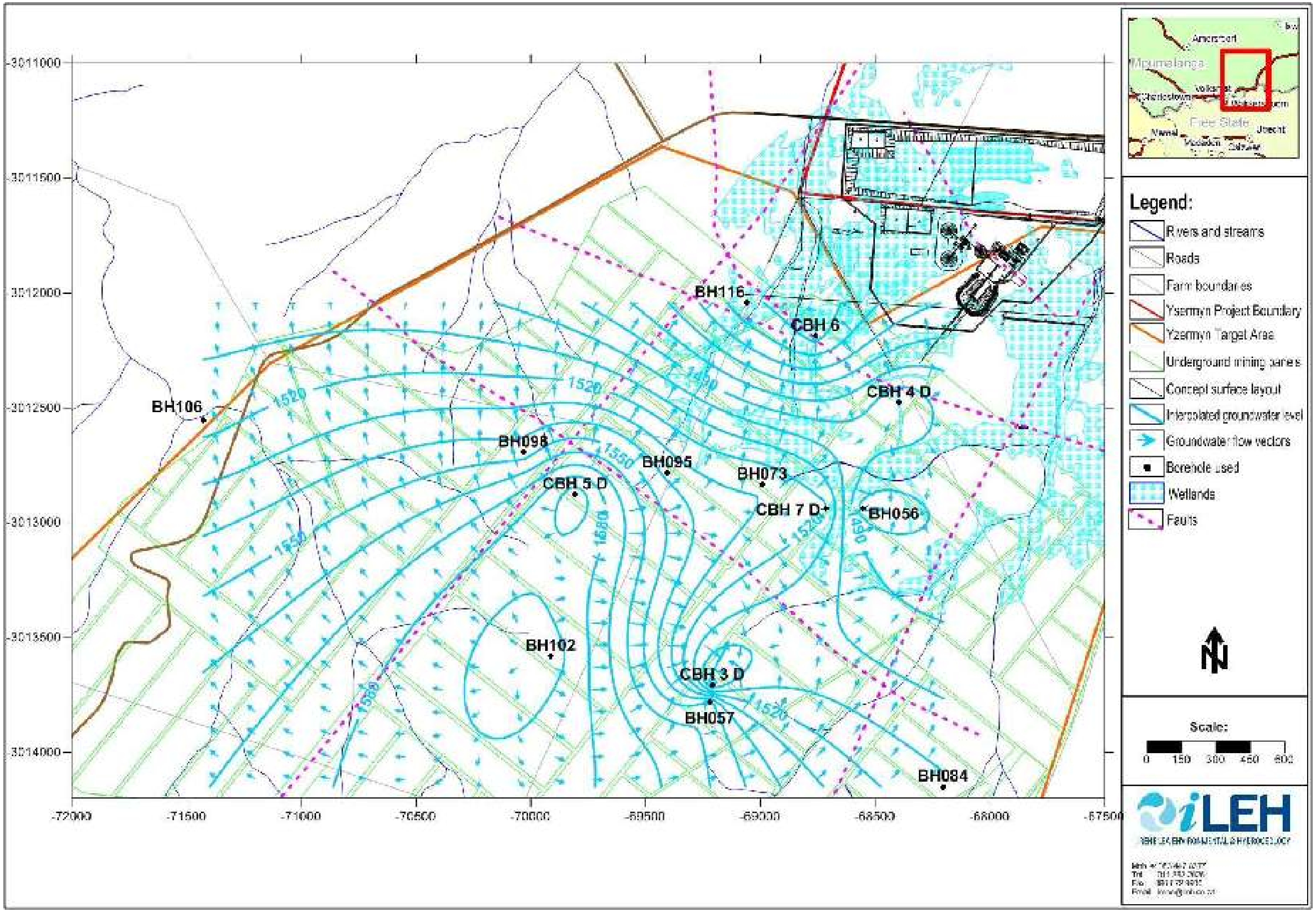


Figure 9: Groundwater flow patterns based on available field measurements for Deep Aquifer (iLEH, 2013)

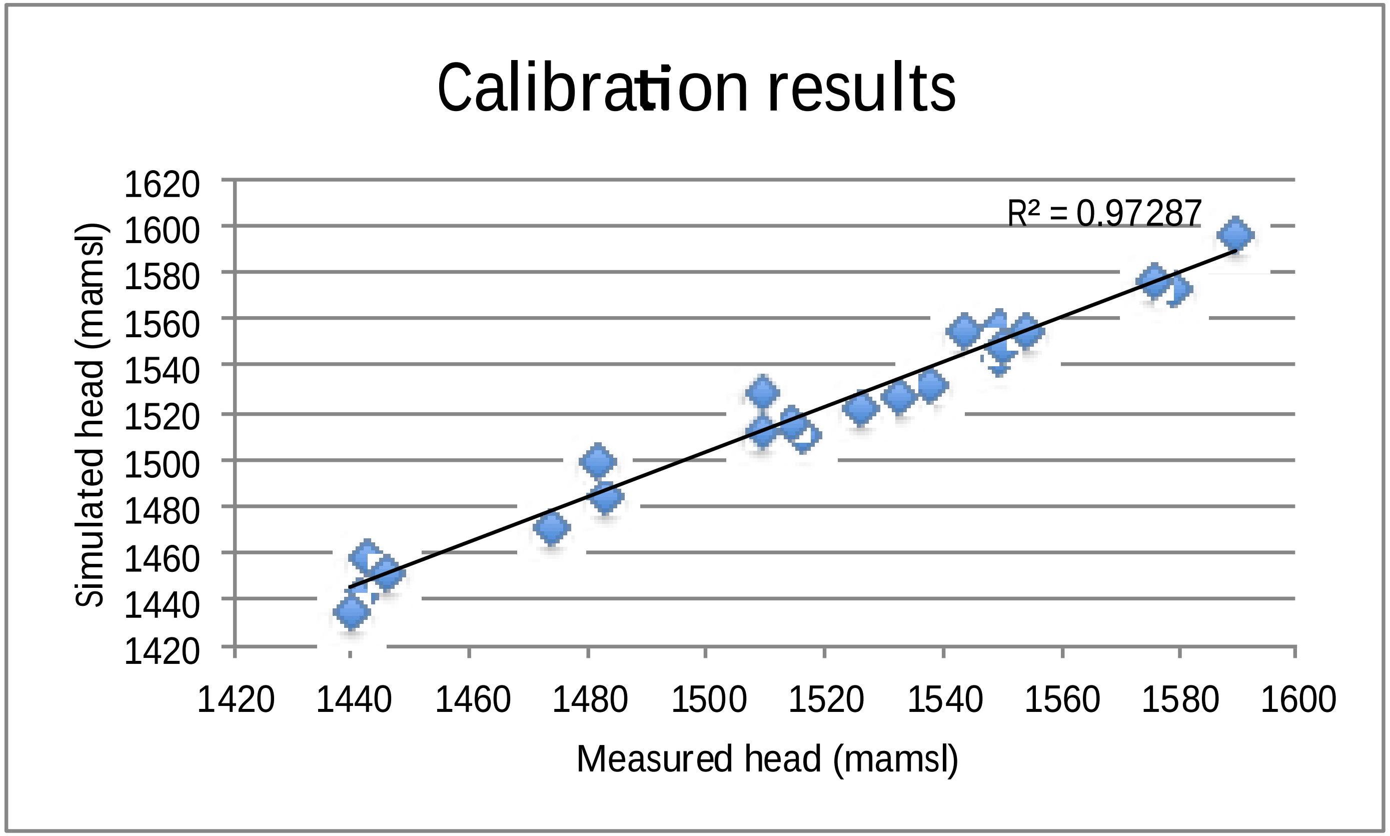


Figure 10: Model Calibration Results (iLEH, 2013)

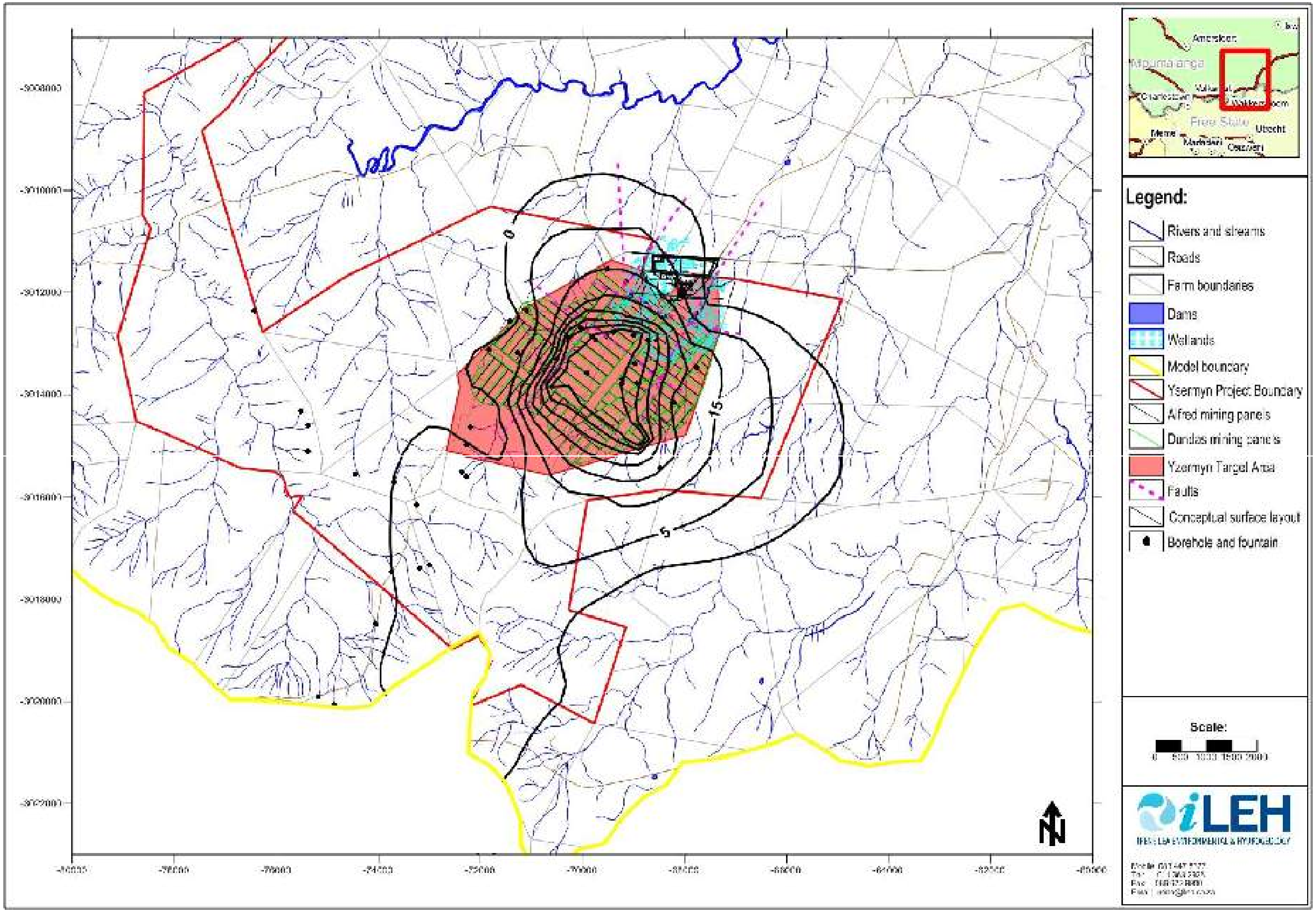


Figure 11: Simulated Drawdown in Deep Aquifer 0 – 5 years (iLEH, 2013)

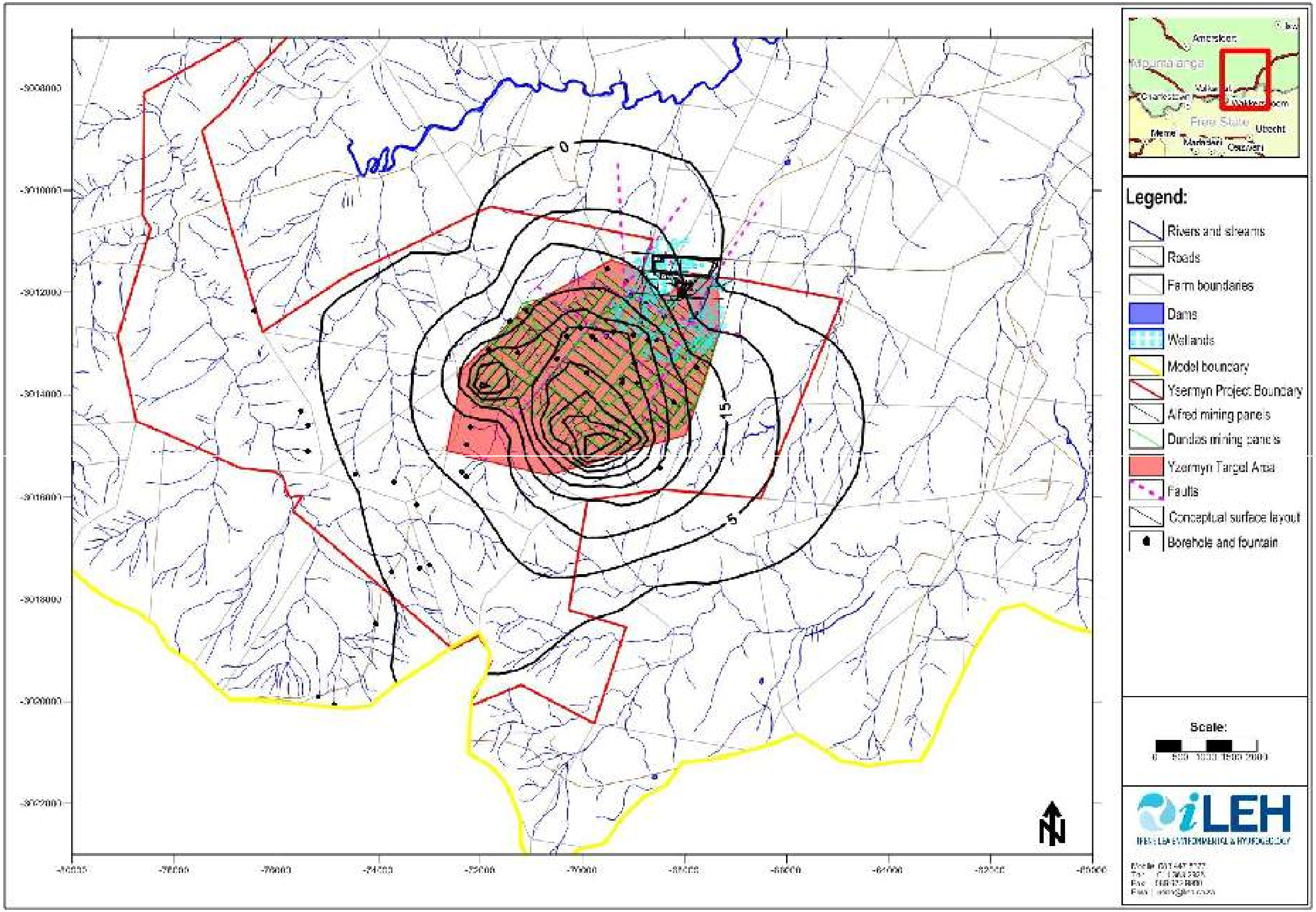


Figure 12: Simulated Drawdown in Deep Aquifer 5 – 10 years (iLEH, 2013)

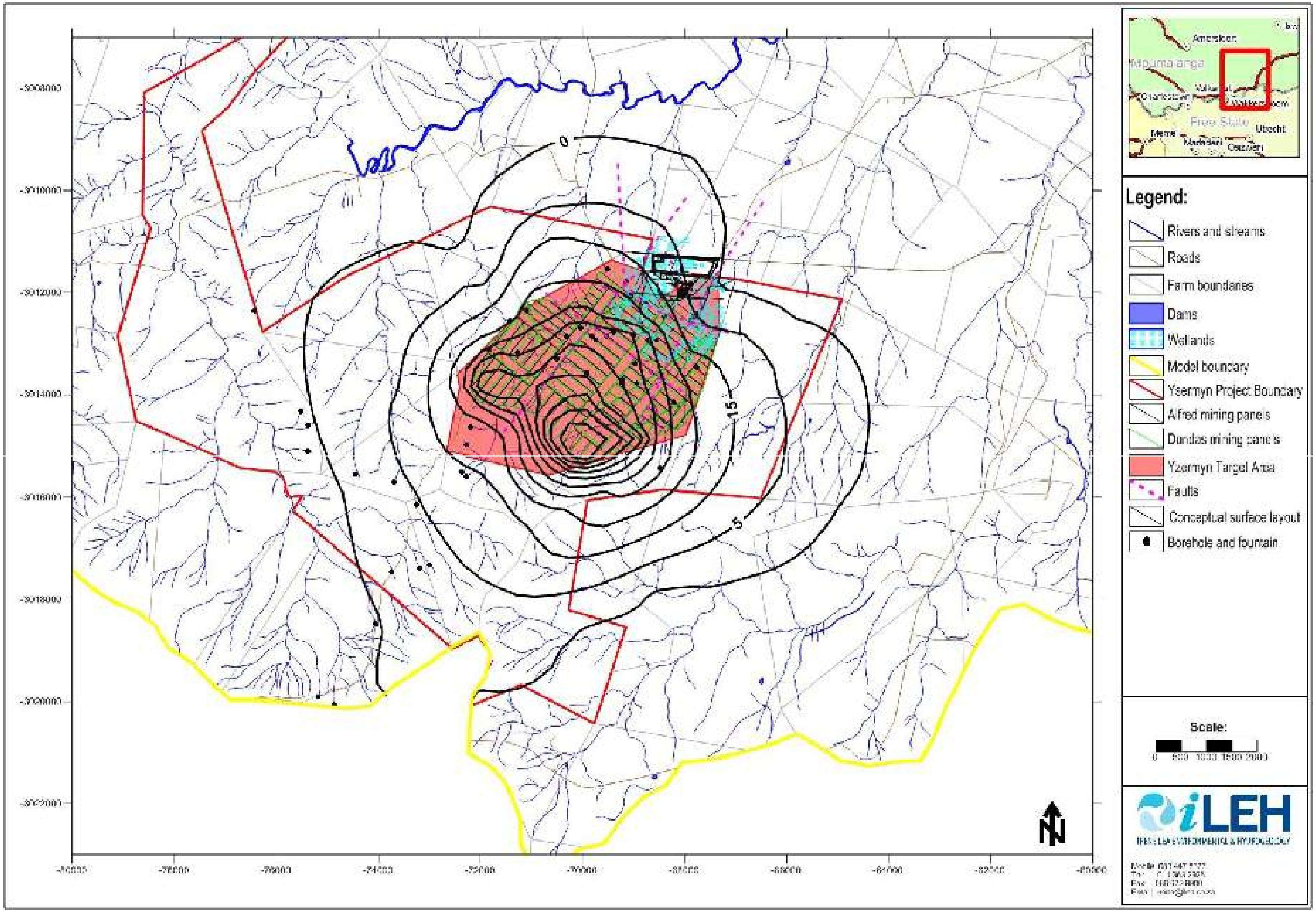


Figure 13: Simulated Drawdown in Deep Aquifer 11– 16 years (iLEH, 2013)

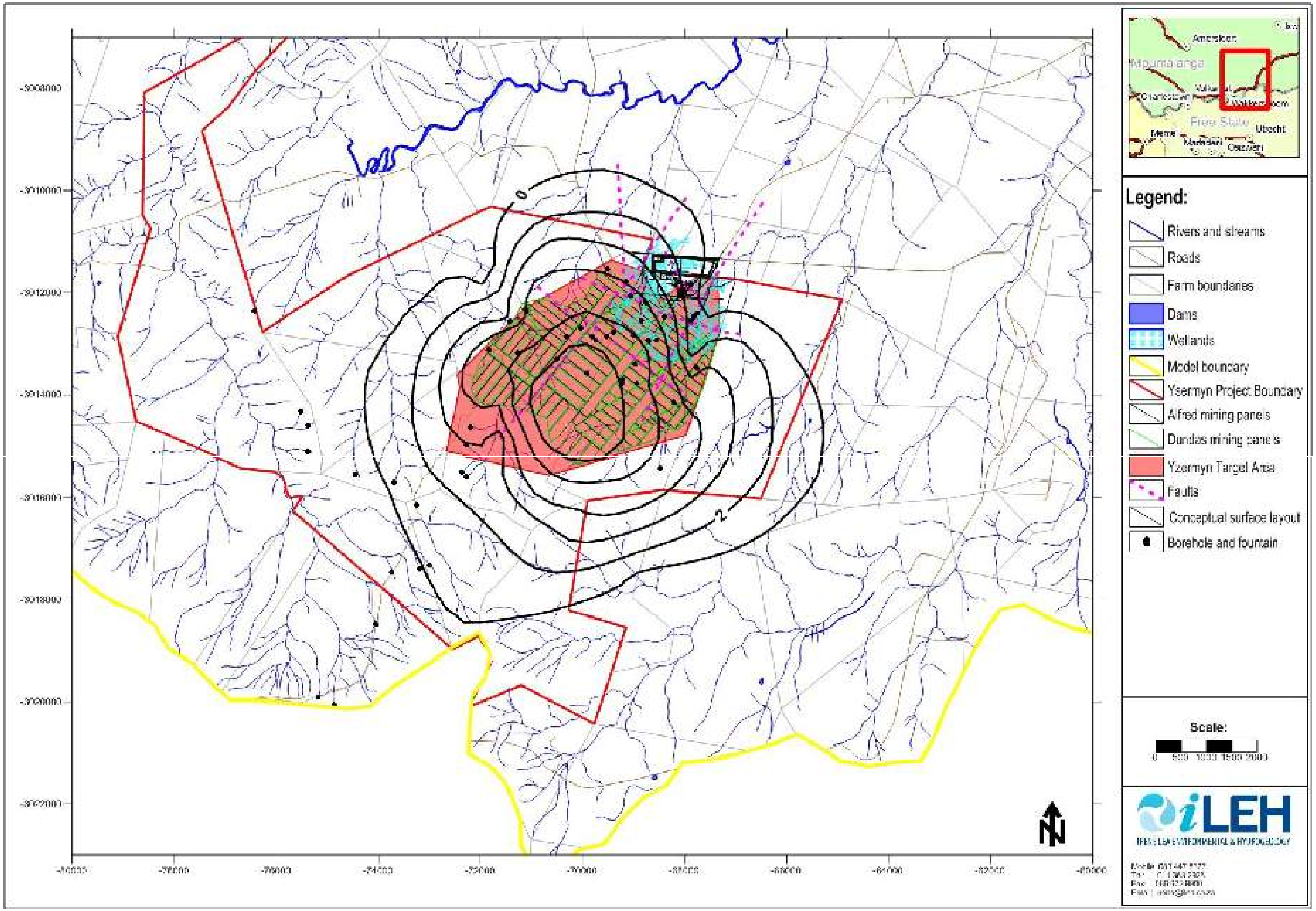


Figure 14: Simulated Drawdown in Shallow Aquifer 11– 16 years (iLEH, 2013)

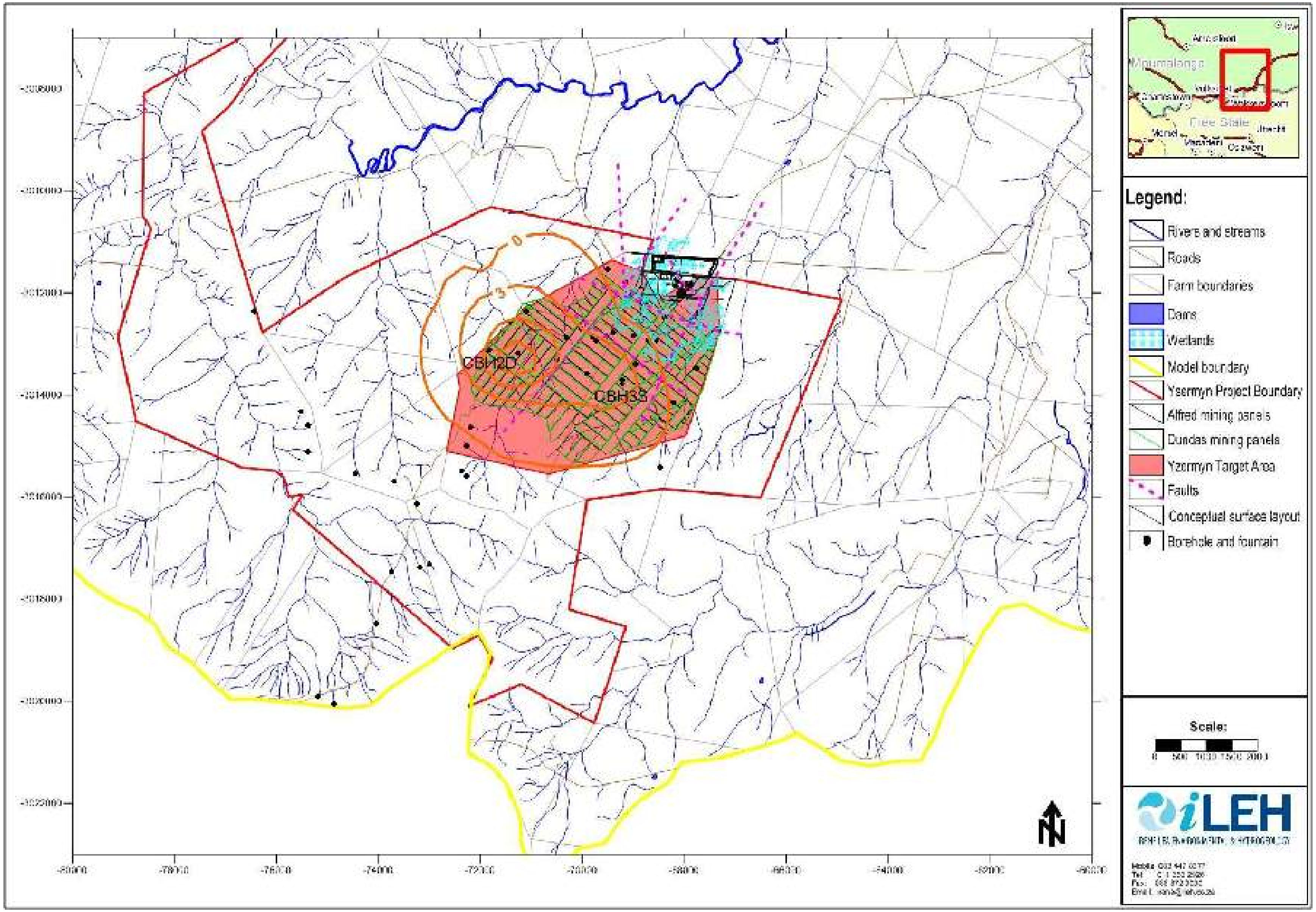


Figure 15: Simulated Drawdown of Extraction from Groundwater Supple Boreholes (iLEH, 2013)

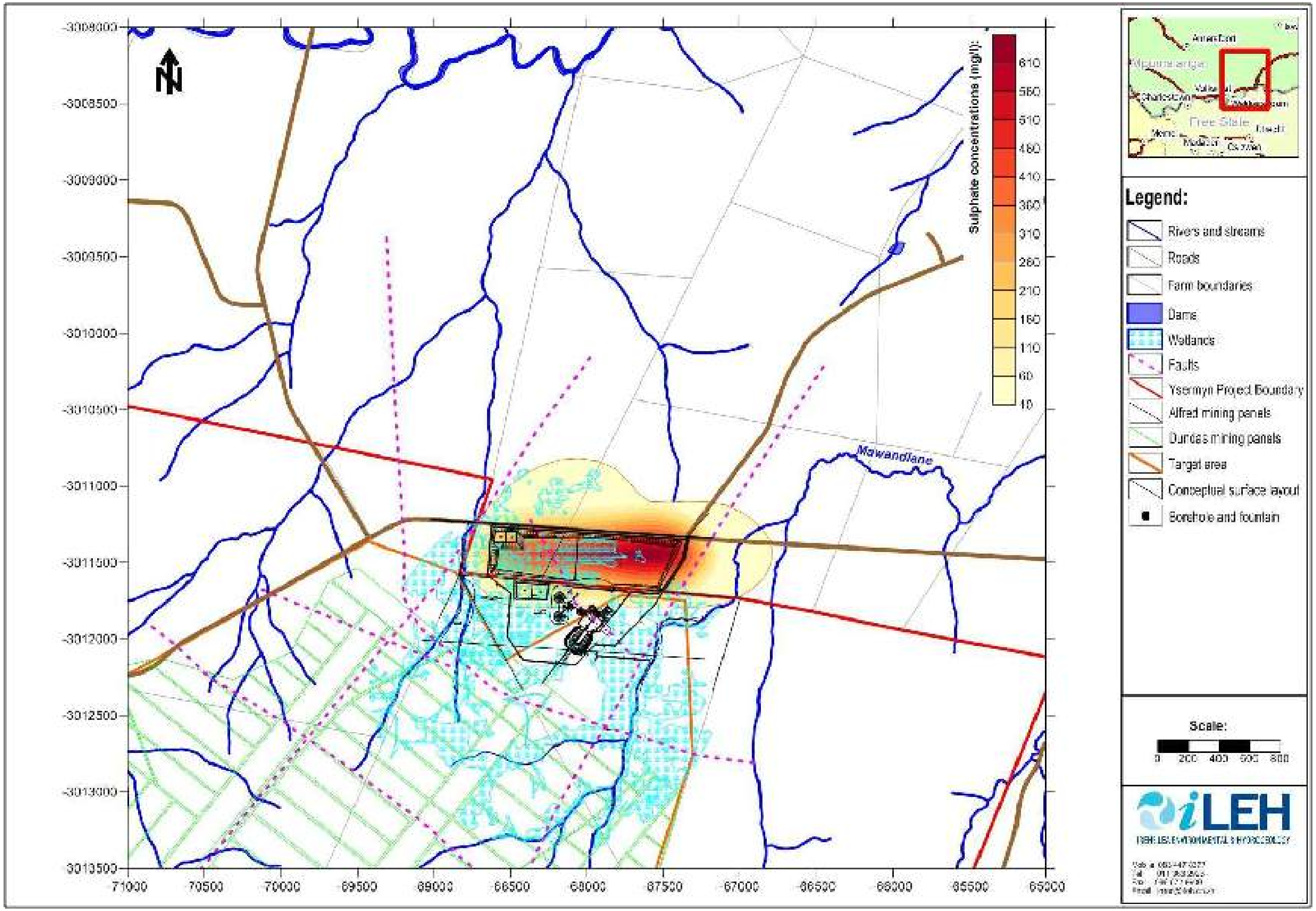


Figure 16: Simulates Sulphate Seepage from Discard facility at end of LOM High Permeability (iLEH, 2013)

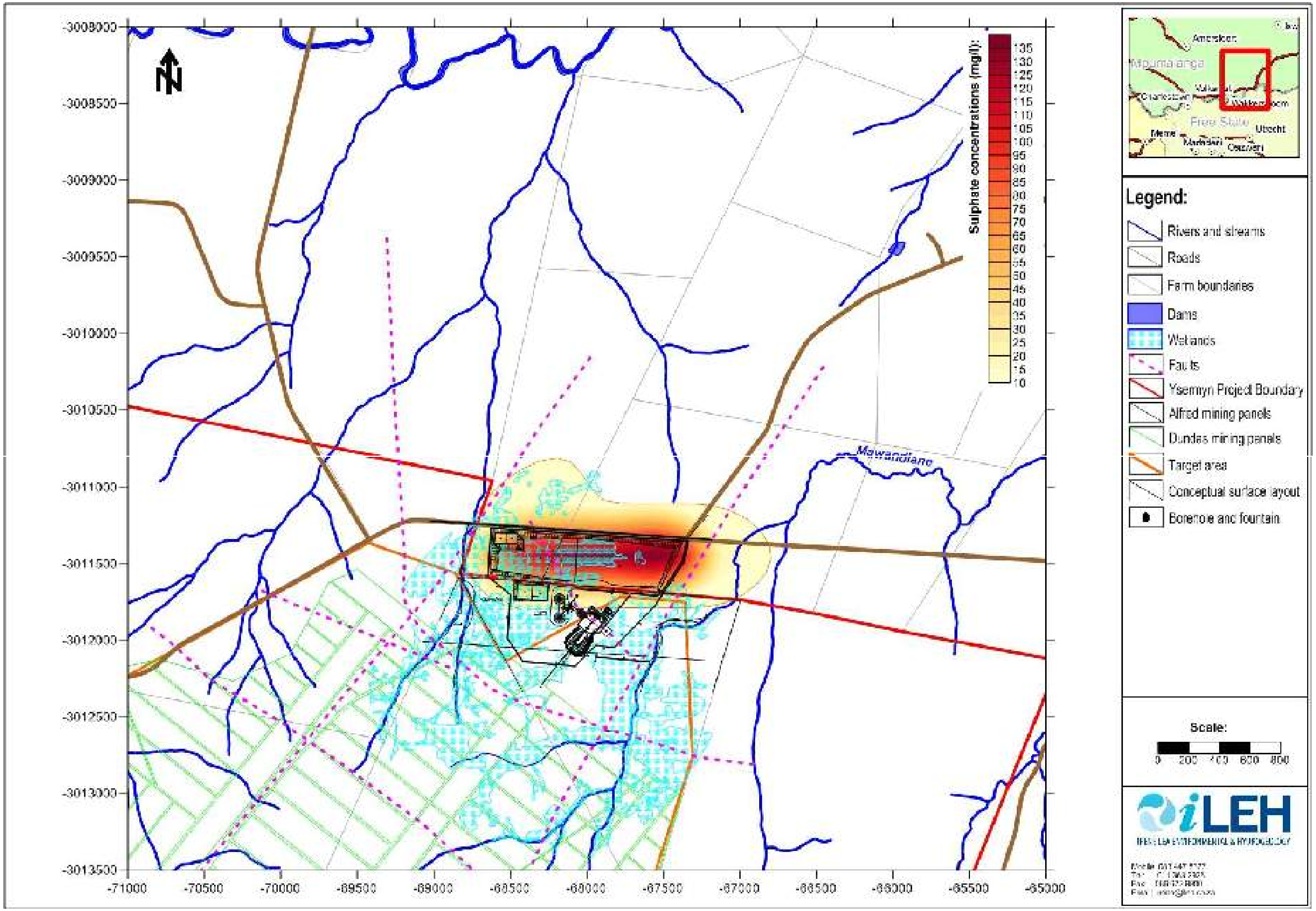


Figure 17: Simulates Sulphate Seepage from Discard facility at end of LOM Low Permeability (iLEH, 2013)

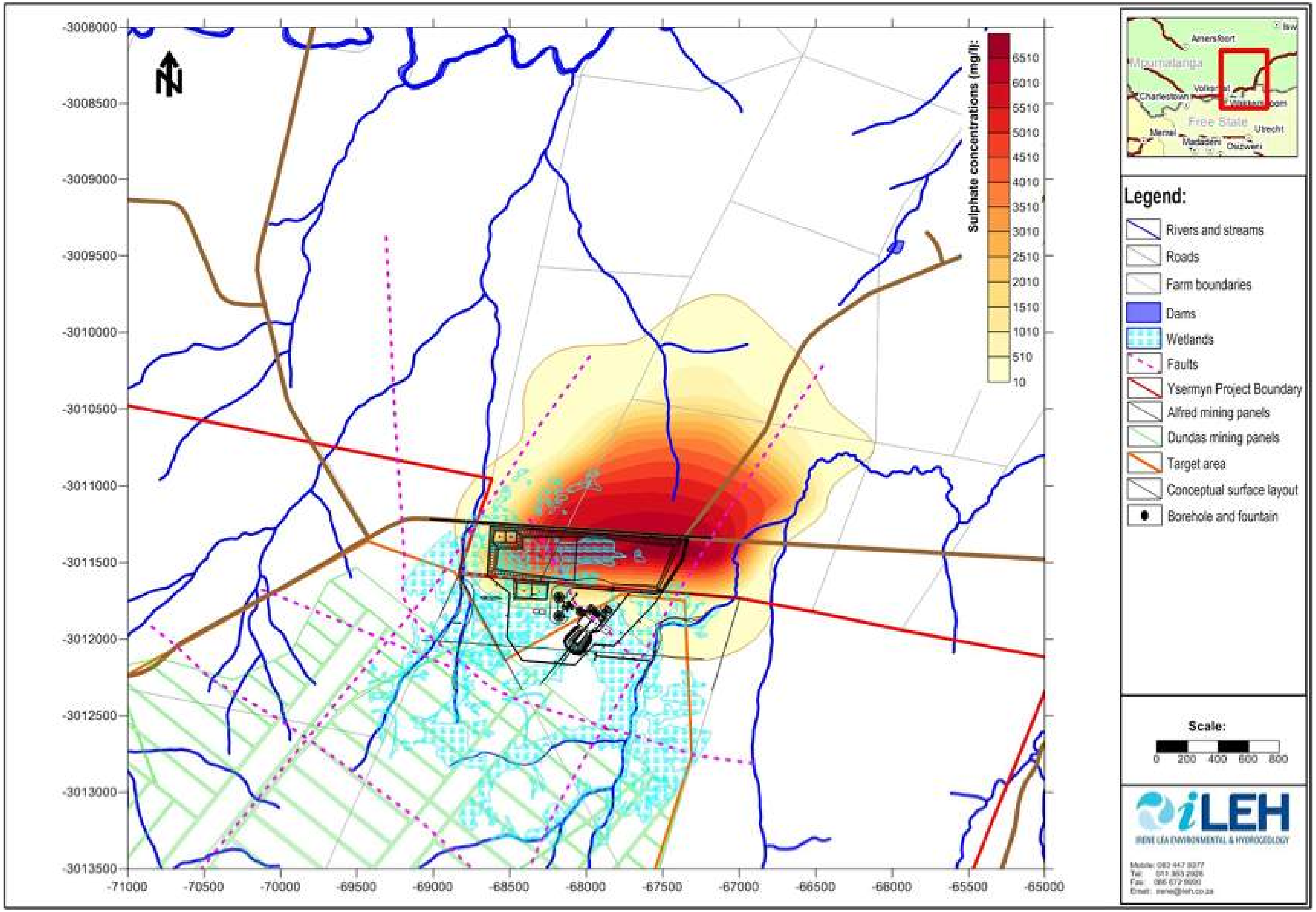


Figure 18: Simulates Sulphate Seepage from Discard facility at 100 years after LOM High Permeability (iLEH, 2013)

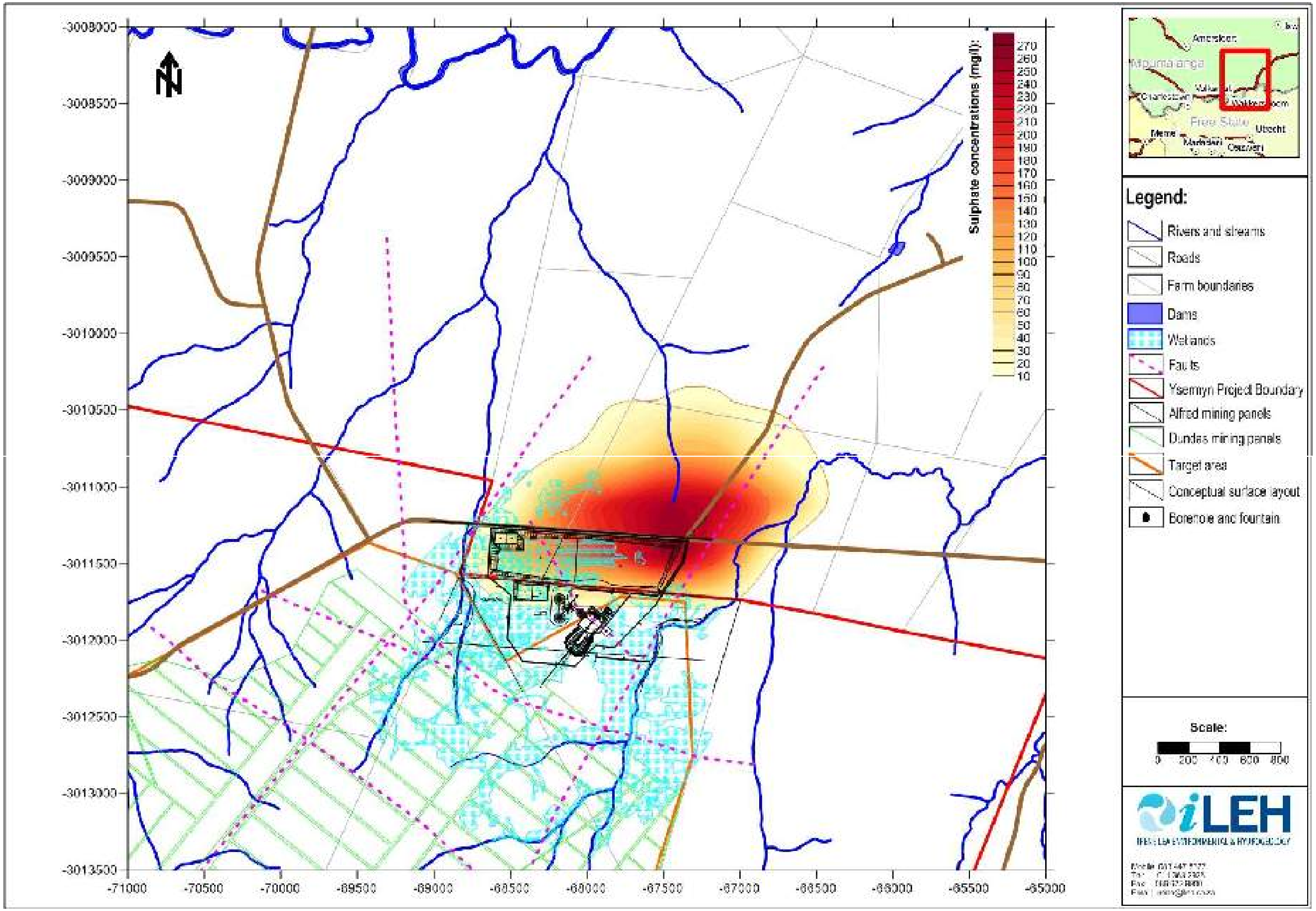


Figure 19: Simulates Sulphate Seepage at Discard facility 100 Years after LOM Low Permeability (iLEH, 2013)

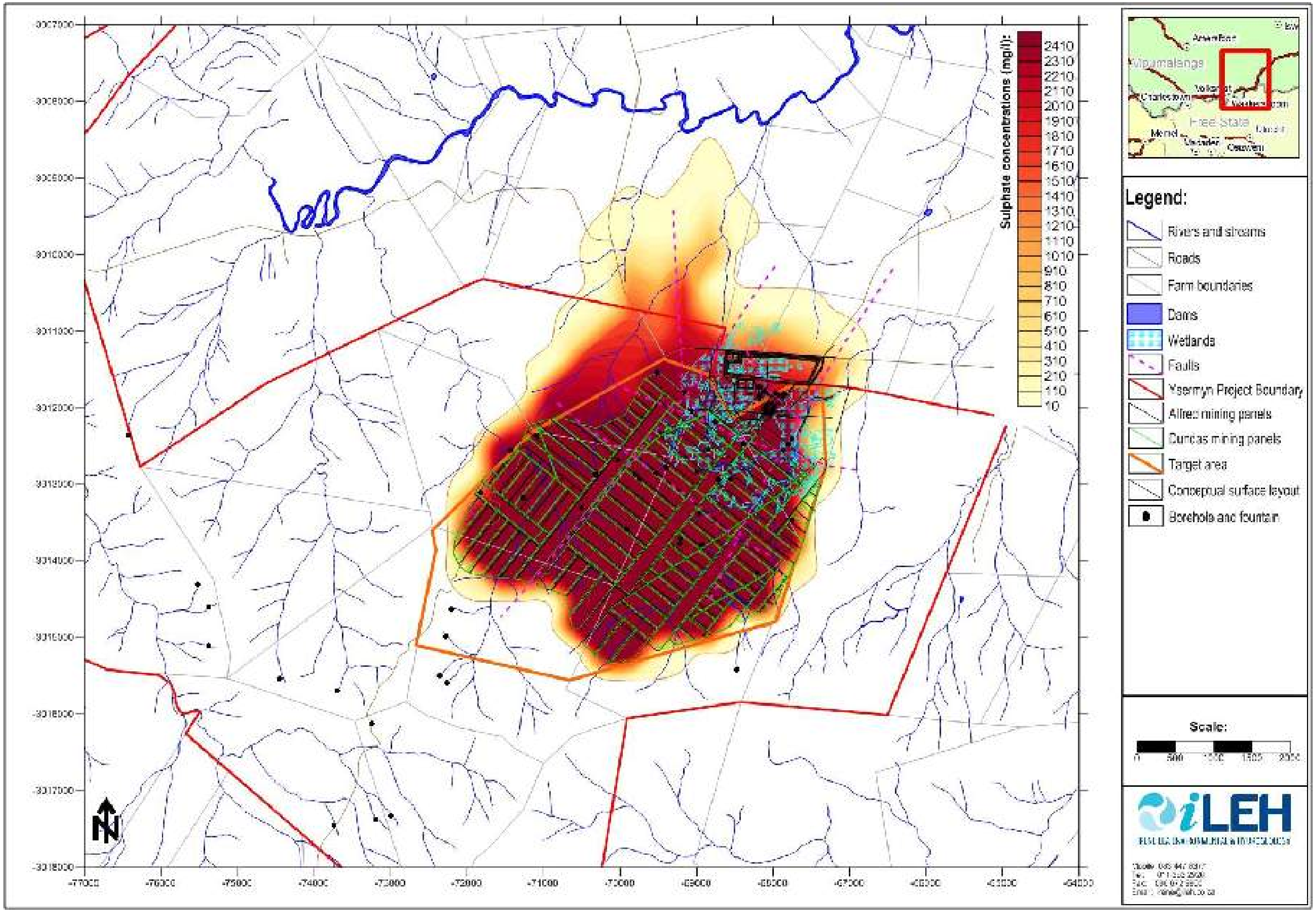
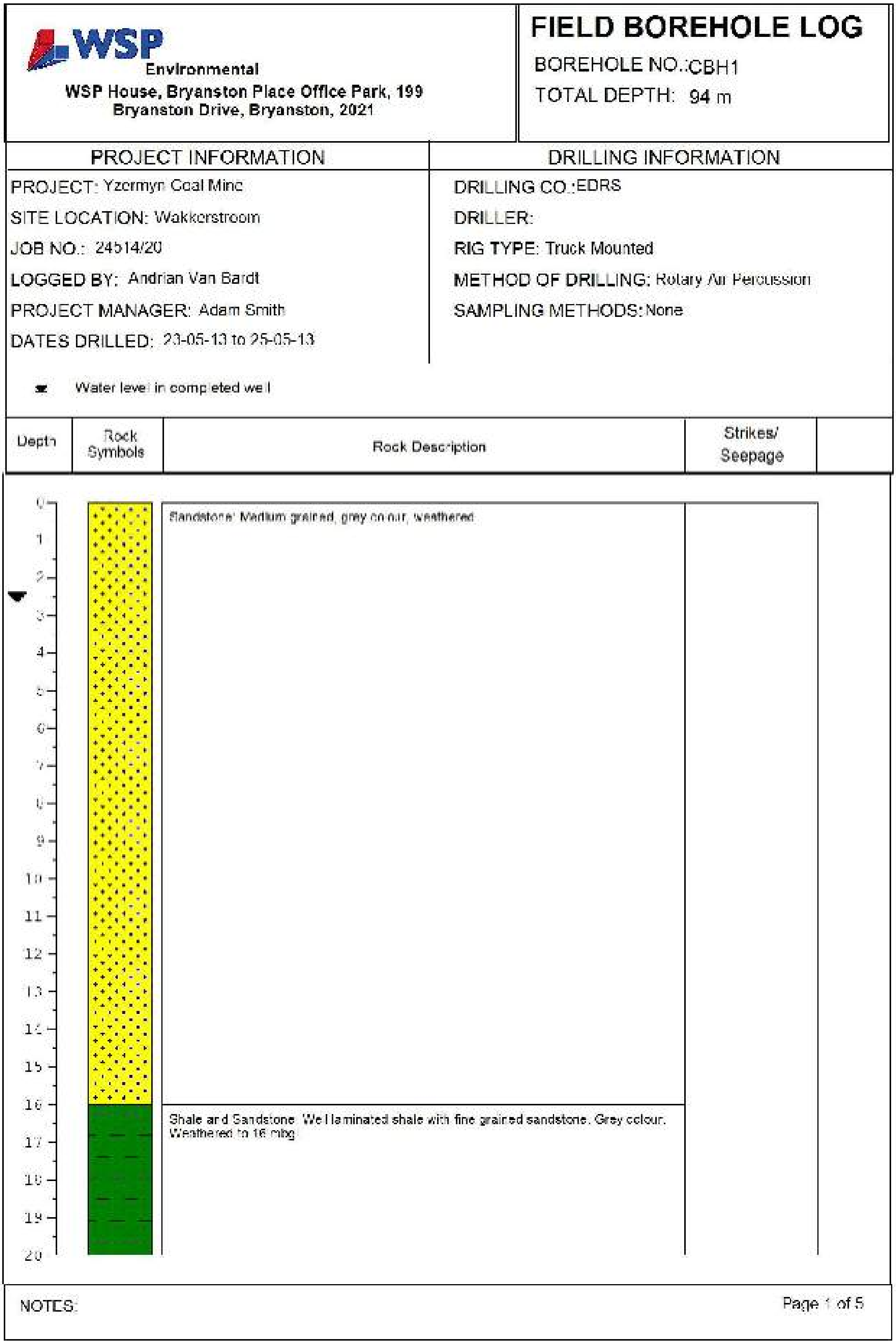


Figure 20: Simulates Sulphate Seepage of Mine Workings 100 Years after LOM (iLEH, 2013)

Appendix B: Drilled Borehole Logs



WSP
Environmental
WSP House, Bryanston Place Office Park, 199
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.:CBH1
TOTAL DEPTH: 94 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 23-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
0–16		Sandstone: Medium grained, grey colour, weathered		
16–20		Shale and Sandstone. Well laminated shale with fine grained sandstone. Grey colour. Weathered to 16 mbg		

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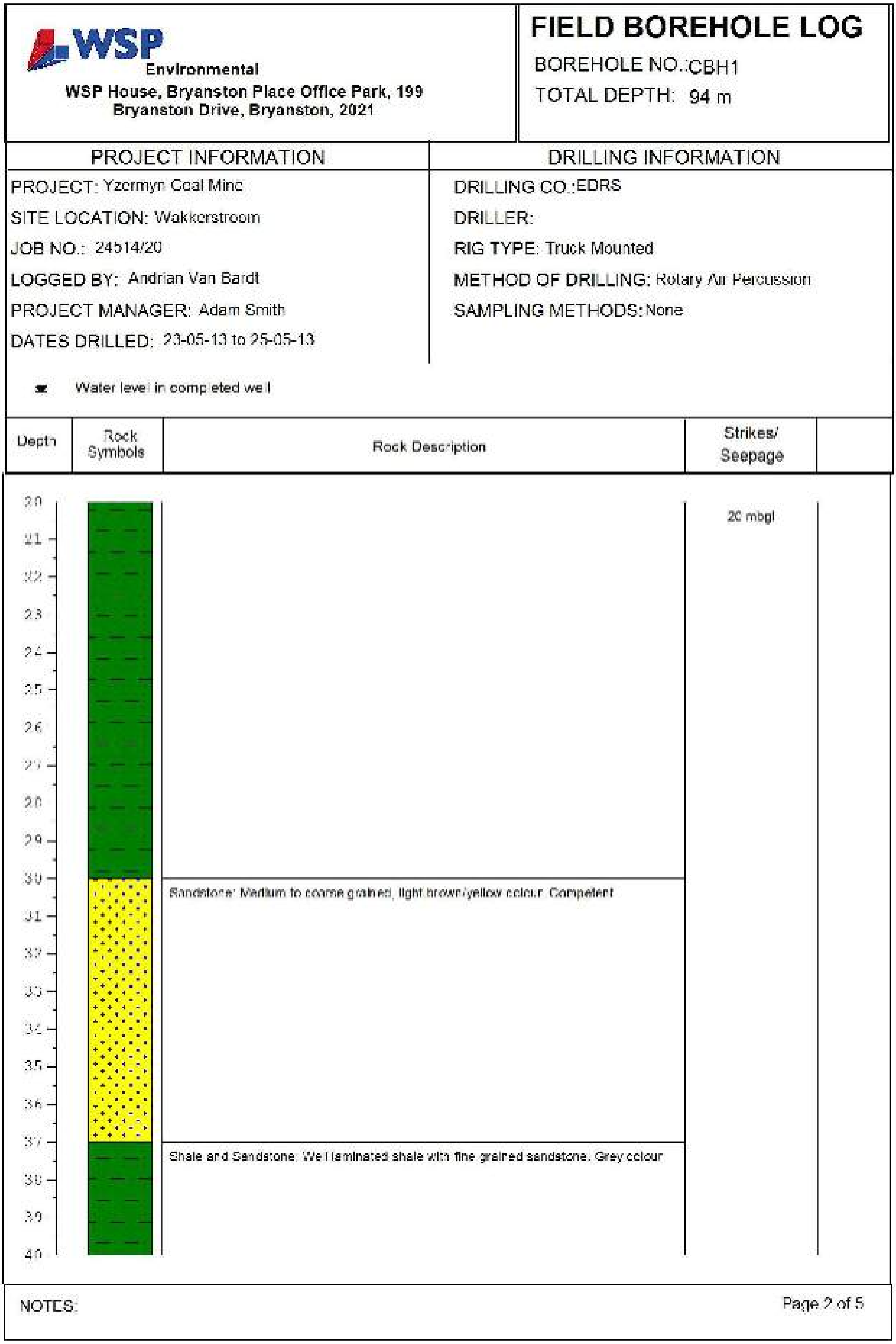

WSP Environmental

WSP House, Bryanston Place Office Park, 199
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.: CBH1

TOTAL DEPTH: 94 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.: EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 23-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
20 – 30	🟩		20 mbgl	
30 – 37	🟨	Sandstone: Medium to coarse grained, light brown/yellow colour. Competent		
37 – 40	🟩	Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour		

NOTES:

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WSP
Environmental
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Bryanston Drive, Bryanston, 2021

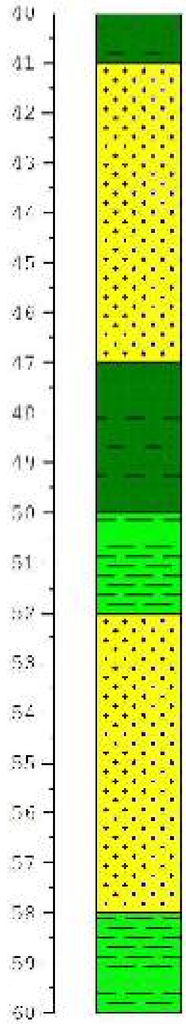
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH1
TOTAL DEPTH: 94 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 23-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage



Sandstone: Coarse grained, white colour competent

Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour. Fresh and competent

Shale: May be interlaminated with carbonaceous shale. Black

Sandstone: Coarse grained, white colour competent

Shale: Carbonaceous, laminated, tabular cuttings. Black

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WSP
Environmental
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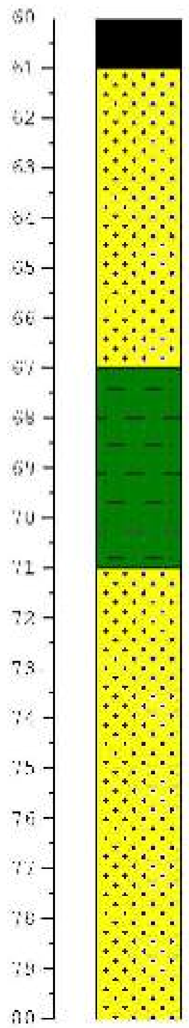
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.: CBH1
TOTAL DEPTH: 94 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.: EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 23-05-13 to 25-05-13	

▼ Water level in completed well



Rock Description	Strikes/ Seepage	
Coal: May be interlaminated with carbonaceous shale, black		
Sandstone: Coarse grained, white colour. competent		
Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour. Fresh and competent		
Sandstone: Coarse grained, white colour. competent		

NOTES:

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Environmental
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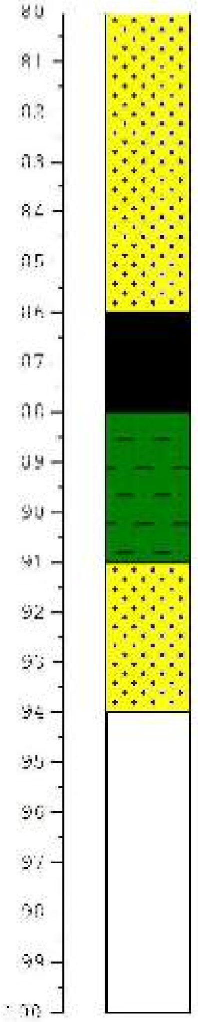
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.:CBH1
TOTAL DEPTH: 94 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 23-05-13 to 25-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage
		Coal: DUNDAS	
		Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour. Fresh and competent	
		Sandstone: Fine grained light grey, competent	

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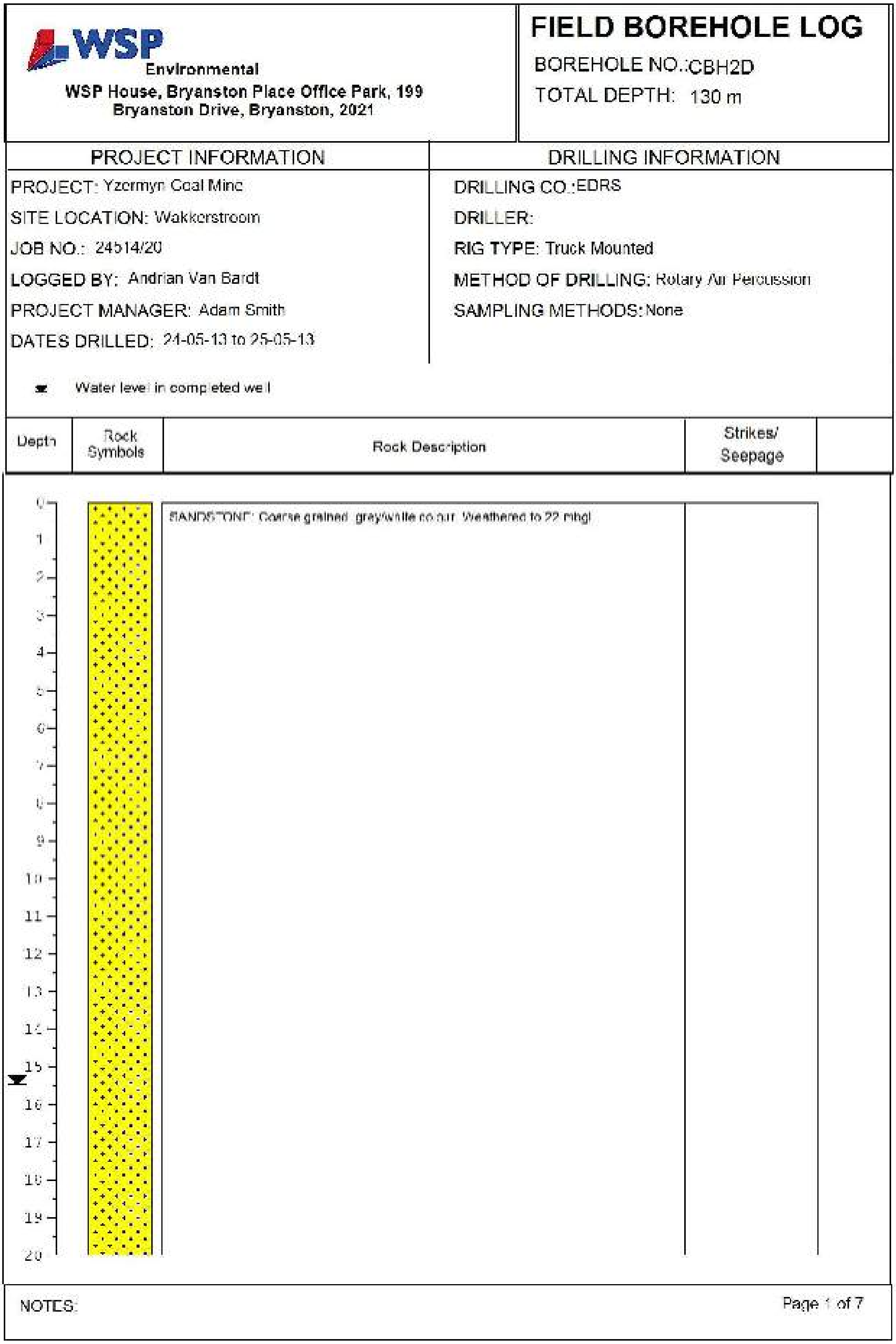

WSP Environmental

WSP House, Bryanston Place Office Park, 199
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
0		SANDSTONE: Coarse grained, grey/white colour. Weathered to 22 mbgl		

NOTES:

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Environmental
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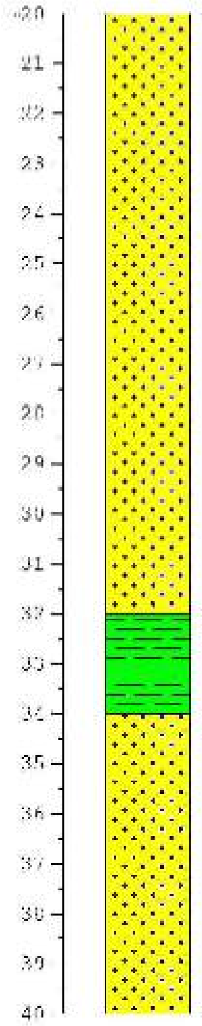
Bryanston Drive, Bryanston, 2021

FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage
20–32			22 mbgl
32–34		SHALE: Dark grey colour, well laminated, fresh and competent	
34–40		SANDSTONE: Medium grained, light grey, fresh and competent	

NOTES:

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WSP
Environmental
WSP House, Bryanston Place Office Park, 199
Bryanston Drive, Bryanston, 2021

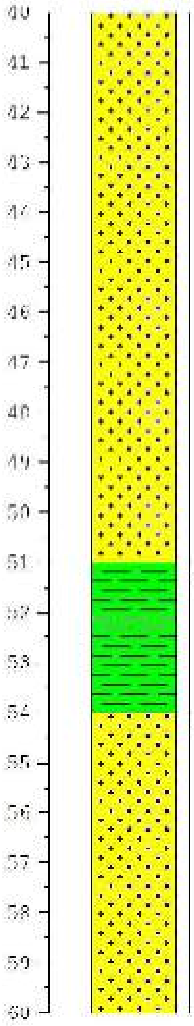
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS:None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



Shale: Grey, well laminated, fresh and competent

SANDSTONE: Medium to coarse grained, white colour, competent

NOTES:

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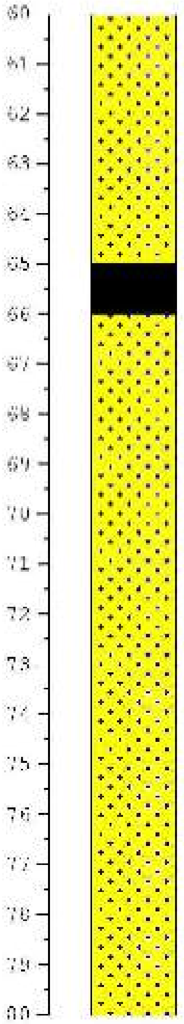
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
60–65				
65–66		COAL: Black colour		
66–80		SANDSTONE: Coarse grained, white colour, competent		



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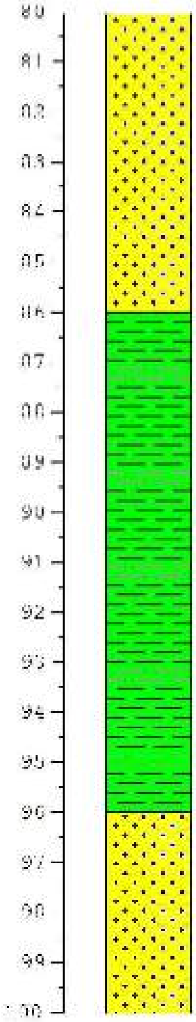
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
			85 mbgl	
		SHALE: Carbonaceous, well laminated, black colour		
		SANDSTONE: Medium grained, light grey, fresh and competent		

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Environmental

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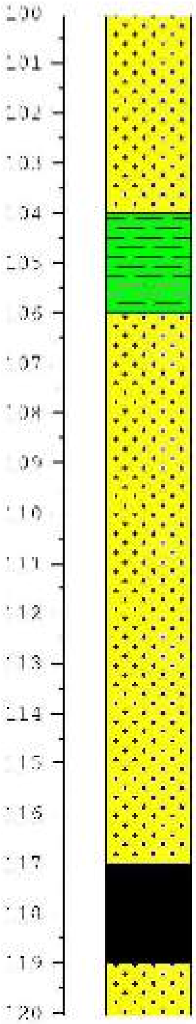
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



SHALE: Carbonaceous, well laminated, black colour

SANDSTONE: Medium grained, light grey, fresh and competent

COAL: ALFRED

SANDSTONE: Coarse grained, white colour, competent

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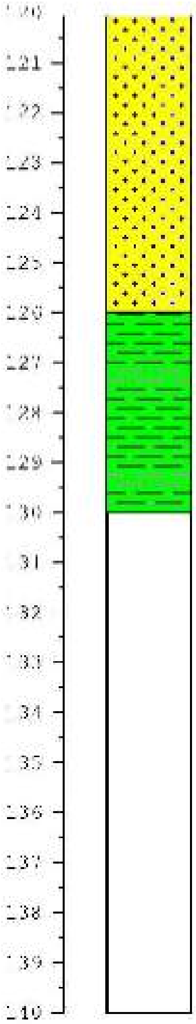
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2D
TOTAL DEPTH: 130 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS:None
DATES DRILLED: 24-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
		SHALE: Interlaminated coal and carbonaceous shale. Black colour		



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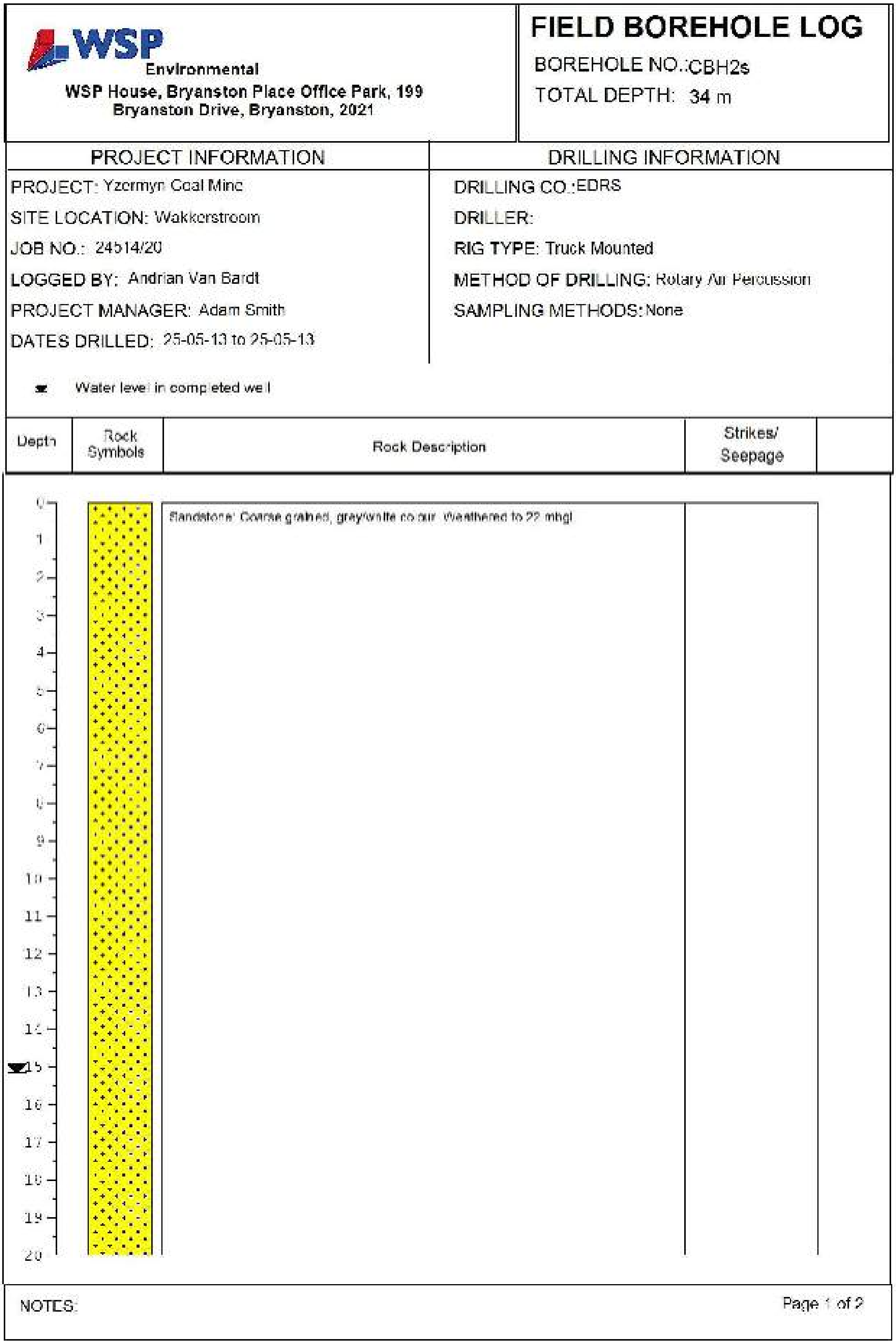

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FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2s

TOTAL DEPTH: 34 m

PROJECT INFORMATION

PROJECT: Yzermyn Coal Mine

SITE LOCATION: Wakkerstroom

JOB NO.: 24514/20

LOGGED BY: Andrian Van Bardt

PROJECT MANAGER: Adam Smith

DATES DRILLED: 25-05-13 to 25-05-13

DRILLING INFORMATION

DRILLING CO.:EDRS

DRILLER:

RIG TYPE: Truck Mounted

METHOD OF DRILLING: Rotary Air Percussion

SAMPLING METHODS:None

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
0		Sandstone: Coarse grained, grey/white colour. Weathered to 22 mbgl		

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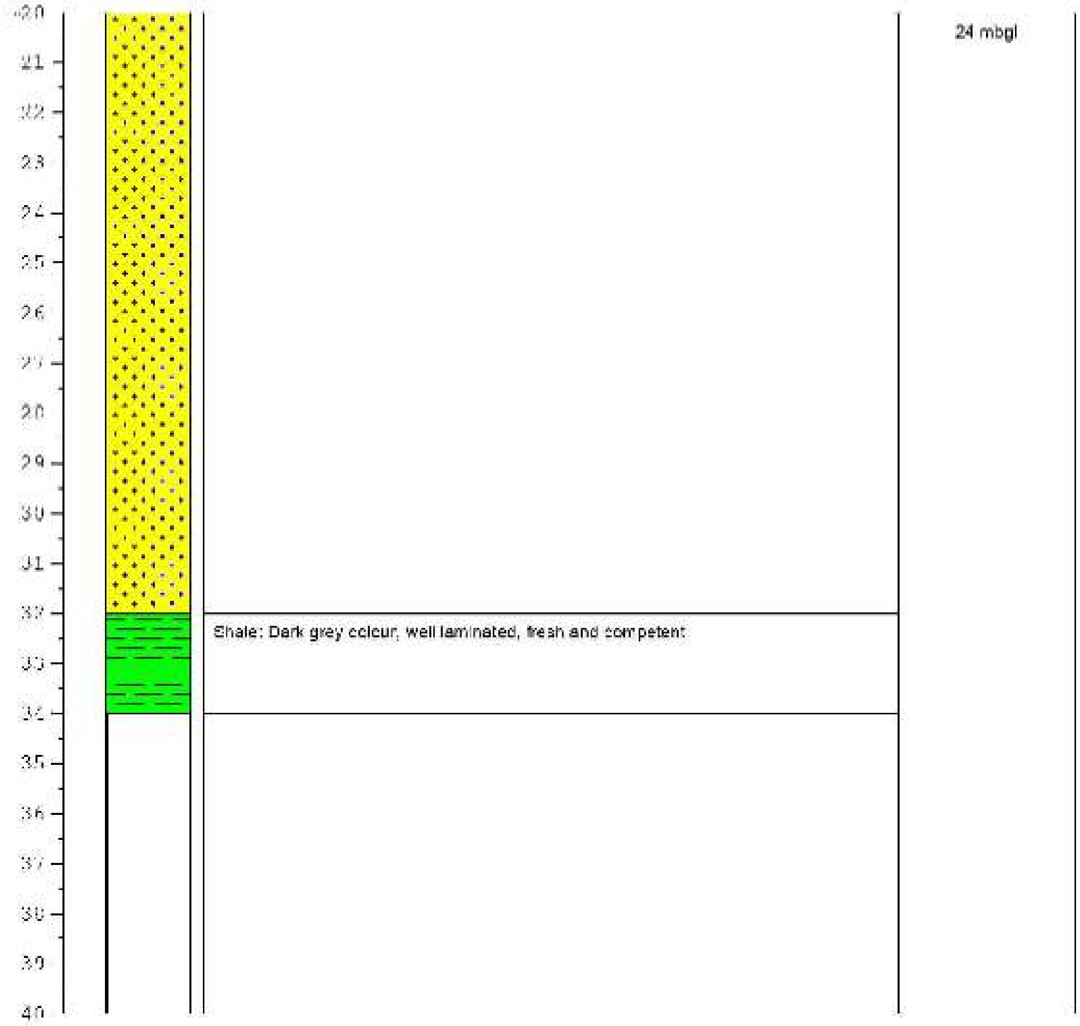
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH2s
TOTAL DEPTH: 34 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 25-05-13 to 25-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



24 mbgl

Shale: Dark grey colour, well laminated, fresh and competent

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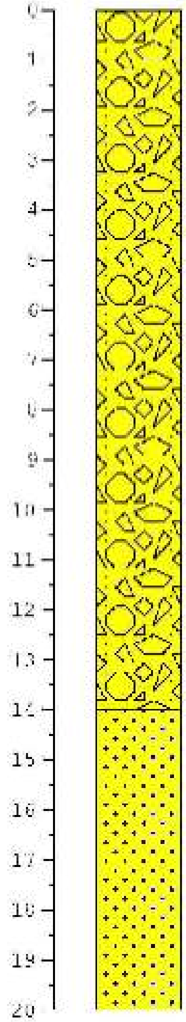
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS:None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage
		COLLUVIUM: Cobbles of dolerite and sandstone, semi rounded	10 mbgl
		SANDSTONE: Medium grained, weathered to 21 mbgl. Grey colour	

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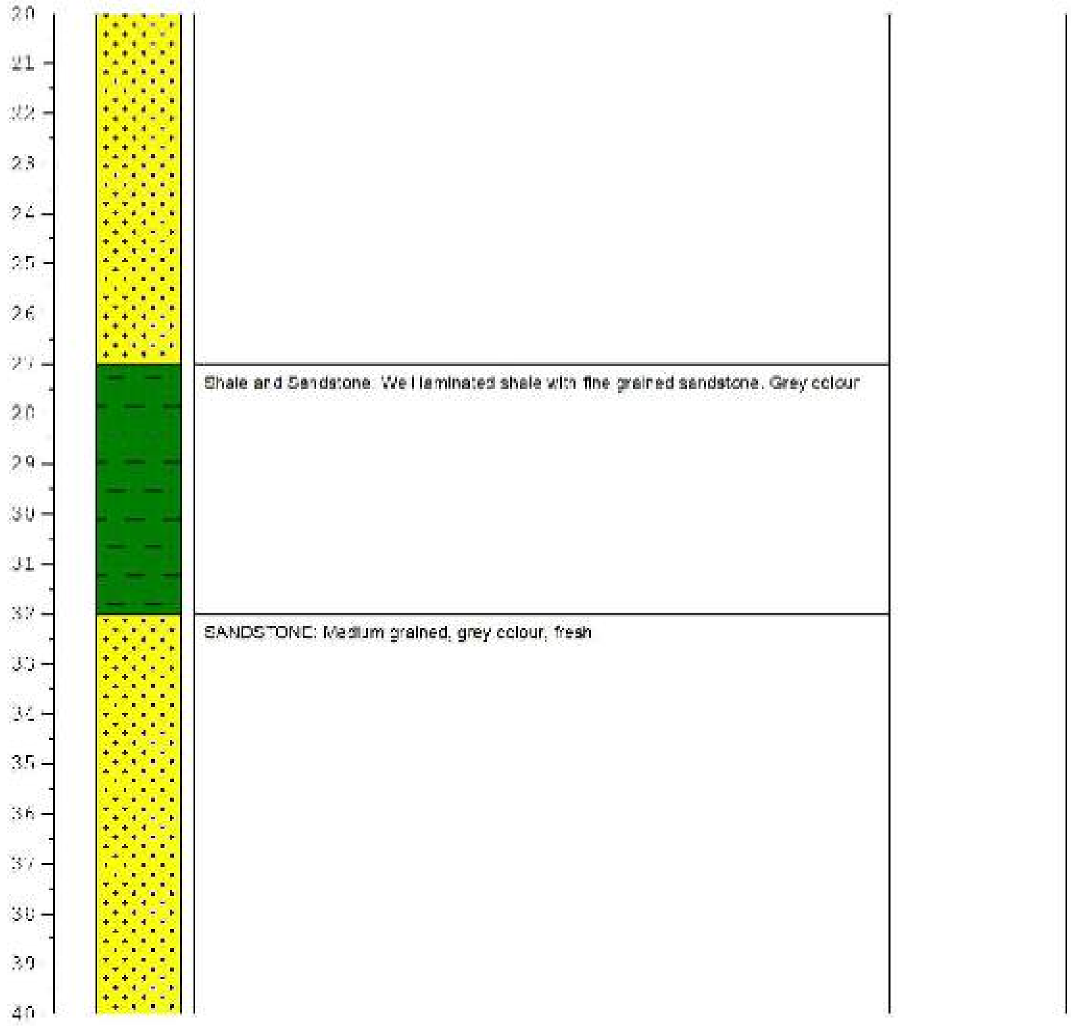
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



Shale and Sandstone. Well laminated shale with fine grained sandstone. Grey colour

SANDSTONE: Medium grained, grey colour, fresh

NOTES:

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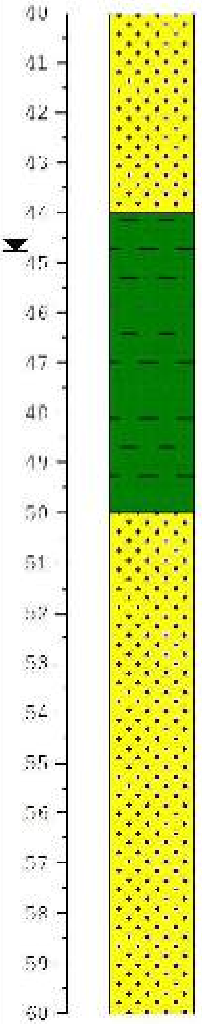
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

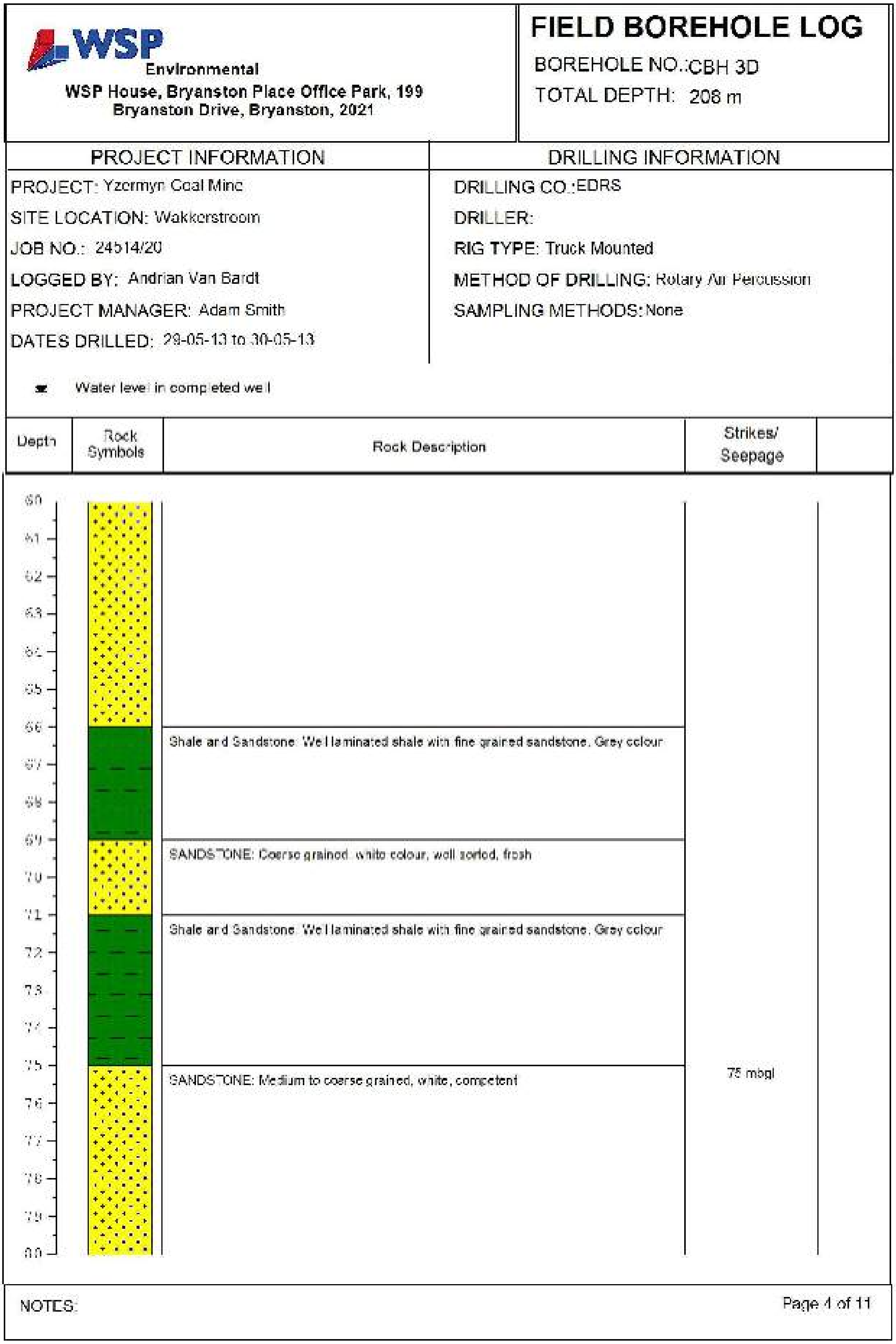
PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
44		Shale and Sandstone. Well laminated shale with fine grained sandstone. Grey colour	44 mbgl	
50		SANDSTONE: Coarse grained white colour, well sorted, fresh		

NOTES:



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FIELD BOREHOLE LOG

BOREHOLE NO.: CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION

PROJECT: Yzermyn Coal Mine
SITE LOCATION: Wakkerstroom
JOB NO.: 24514/20
LOGGED BY: Andrian Van Bardt
PROJECT MANAGER: Adam Smith
DATES DRILLED: 29-05-13 to 30-05-13

DRILLING INFORMATION

DRILLING CO.: EDRS
DRILLER:
RIG TYPE: Truck Mounted
METHOD OF DRILLING: Rotary Air Percussion
SAMPLING METHODS: None

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
60	🟨			
66	🟩	Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour		
69	🟨	SANDSTONE: Coarse grained, white colour, well sorted, fresh		
71	🟩	Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour		
75	🟨	SANDSTONE: Medium to coarse grained, white, competent	75 mbgl	
80				

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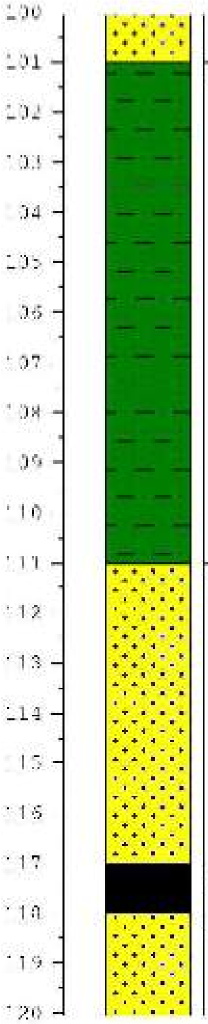
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS:None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well



Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
100				
101		Shale and Sandstone. Well laminated shale with fine grained sandstone. Grey colour		
102				
103				
104				
105				
106				
107				
108				
109				
110				
111		SANDSTONE: Coarse grained, white colour, well sorted, fresh		
112				
113				
114				
115				
116				
117		COAL: Black colour		
118		SANDSTONE: Coarse grained, white colour, well sorted, fresh		
119				
120				

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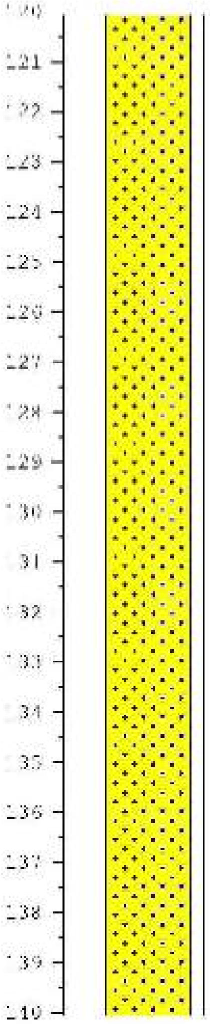
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



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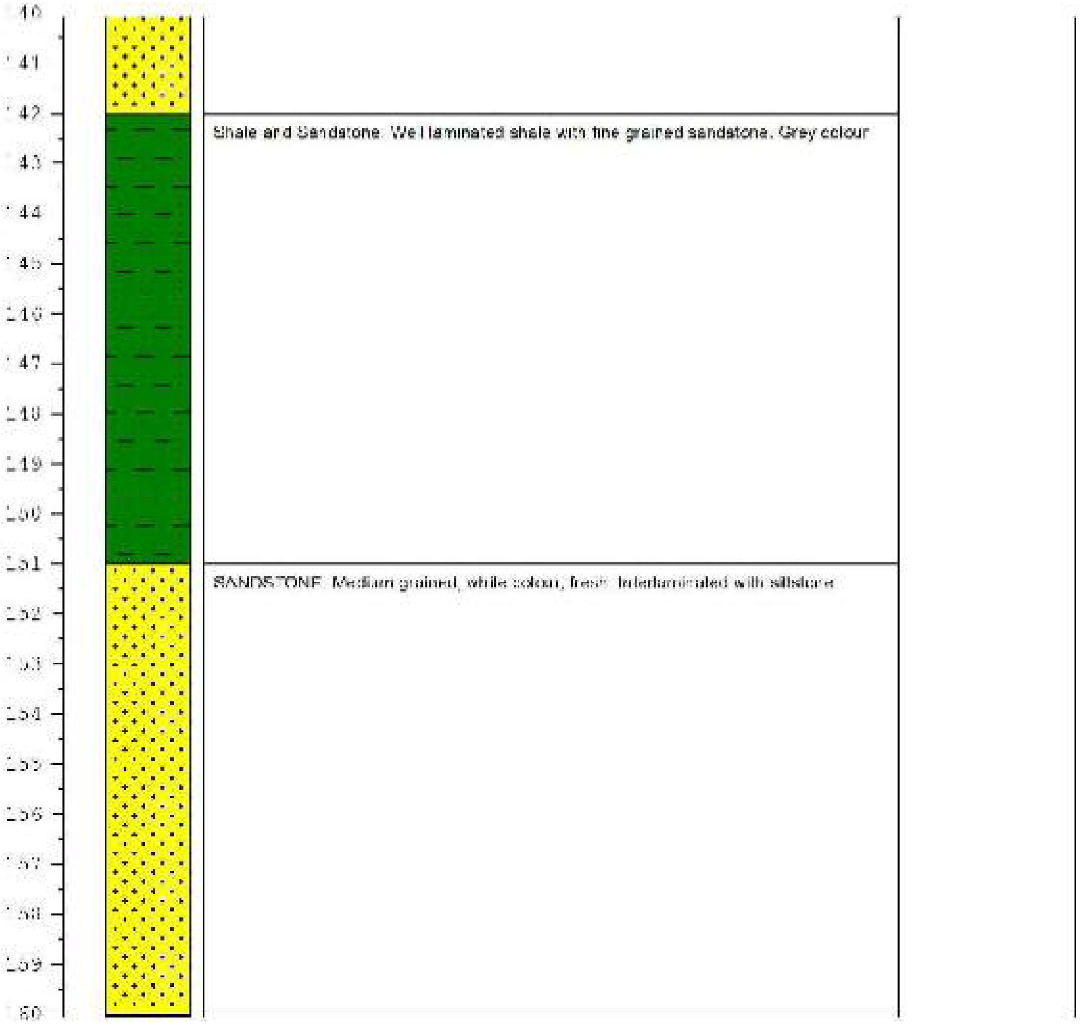
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS:None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well

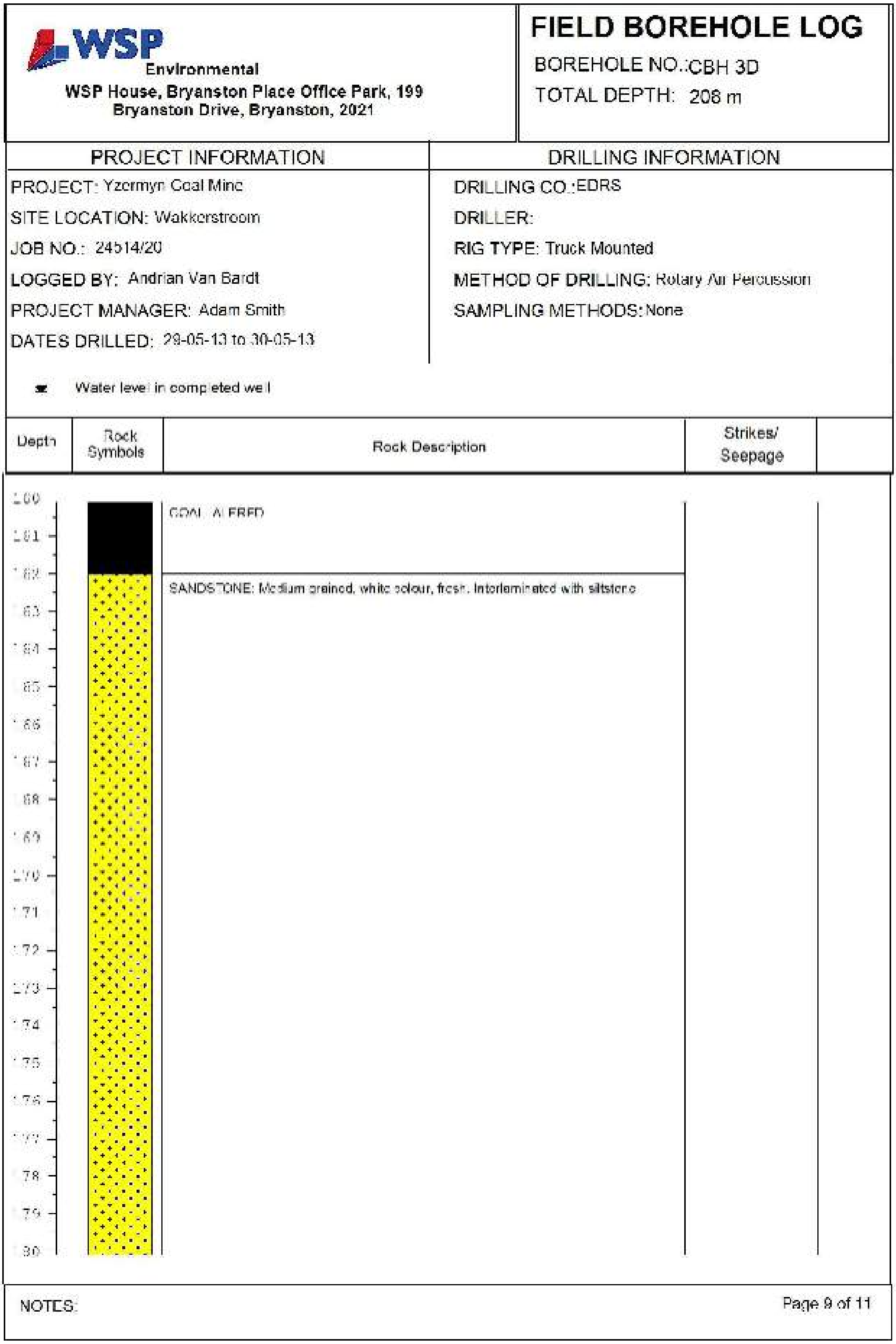
Depth	Rock Symbols	Rock Description	Strikes/ Seepage	



Shale and Sandstone. Well laminated shale with fine grained sandstone. Grey colour

SANDSTONE. Medium grained, white colour, fresh. Interlaminated with siltstone

NOTES:



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FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 29-05-13 to 30-05-13	

▼ Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	
160	■	COAL: ALTERED		
161				
162	▨	SANDSTONE: Medium grained, white colour, fresh. Interlaminated with siltstone		
163				
164				
165				
166				
167				
168				
169				
170				
171				
172				
173				
174				
175				
176				
177				
178				
179				
180				

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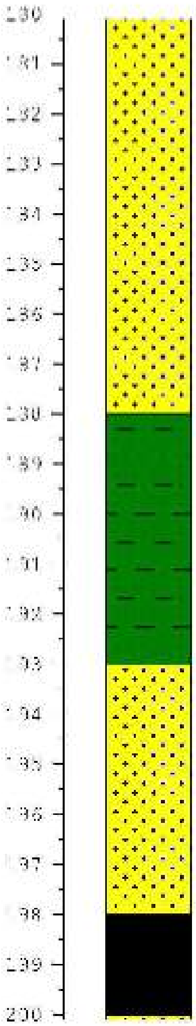
FIELD BOREHOLE LOG

BOREHOLE NO.:CBH 3D
TOTAL DEPTH: 208 m

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Yzermyn Coal Mine	DRILLING CO.:EDRS
SITE LOCATION: Wakkerstroom	DRILLER:
JOB NO.: 24514/20	RIG TYPE: Truck Mounted
LOGGED BY: Andrian Van Bardt	METHOD OF DRILLING: Rotary Air Percussion
PROJECT MANAGER: Adam Smith	SAMPLING METHODS: None
DATES DRILLED: 29-05-13 to 30-05-13	

Water level in completed well

Depth	Rock Symbols	Rock Description	Strikes/ Seepage	

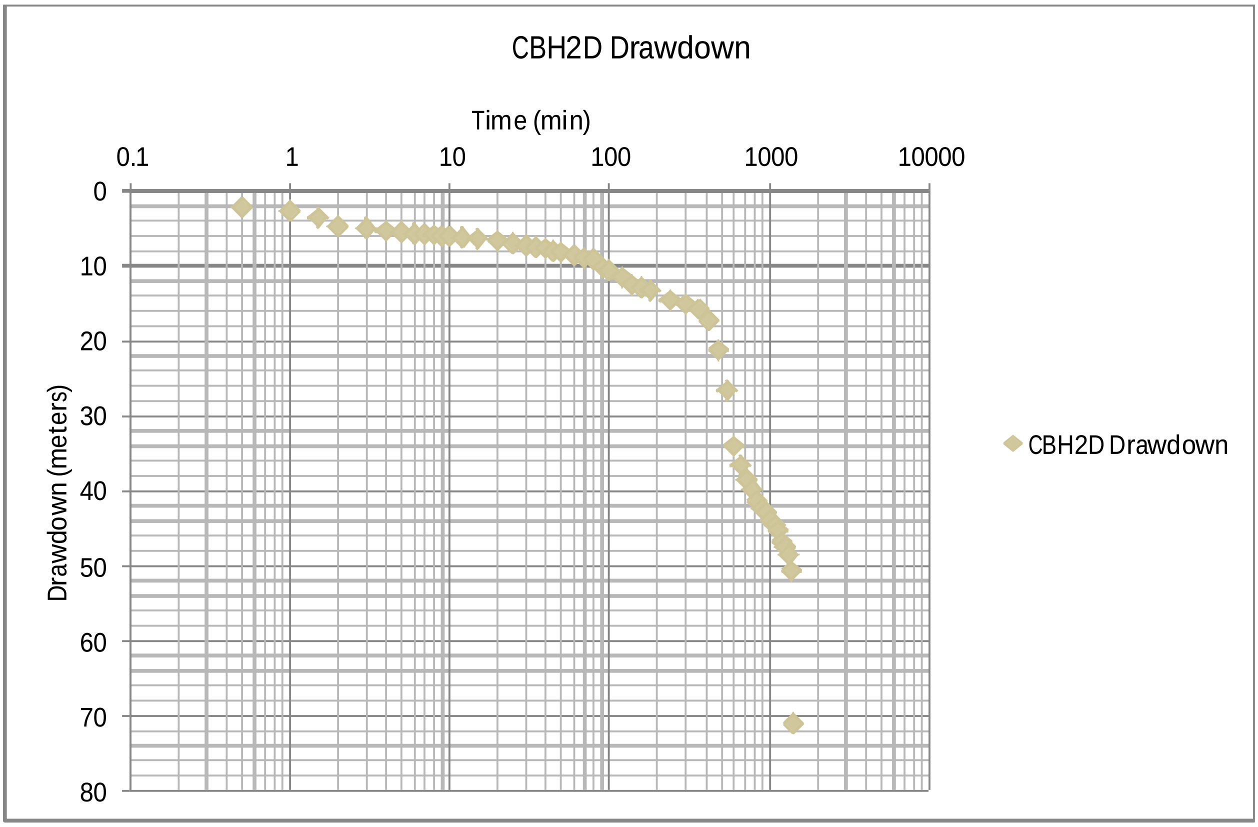


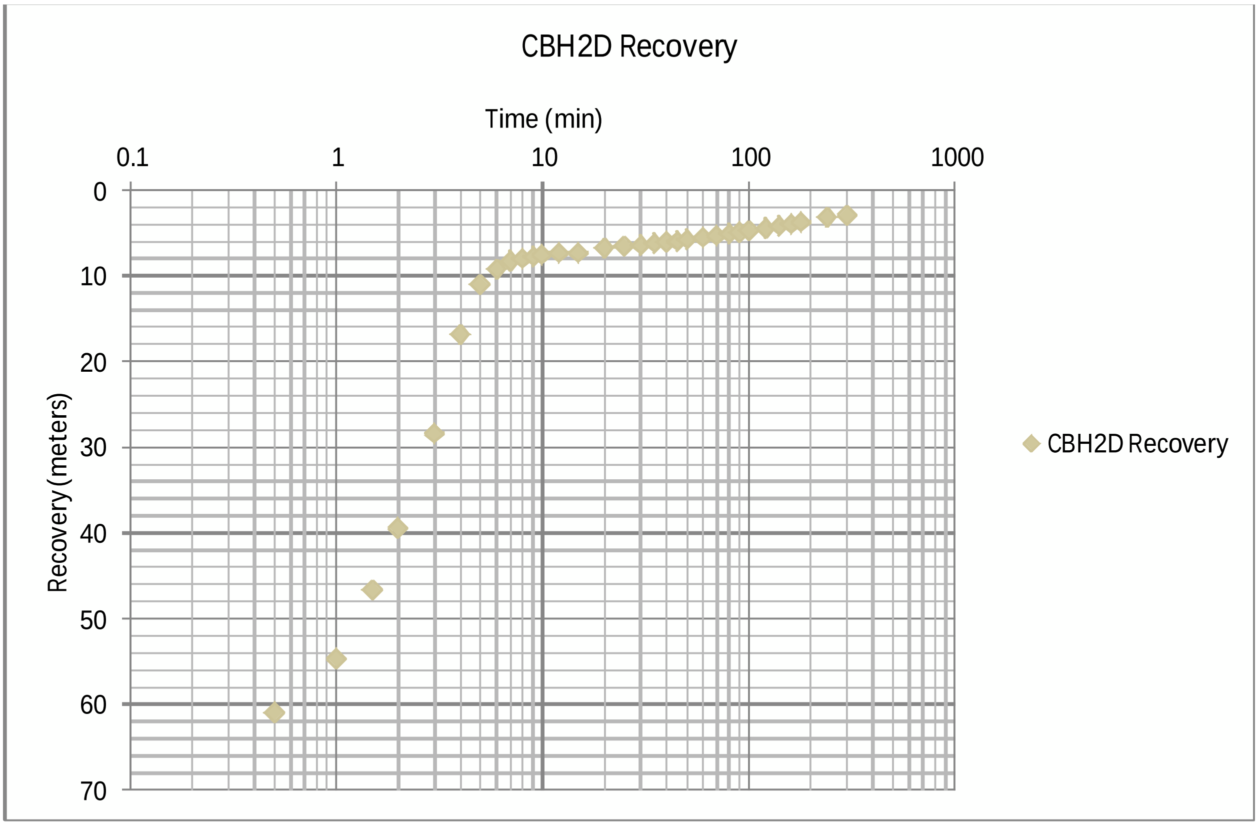
Shale and Sandstone: Well laminated shale with fine grained sandstone. Grey colour

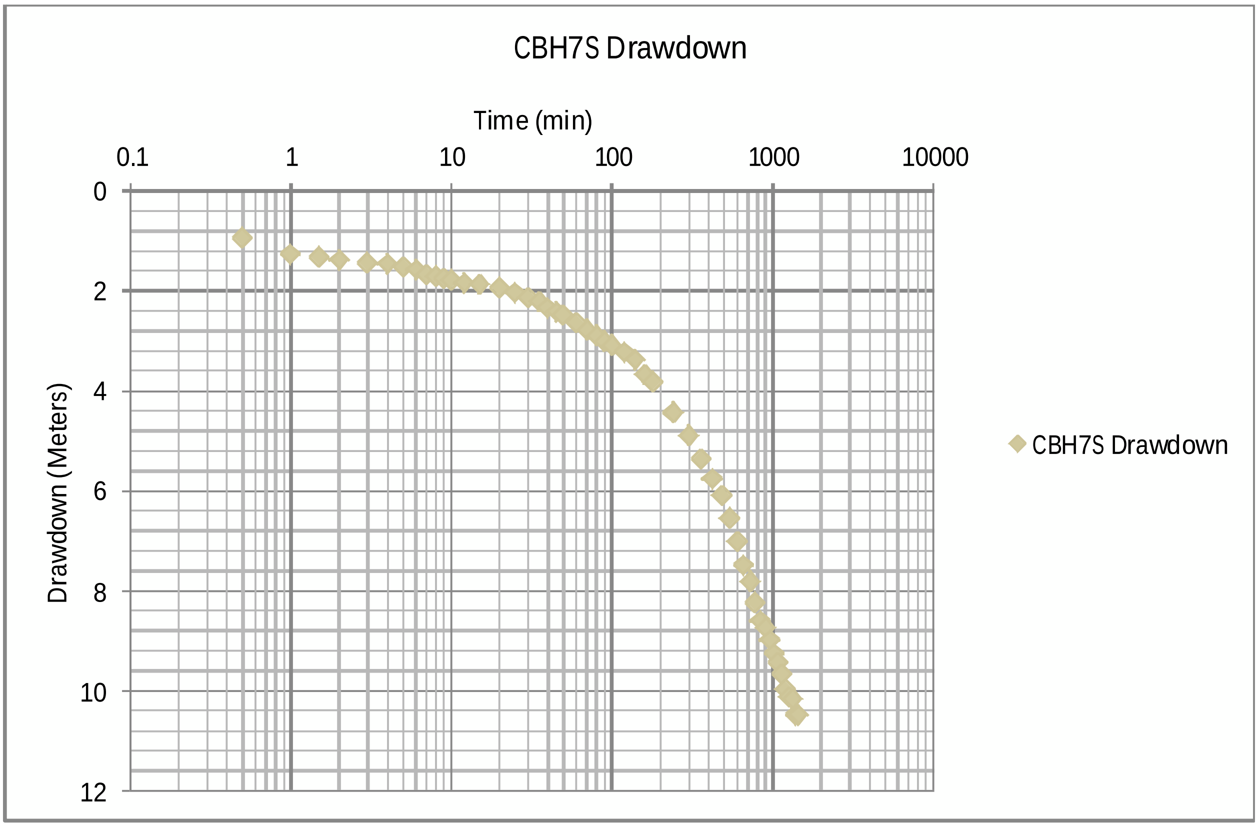
SANDSTONE: Medium grained, grey/white colour, fresh

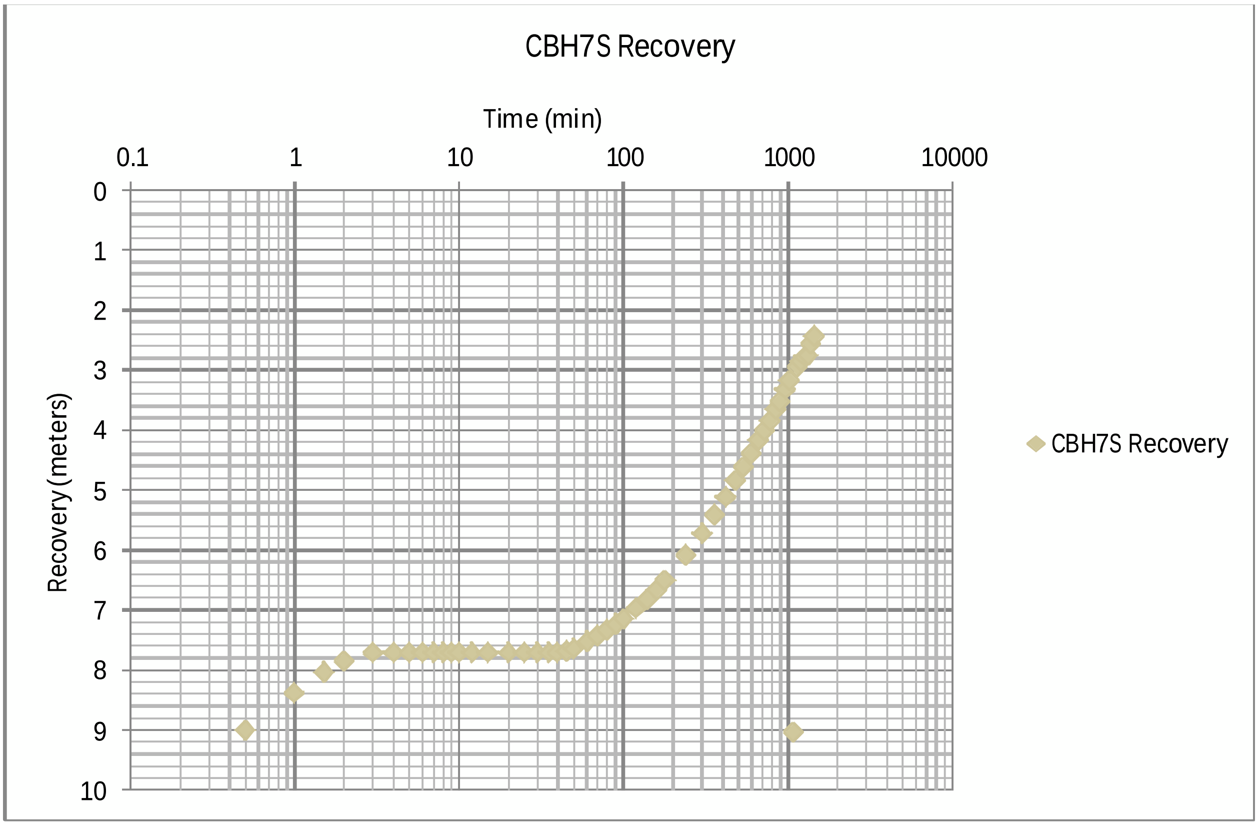
COAL: DUNDAS

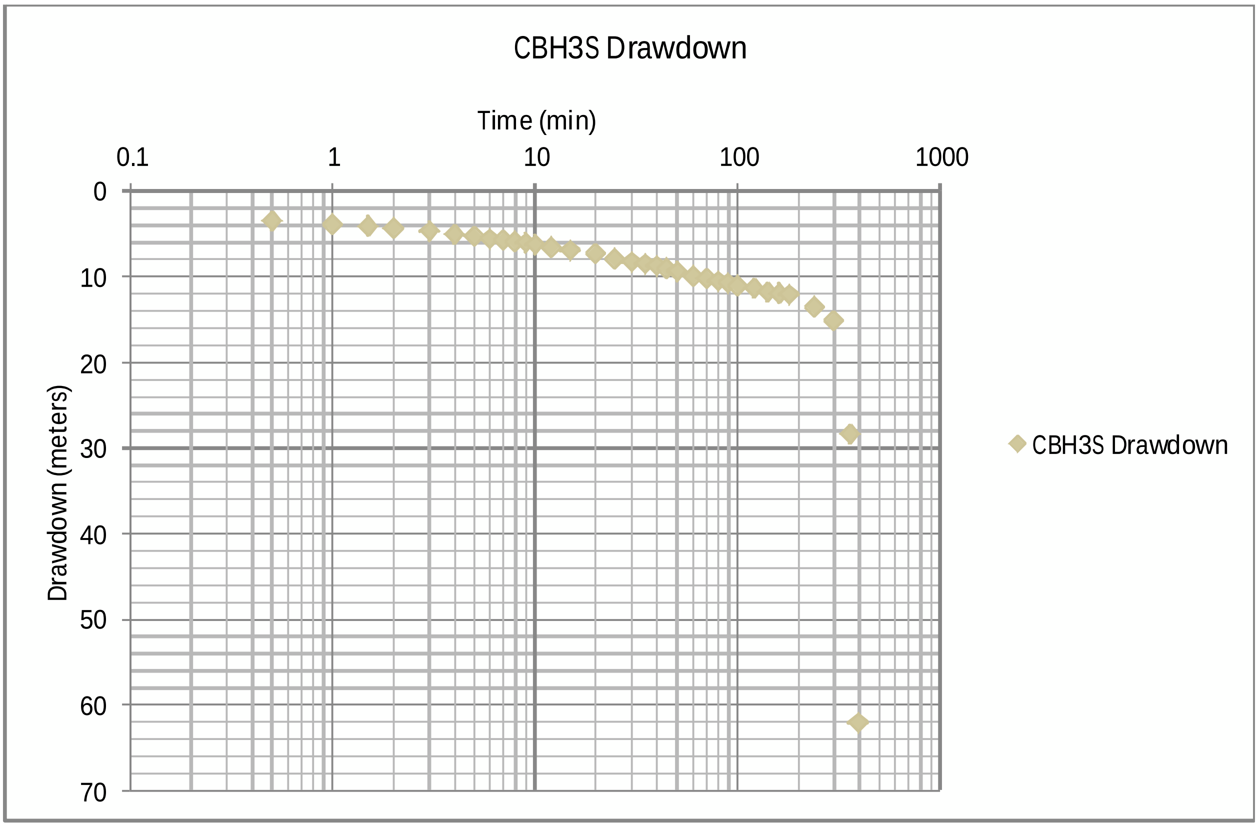
NOTES:

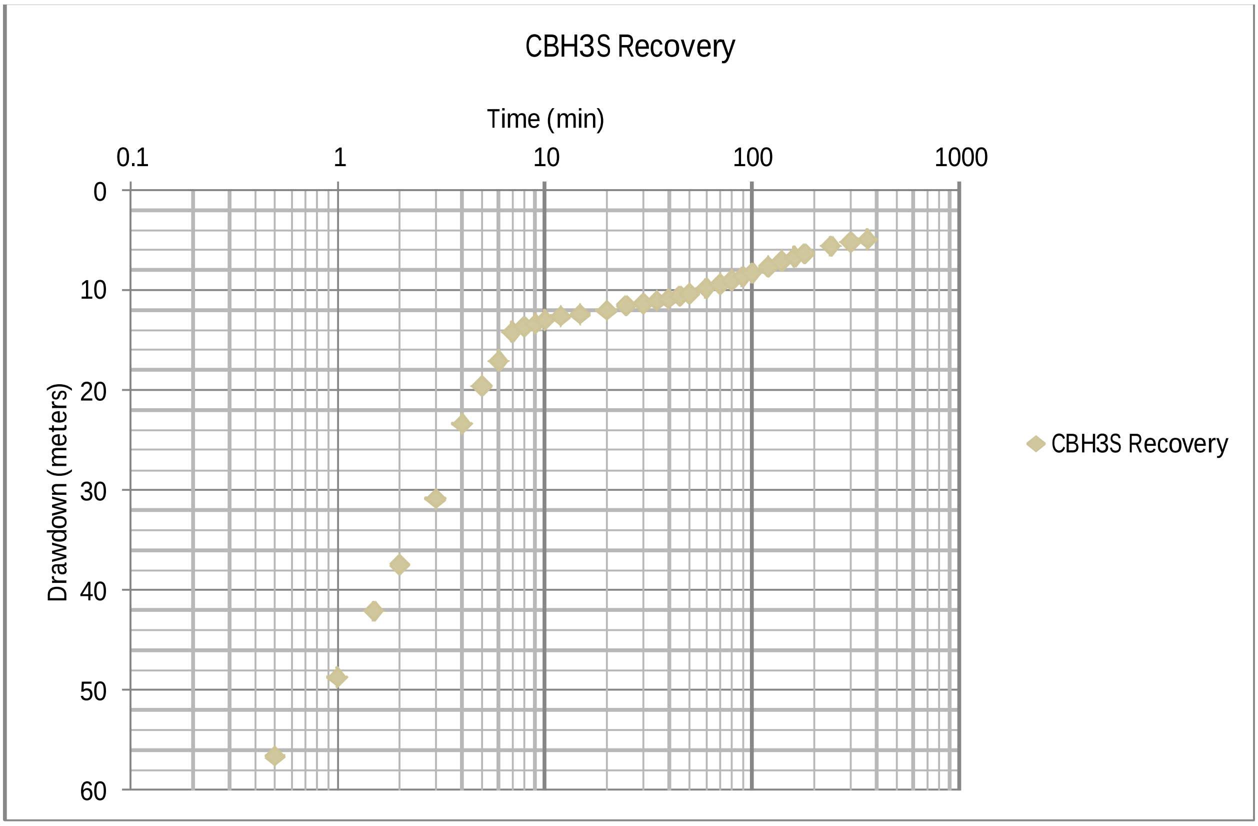

CBH2D Drawdown
Time (min)
0.1
1
10
100
1000
10000
0
10
20
30
40
50
60
70
80
Drawdown (meters)
◆ CBH2D Drawdown


CBH2D Recovery
Time (min)
0.1
1
10
100
1000
0
10
20
30
40
50
60
70
Recovery (meters)
◆ CBH2D Recovery


CBH7S Drawdown
Time (min)
0.1
1
10
100
1000
10000
0
2
4
6
8
10
12
Drawdown (Meters)
◆ CBH7S Drawdown


CBH7S Recovery
Time (min)
0.1
1
10
100
1000
10000
0
1
2
3
4
5
6
7
8
9
10
Recovery (meters)
◆ CBH7S Recovery


CBH3S Drawdown
Time (min)
0.1
1
10
100
1000
Drawdown (meters)
0
10
20
30
40
50
60
70
◆ CBH3S Drawdown


CBH3S Recovery
Time (min)
0.1
1
10
100
1000
Drawdown (meters)
0
10
20
30
40
50
60
◆ CBH3S Recovery

Appendix D: Slug Test Data

CBH1		CBH2S		CBH4D		CBH5S	
Time	Recovery	Time	Recovery	Time	Recovery	Time	Recovery
(min)	m/mm	(min)	(m/mm)	(min)	(m/mm)	(min)	(m/mm)
	2.41	`	15.88		38.72		13.42
0	1.17	0	15.14	0	37.69	0	12.81
0.5	1.2	0.5	15.15	0.5	37.74	0.5	12.95
1	1.2	1	15.23	1	37.79	1	13
1.5	1.21	1.5	15.28	1.5	37.79	1.5	13.03
2	1.21	2	15.3	2	37.86	2	13.12
3	1.21	3	15.37	3	37.89	3	13.15
4	1.21	4	15.41	4	37.95	4	13.19
5	1.22	5	15.41	5	38.02	5	13.22
6	1.22	6	15.48	6	38.05	6	13.26
7	1.22	7	15.53	7	38.08	7	13.26
8	1.22	8	15.6	8	38.01	8	13.27
9	1.22	9	15.65	9	38.13	9	13.28
10	1.22	10	15.7	10	38.17	10	13.3
12	1.22	12	15.78	12	38.23	12	13.33
15	1.22	15	15.8	15	38.29	15	13.34
20	1.22	20	15.8	20	38.33	20	13.35
25	1.22	25	15.82	25	38.34	25	13.35
30	1.23	30	15.85	30	38.36	30	13.37
35	1.23	35	15.85	35	38.37	35	13.37
40	1.25	40	15.85	40	38.38	40	13.37
45	1.25	45	15.85	45	38.38	45	13.37
50	1.25	50	15.85	50	38.39	50	13.37
60	1.25	60	15.85	60	38.39	60	13.37
70	1.25	70	15.85	70	38.39	70	13.37
80	1.25	80	15.85	80	38.39	80	13.37
90	1.25	90	15.85	90	38.39	90	13.37
100	1.25	100	15.85	100	38.39		

CBH6			CBH7D	
Time	Recovery		Time	Recovery
(min)	m/mm		(min)	(m/mm)
	15.27			75.37
0	14.01		0	74.06
0.5	14.04		0.5	74.09
1	14.05		1	74.1
1.5	14.05		1.5	74.11
2	14.05		2	74.15
3	14.06		3	74.18
4	14.07		4	74.2
5	14.07		5	74.24
6	14.07		6	74.29
7	14.07		7	74.31
8	14.07		8	74.32
9	14.07		9	74.32
10	14.07		10	74.33
12	14.08		12	74.35
15	14.08		15	74.37
20	14.08		20	74.38
25	14.08		25	74.4
30	14.08		30	74.4
35	14.08		35	74.4
40	14.08		40	74.41
45	14.1		45	74.42
50	14.12		50	74.44
60	14.12		60	74.44
70	14.13		70	74.44
80	14.13		80	74.44
90	14.13		90	74.44
100	14.13		100	74.44
110	14.13			

Appendix E: Impact Rating Sheets

Geohydrology

				A	B	C	D	E	F	G	(DxG)	(DxG)
Ref.	**Phase**	**Impact Description**	**Mitigation Measure**	**Severity**	**Duration**	**Extent**	**Consequence (A+B+C)/3**	**Frequency**	**Probability**	**Likelihood (E+F)/2**	**Environmental Significance (Without Mitigation)**	**Environmental Significance (With Mitigation)**
1.1	Construction Phase : Construction of Adit	**Groundwater Availability:** Local dewatering around the adit.	Seal walls to reduce groundwater seepage into the adit.	2.0	4.0	1.0	2.3	1.0	5.0	3.0	**7.0**	
				1.0	4.0	1.0	2.0	1.0	5.0	3.0		**6.0**
1.2	Construction Phase : Construction of Adit	**Groundwater Quality:** Not expected to have significant impact as groundwater will flow into adit and potentially contaminated water will not flow out	Spill prevention and clean-up procedures	2.0	1.0	1.0	1.3	3.0	4.0	3.5	**4.7**	
				2.0	1.0	1.0	1.3	3.0	3.0	3.0		**4.0**
1.3	Construction Phase : Construction of Adit	**Groundwater Quality:** Inflow of groundwater into the underground workings.	Dewatering of underground workings.	3.0	5.0	1.0	3.0	5.0	5.0	5.0	**15.0**	
				2.0	5.0	1.0	2.7	5.0	5.0	5.0		**13.3**
1.4	Operational Phase	**Groundwater Availability:** Dewatering of the aquifer as mining progresses.	Alternative water supplies to local water users. Wetland offsets and restoration.	4.0	5.0	3.0	4.0	5.0	5.0	5.0	**20.0**	
				3.0	5.0	3.0	3.7	5.0	5.0	5.0		**18.3**

Geohydrology

				A	B	C	D	E	F	G	(DxG)	(DxG)
Ref.	**Phase**	**Impact Description**	**Mitigation Measure**	**Severity**	**Duration**	**Extent**	**Consequence (A+B+C)/3**	**Frequency**	**Probability**	**Likelihood (E+F)/2**	**Environmental Significance (Without Mitigation)**	**Environmental Significance (With Mitigation)**
1.5	Operational Phase	**Groundwater Availability:** Aquifer dewatering near water supply boreholes.	Manage groundwater abstraction within sustainable rates. Consider alternative water supply sources to groundwater.	2.0	4.0	1.0	2.3	5.0	3.0	4.0	**9.3**	
				1.0	4.0	1.0	2.0	5.0	3.0	4.0		**8.0**
1.6	Operational Phase	**Groundwater Availability:** Possible contamination from the discard dump.	Reduce permeability of facility footprint (compaction, liner).	4.0	5.0	3.0	4.0	5.0	5.0	5.0	**20.0**	
				3.0	5.0	2.0	3.3	5.0	5.0	5.0		**16.7**
1.7	Operational Phase	**Groundwater Quality:** Decant of groundwater from underground workings.	Seal adit entrance and other decant points.	3.0	5.0	2.0	3.3	4.0	2.0	3.0	**10.0**	
				1.0	5.0	1.0	2.3	3.0	2.0	2.5		**5.8**
1.8	After Mine Closure Phase	**Groundwater Availability:** Groundwater contamination from discard facility and underground mine.	Seal faults and fractures encountered during mining. Seal adit entrance and other decant points. Reduce discard footprint permeability (compaction, liner).	4.0	5.0	3.0	4.0	4.0	2.0	3.0	**12.0**	
				2.0	5.0	2.0	3.0	3.0	2.0	2.5		**7.5**

Appendix F: Groundwater Management Programme

Management Measure Ref.	Management Recommendations	Action Ref.	Required Action	Responsible Party	Phase
1.1	Water that is required for underground mining must be kept in a dedicated sump	1.1	This should be incorporated into an EMPR and initiated by mine environmental manager	Mine planner, Environmental Manager	Pre-construction/ Construction
1.2	Ensure that pollution control dams on surface are adequately sized to accommodate excess underground water	1.2	This should be incorporated into an EMPR and initiated by mine environmental manager	Mine planner, Environmental Manager	Pre-construction/ Construction
1.3	Prevent dirty water runoff from leaving the general mining area	1.3	This will be achieved with a cutoff trench around the adit, plant and discard facility	Mine planner, Environmental Manager	Pre-construction/ Construction
1.4	Prevent contaminated seepage from the stockpiles and coal washing areas to the underlying aquifers	1.4	Plant area must be paved	Mine planner, Environmental Manager	Pre-construction/ Construction
1.5	All dirty water from the plant area must be contained in the plant pollution control dams and re-used in the mining process	1.5	This should be incorporated into an EMPR and initiated by mine environmental manager	Mine planner, Environmental Manager	Pre-construction/ Construction
1.6	Minimize infiltration of poor quality water to the underlying aquifers.	1.6	Compact the base of the discard facility	Mine Planner Environmental Manager	Pre-construction/ Construction
1.7	Minimise groundwater seepage into the excavations	1.7	Seal the adit walls	Mine Planner Environmental Manager	Pre-construction/ Construction
1.8	Groundwater Monitoring programme	1.8	This should be incorporated into an EMPR and initiated by mine environmental manage	WSP, Environmental Manager	Operational/ Decommissioning/ Rehabilitation
1.9	Minimise groundwater seepage to the workings and to limit the impact of mine dewatering	1.9	Seal of water bearing geological structures like faults and dykes as they are	Mine Planner	Operational/ Decommissioning/

Management Measure Ref.	Management Recommendations	Action Ref.	Required Action	Responsible Party	Phase
			intersected in the underground workings		
2.0	Prevent subsidence in the overburden material and pillar failure in the underground workings	2.0	Implement sound geotechnical and rock mechanic principles	Mine Planner and Mine Engineer	Operational/ Decommissioning
2.1	Minimise the rate at which groundwater quality will deteriorate	2.1	In the long-term excess seepage must be removed to a suitable facility on surface or in the underground workings during the operational phase to limit the reaction of pyrite with oxygen and water	Mine Planner	Decommissioning
2.2	Prevent decant	2.2	The adit must be sealed using sound engineering principles	Mine Planner and Mine Engineer	Decommissioning

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Traffic Impact Assessment

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TRAFFIC ENGINEERING SERVICES

TRAFFIC IMPACT STUDY REPORT

PROPOSED NEW YZERMYN COAL MINE NEAR PIET RETIEF, MPUMALANGA

August 2013 Revised:

Quality Management

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Signature	CHutchinson			
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Signature				
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TRAFFIC IMPACT STUDY REPORT

PROPOSED NEW YZERMYN COAL MINE NEAR DIRKIESDORP, MPUMALANGA

2013/08/01

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Contents

Contents

1 Introduction

1.1 Purpose

WSP SA Civil and Structural Engineers were appointed by WSP Environment & Energy to prepare a Traffic Impact Assessment for the proposed new Yzermyn coal mine near Piet Retief in Mpumalanga.

1.2 Locality

The site of the proposed mine is situated approximately 10km south-west of Dirkiesdorp along the existing dirt road. Dirkiesdorp is located approximately midway between Wakkerstroom and Piet Retief when traveling along the R543. (See Figure 1: Locality Map.)

1.3 Scope

This study covers the following aspects related to traffic:

- A brief description of the proposed development;
- Discussion of trip generation, distribution and assignment associated with the proposed mine;
- Analysis of traffic operating conditions for the proposed mine;
- Comment on public and road safety issues;
- Comment on on-going road pavement management and maintenance; and
- Conclusions and recommendations.

Figure 1: Locality Plan

2 Description of the Development

2.1 Existing Land Use

The land surrounding the proposed mine site is generally open uncultivated land with small areas of cultivated agricultural land in some places.

There are two townships between the proposed mine site and the Piet Retief siding to the North of the proposed mine. The Dirkiesdorp township is approximately 10km north-east of the site and the KwaSema township is approximately 25km north-east of the site (see Figure 1: Locality Map).

There are two schools in the study area, one along the dirt road between Dirkiesdorp and the proposed mine site (shown in Photo 1, Appendix A) and the other in Dirkiesdorp. This may raise safety issues, discussed in Section 6, Public and Road Safety.

2.2 Proposed Development

The proposed Yzermyn coal mine will produce just under 2 Mt per annum at maximum operating capacity. Construction is estimated to commence towards the end of 2014 with the commissioning phase of the mine starting in 2016. The expected lifespan of the mine will be 15 years.

The coal from Yzermyn will be transported by means of 30 ton capacity trucks (similar to that shown in Photo 2, Appendix A) along the route of the existing dirt road past Dirkiesdorp, towards Piet Retief along the R543. Once at the existing Piet Retief siding, the coal will be transported via rail from Piet Retief to the Richards Bay Coal Terminal.

Production at Yzermyn as well as the transportation of the product will occur 6 days per week.

2.3 Existing Road Network

The proposed mine is to be situated on the western side of the R543 between Wakkerstroom and Dirkiesdorp, to the south-west of Piet Retief which is to the west of the intersection of the R543 and the N2. Access to the site will be via the existing intersection with the R543 and Vaalbank Road in Dirikiesdorp. The intersection is shown in Photo 3, Appendix A and is labelled Intersection 1. The R543 in the vicinity of Intersection 1 is a tarred, 2-lane undivided road. The speed limit along the R543 in the vicinity of the intersection is 60 km/h. Vaalbank Road is a dirt road providing access to the proposed mine site.

There is another intersection along the R543 where heavy vehicles are deployed (R543 and Uitgevallen Road Intersection). This intersection will be called Intersection 2 and is approximately 20km North-east of Intersection 1 (R543 and Vaalbank Road). The R543 in the vicinity of Intersection 2 is a tarred, 2-lane undivided road with localised widening at the intersection. The speed limit along the R543 in the vicinity of Intersection 2 is 80 km/h.

Further north along the R543, approximately 25km from Intersection 2, is the intersection of the R543 and the access road to the Piet Retief Railway Siding. This intersection will be known as Intersection 3. The speed limit along the R543 in the vicinity of Intersection 3 is 60 km/h. The entrance to the Railway Siding is shown in Photos 4 and 5, Appendix A.

The three intersections mentioned above are identified on the Locality Plan (Figure 1).

3 Traffic Data

Manual, classified traffic counts were conducted at Intersections 1, 2 and 3 on Wednesday, 16 March 2012 between 06:00 and 18:00 (12 hours). Intersection 2 will not be analysed further in this study as the impact of the free-flow through movements on this intersection will be negligibly small. The resulting AM and PM peak hour traffic volumes at intersections 1 and 3 are shown in Figures 2 and 3. The volumes shown in Figures 2 and 3 are given in passenger car units (PCU's). It was assumed that 1 heavy vehicle is equivalent to 8 passenger car units.

24-Hour electronic traffic counts were undertaken over a 7-day period at two locations along the R543. Classified (light and heavy) counts of vehicles in each direction were carried out starting on Thursday, 17 May 2012 to Wednesday, 23 May 2012 at the following two locations:

- E-1: on the R543 between Intersection 1 and 2; and
- E-2: on the R543 between Intersection 2 and 3.

See Figure 1 for the location of Station E-1 and E-2.

It can be seen from these counts that the daily volumes of traffic are relatively low, with 7-day (24 hours) averages as follows:

Table 3.1: Seven-day Average Volumes (24-hours)

Station	Vehicles Classification	Northbound	Southbound	Both directions
E-1	Light	339	331	673
	Heavy	104	104	206
	All	445	437	879
E-2	Light	525	604	1126
	Heavy	130	95	224
	All	654	697	1352

The detailed traffic count data are included herewith in Appendix B.

Figure 2: Traffic Counts (2012) AM Peak Hour Traffic at Intersections 1 and 3

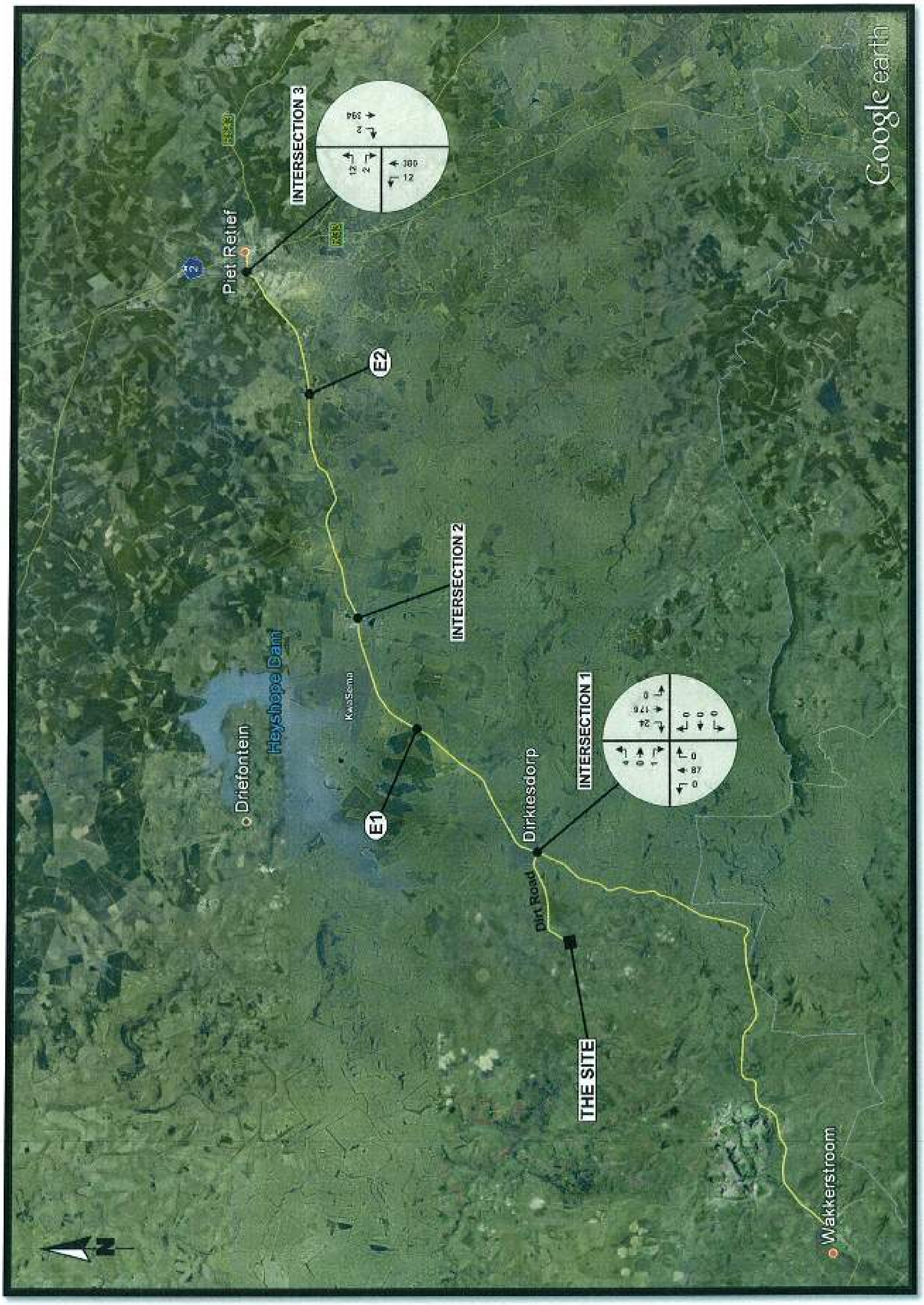


Figure 3: Traffic Counts (2012) PM Peak Hour Traffic at Intersections 1 and 3

4 Trip Generation, Distribution and Assignment

4.1 Trip Generation

Trip generation rates for this type of development are not available from standard sources. The trip generation used has been extracted from information provided by the client. This information is sub-divided into the construction phase, the commissioning phase and the operating phase and can be summarised as follows:

4.1.1 Construction Phase

It is expected that the Construction Phase will commence in 2015 and is estimated to continue for approximately 6 months. It was also assumed that the construction plant will remain on site for the duration of the construction phase and the impact of the construction on the surrounding road network is therefore considered to be negligible.

4.1.2 Commissioning and Operating Phase

Yzermyn mine is expected to be commissioned in 2016 operation will ramp up to full capacity within the third year of operation (2018). The expected annual production volumes are given in Table 4.1 below:

Table 4.1: Estimated Annual Production Volumes

Annual Production (Mtpa)													
2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
0.82	1.39	1.90	1.96	1.94	1.94	1.96	1.89	1.94	1.96	1.93	1.83	1.35	0.29

- **Coal Transportation**

  Product will be transported for 20 hours (two 10-hour shifts) on weekdays and during the single shift on a Saturday. The 30-ton haul trucks will transport the coal via the existing dirt road through Dirkiesdorp towards Piet Retief along the R543 to the Piet Retief siding. It was assumed that one empty truck will return to Yzermyn mine for every loaded truck that departs from the mine.

  Initially five 30-ton trucks will be needed per hour on weekdays for transporting the product to the siding. Peak operation will be reached by 2018, at which point twelve 30-ton trucks per hour will be required during the weekdays.

- **Labour Transportation**

  It was assumed that all employees will start working with the commissioning of the mine in 2016. The total staff component of Yzermyn mine is expected to be 350 people.

  The mine will operate in two 10-hour shifts during the week (Monday to Friday) from 06:00 to 16:00 and from 15:00 to 01:00. There will also be a "dog" shift from 01:00 to 06:00 (5-hours). There will only be one shift on a Saturday, which was not considered in the analysis because the weekday traffic volumes will be the worst case scenario.

The distribution between skilled, semi-skilled and unskilled staff was assumed to be 30%, 15% and 55% respectively. The skilled workers will work predominantly during the day-shift. The unskilled workers were further distributed; 10% were assumed to travel to and from the town of Dirkiesdorp, 10% to and from the town of KwaSema and 80% coming from other nearby towns; i.e. Piet Retief to the north and Volksrust and Wakkerstroom to the south.

The 350 employees will be split into the different shifts as follows; day shift (06:00 to 16:00) will comprise of 55% of the total employees, night shift (15:00 to 01:00) will be 35% and dog shift (01:00 to 06:00) will be 10%.

The staff composition as explained above is summarised in Table 4.2.

There will be approximately 50 private vehicles transporting employees to/from the mine, assuming that all private vehicles are owned by the skilled employees, i.e. most private vehicle trips are expected during the day-shift. For a worst case scenario, vehicle occupancy of 1 person per private vehicle was assumed. It was assumed employees without private vehicles will use minibus taxis which can transport approximately 15 passengers.

The employee's trip generation as explained above is summarised in Table 4.3.

Table 4.2: Staff Composition

Description	Total employees	Day Shift (55%)	Night Shift (35%)	Dog Shift (10%)
Skilled (30%)	**105**	84(1)	16(1)	5(1)
Semi-skilled (15%)	**53**	23	23	7
Unskilled from Dirkiesdorp	***19***	*9*	*8*	*2*
Unskilled from KwaSema	***19***	*9*	*8*	*2*
Unskilled from Other	***154***	*68*	*67*	*19*
Total unskilled (55%)	**192**	86	83	23
TOTAL	**350**	**193**	**122**	**35**

1. *Skilled employees work predominantly day-shift. It was assumed that 80% of the skilled employees will work during the day shift (6:00 to 16:00), 15% during the night shift (15:00 to 01:00) and 5% during the dog shift.*

Table 4.3: Employee Trip Generation

Description	Total Trips	Day Shift (55%)	Night Shift (35%)	Dog Shift (10%)
Private Vehicles	**50**	40(2)	8(2)	2(2)
To/from Dirkiesdorp	***3***	*1*	*1*	*1*
To/from KwaSema	***3***	*1*	*1*	*1*
To/from Other	***18***	*9*	*7*	*2*
Minibus Taxis	**24**	11	9	4
TOTAL	**74**	**51**	**17**	**6**

2. *Skilled employees work predominantly day-shift and these employees will own the private vehicles. The private vehicles were distributed the same as the skilled employees distributions; 80% for day shift (6:00 to 16:00), 15% for night shift (15:00 to 01:00) and 5% for dog shift.*

4.2 Trip Distribution and Assignment

To consider the worst case scenario it was assumed that the employee trips would occur during the AM and PM peak hours of the background traffic.

Most of the residential areas in the vicinity of the mine are located along the R543, north of the site which includes Dirkiesdorp, KwaSema and Piet Retief and south of the site to Wakkerstroom and Volksrust. It was assumed that 10% of the unskilled workers will travel to and from Dirkiesdorp, 10% unskilled will travel to and from KwaSema and the 80% unskilled, all semi-skilled and all skilled workers will travel to and from "other destinations" namely; Piet Retief (north) or Wakkerstroom and Volksrust (south). A 50:50 split between the north and south was assumed for trips to "other destinations".

Those trips to/from Dirkiesdorp will only effect the access at the proposed mine site, Intersection 1 is on the outskirts of Dirkiesdorp and will not be effected.

Those trips to/from KwaSema will affect the access at the proposed mine site and Intersection 1 as the town in further north of Dirkiesdorp.

Those trips to/from Piet Retief will affect the access at the proposed mine site, Intersection 1 and Intersection 3. Intersection 2 was disregarded because the impact of the free-flow through movements on this intersection will be negligibly small.

Those trips to/from Wakkerstroom will affect the access at the proposed mine site and Intersection 1 as the town in south of Dirkiesdorp and the proposed mine.

As the day shift (6:00 to 16:00) and the night shift (15:00 to 01:00) overlap, it was assumed for a worst case scenario that the minibus taxis dropping employees off for the 15:00 shift will not wait for the 16:00 shift to leave and therefore each shift, day and night, will have their own set of minibus taxis. The dog shift staff was assumed to depart with the minibus taxis which drop off the day shift at 06:00.

The loaded trucks will travel north to Piet Retief and once unloaded will travel back south to the mine. The trucks will affect Intersections 1 and 3. Intersection 2 was disregarded because the impact of the free-flow through movements on this intersection will be negligibly small.

The generated trips during the weekday peak hours at commissioning stage (2016) are shown in Figures 4 and 5. The generated trips at peak operation (by 2018) are shown in Figures 6 and 7.

4.3 Traffic Growth

An annual growth rate of 3% was assumed for the background traffic.

The assigned generated traffic was combined with the background traffic to produce the expected total AM and PM peak traffic volumes for the base year (2016) without Yzermyn Mine (Figures 8 and 9) and with Yzermyn Mine (Figures 10 and 11).

The total AM and PM traffic volumes in 2018, when operations will reach maximum capacity, are shown in Figures 12 and 13.

The total horizon year traffic volumes (2021) without Yzermyn Mine are shown in Figures 14 and 15 and the horizon year (2021) with Yzermyn Mine is shown in Figures 16 and 17.

The volumes shown in Figures 8 to 17 are given in PCU's.

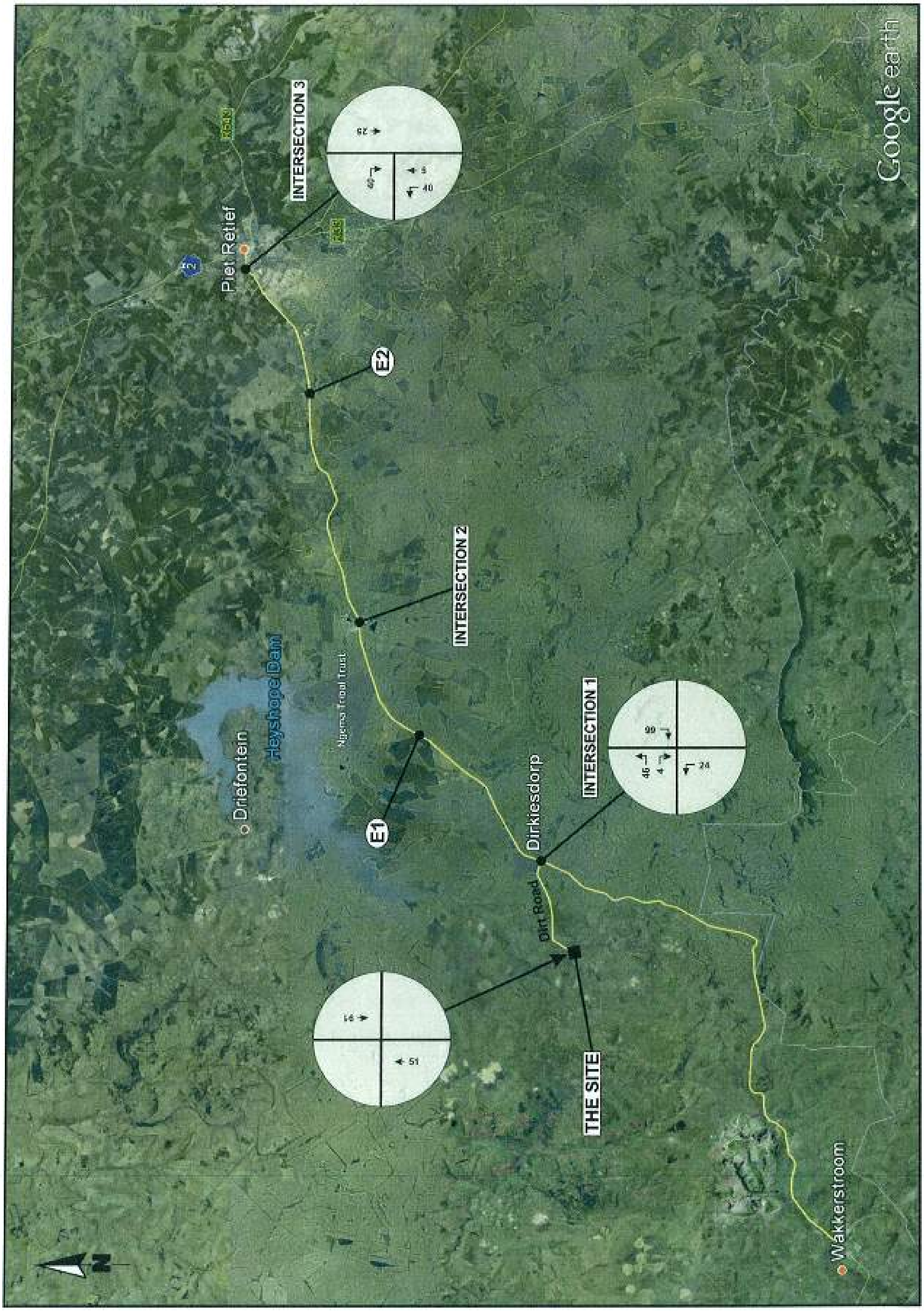


Figure 4: Generated AM Peak Hour Trips at Commissioning Stage (2016)

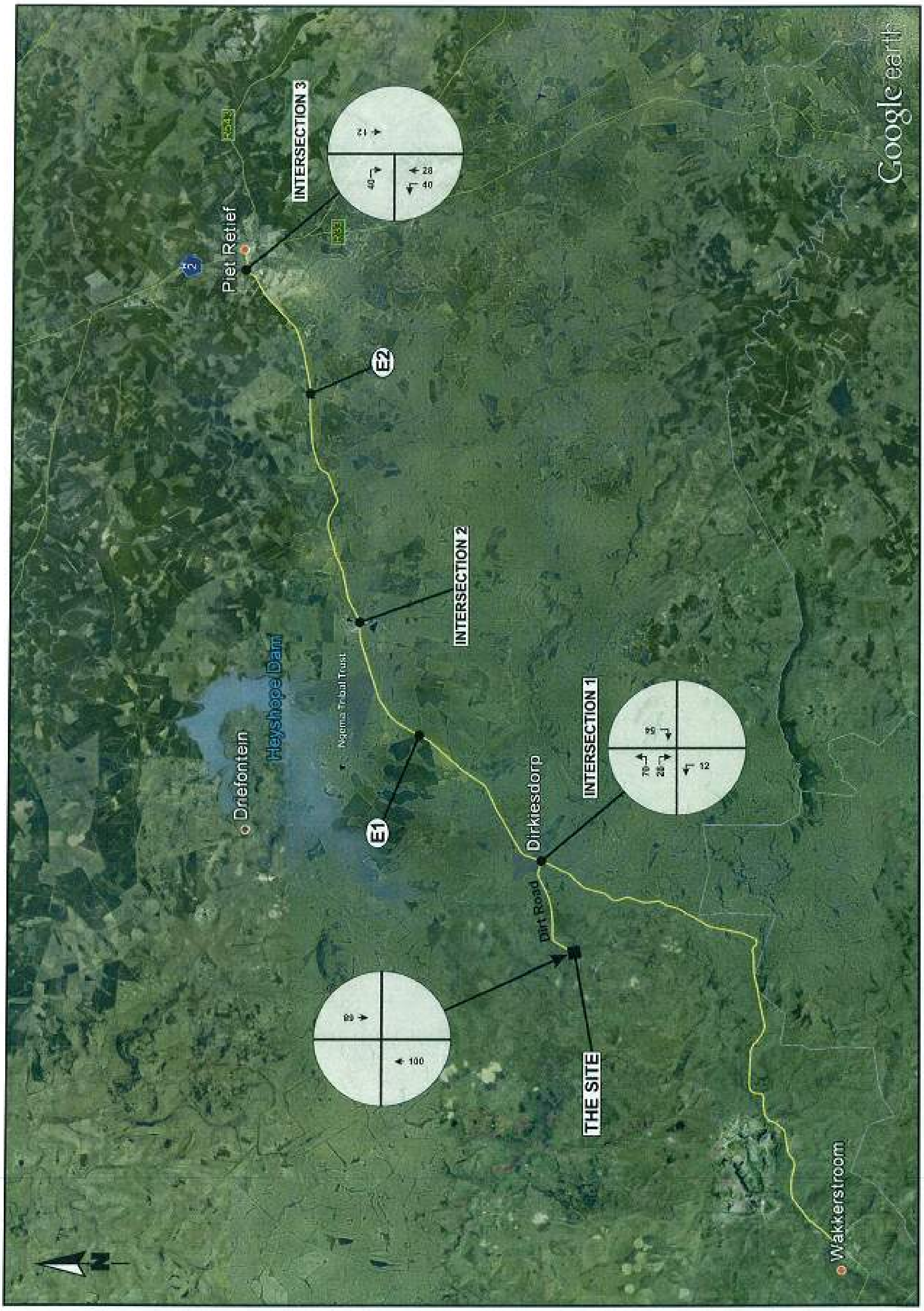


Figure 5: Generated PM Peak Hour Trips at Commissioning Stage (2016)

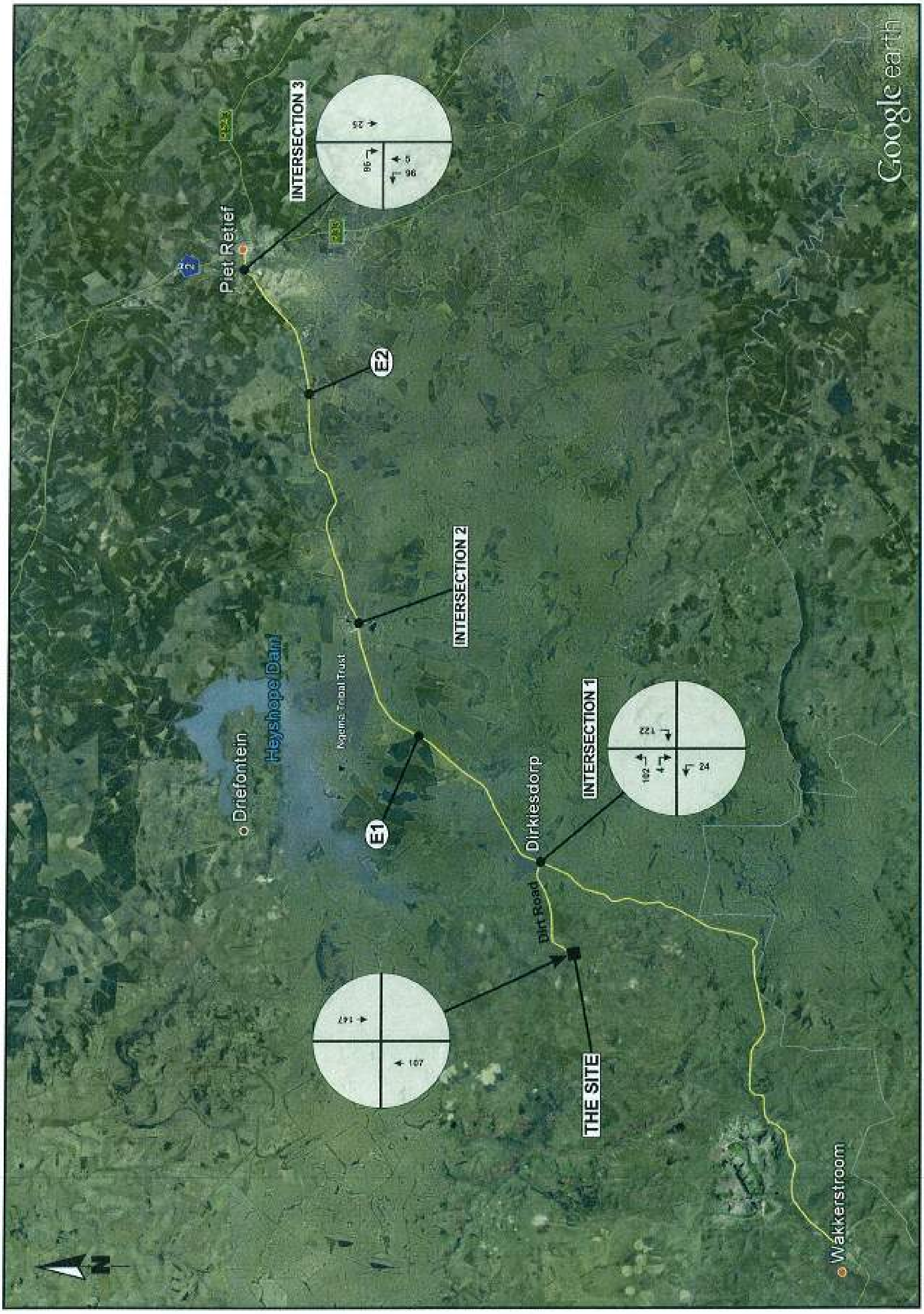


Figure 6: Generated Trips at Full Operation (by 2018) AM Peak Hour

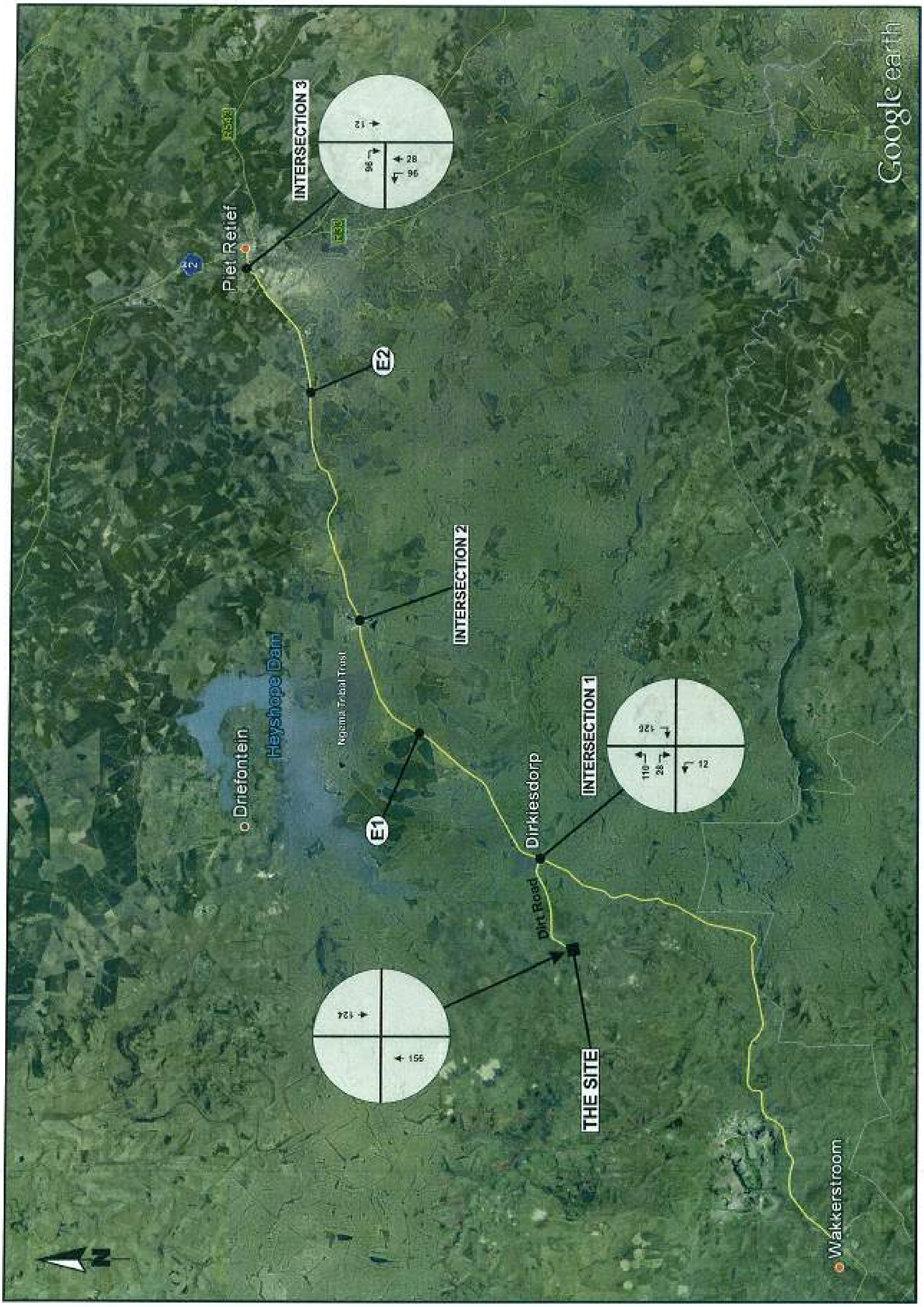


Figure 7: Generated Trips at Full Operation (by 2018) PM Peak Hour

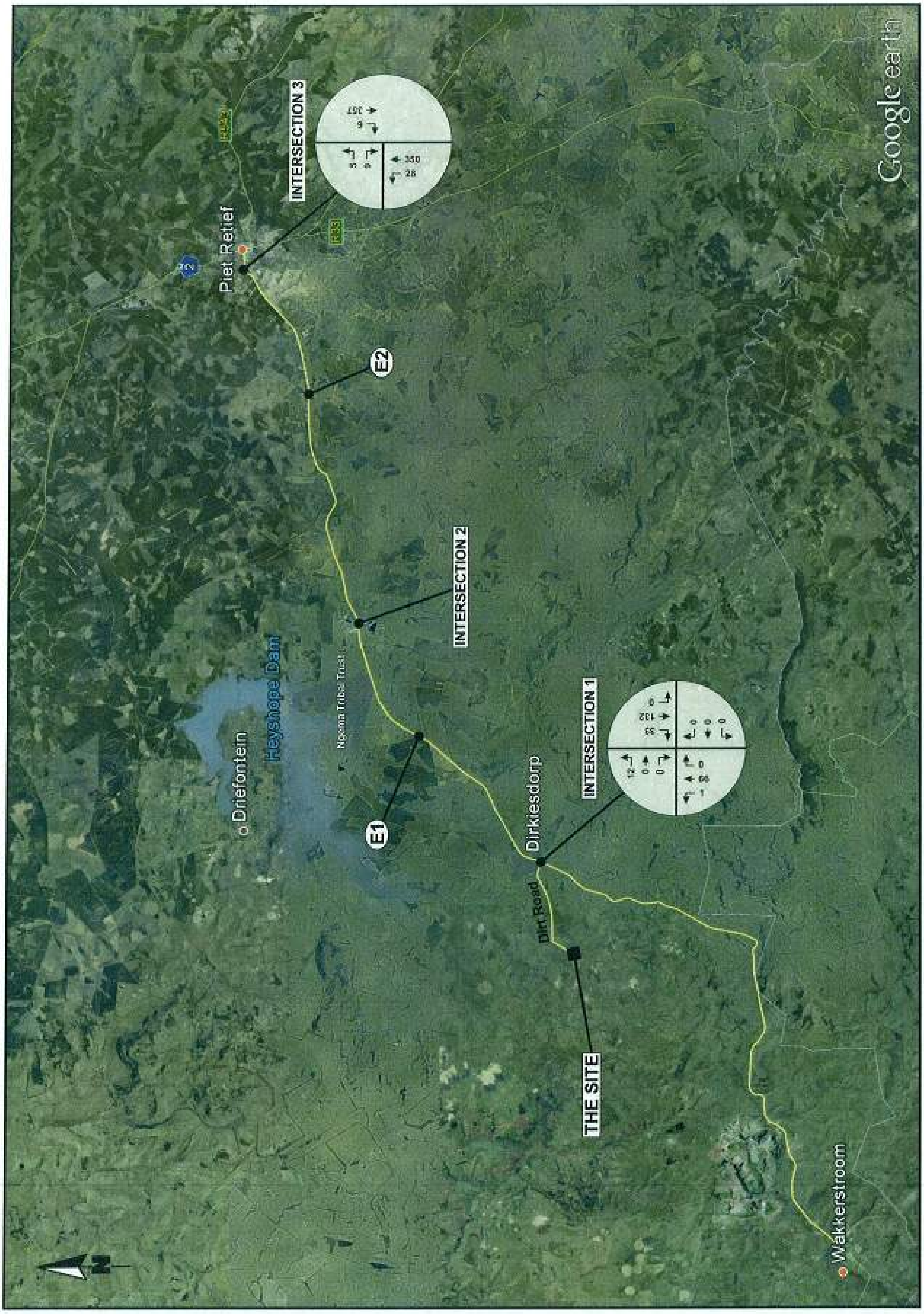


Figure 8: Base Year (2016) AM Peak Hour Traffic

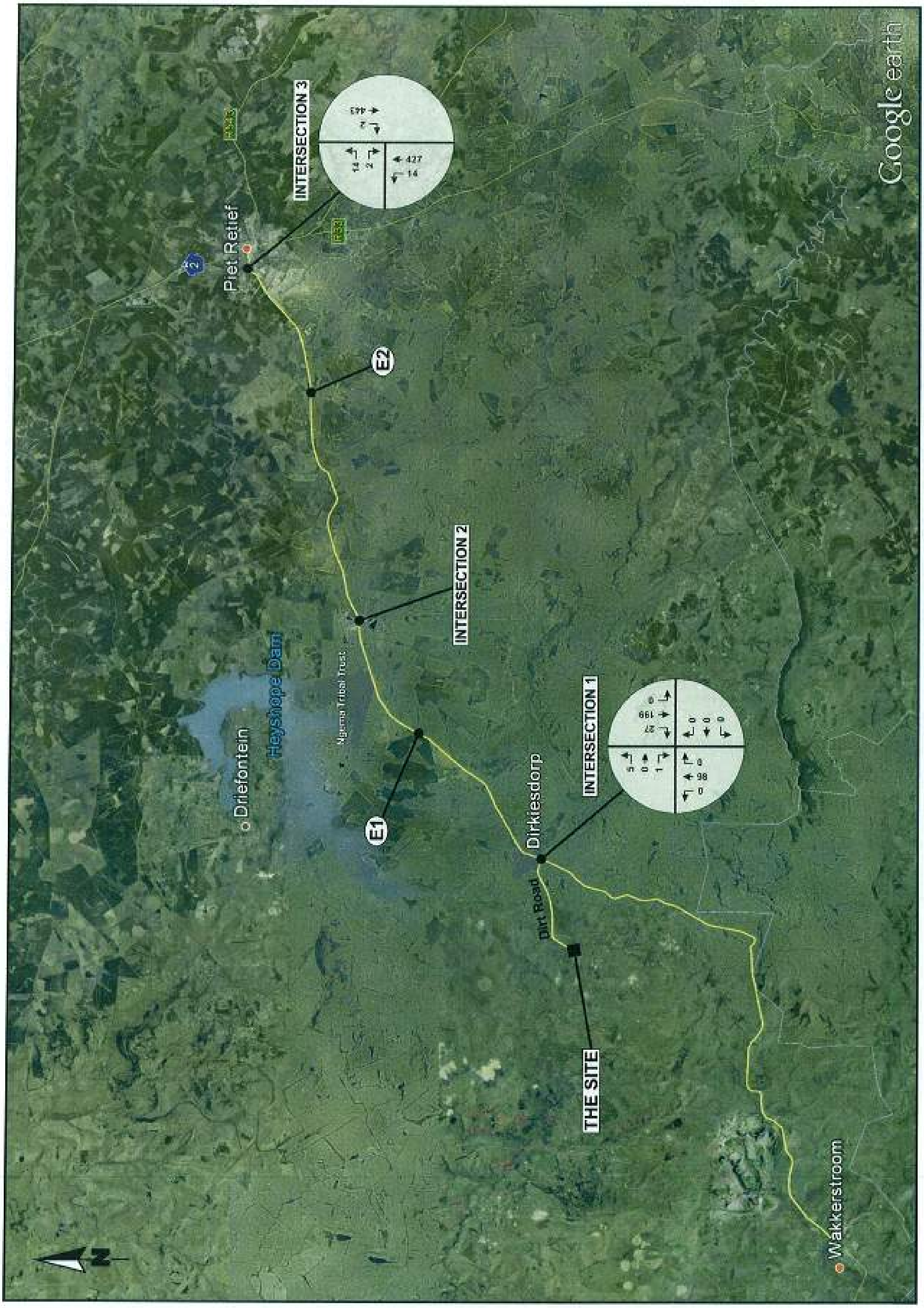


Figure 9: Base Year (2016) PM Peak Hour Traffic

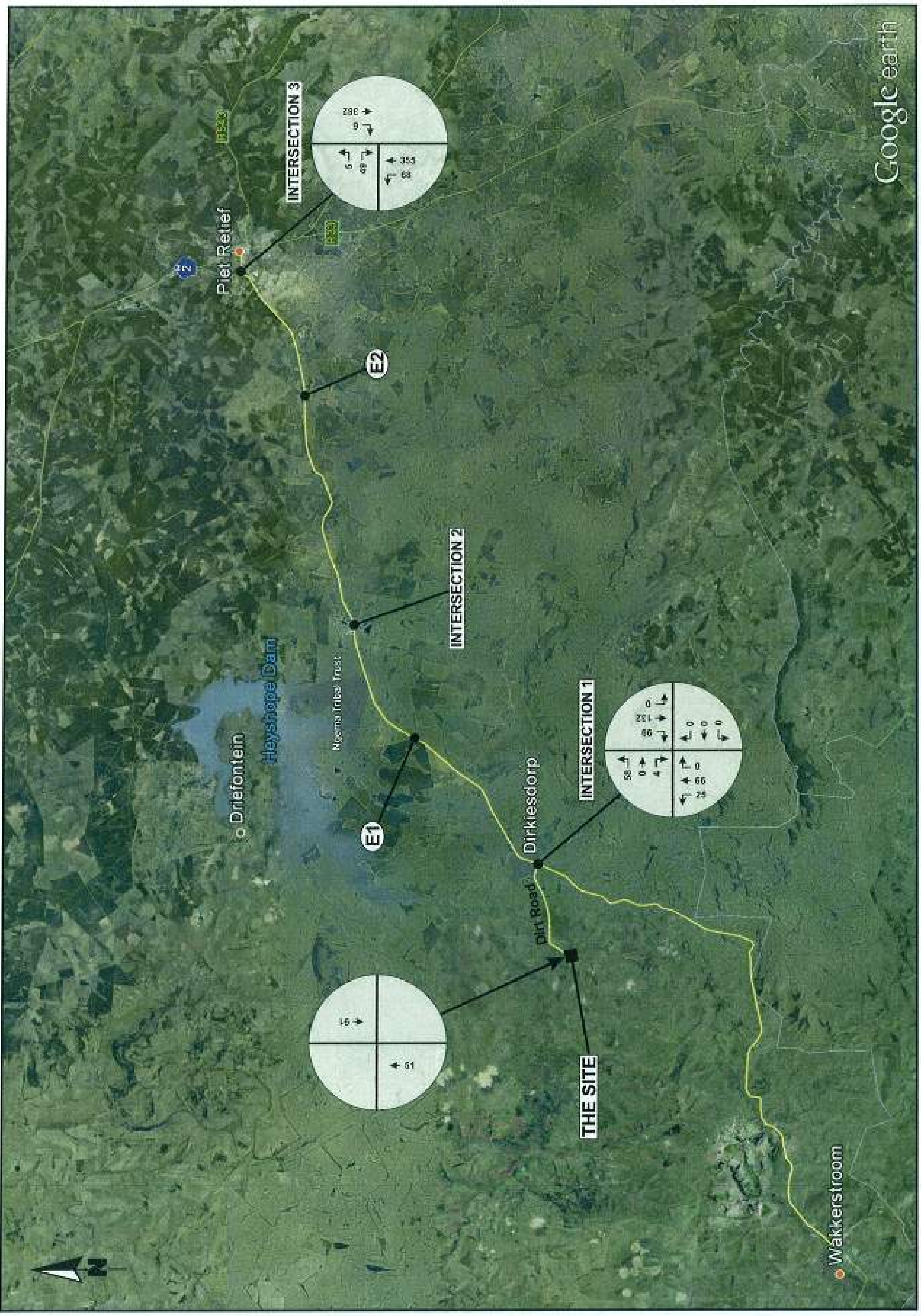


Figure 10: Base Year (2016) AM Peak Hour Traffic with Yzermyn Mine

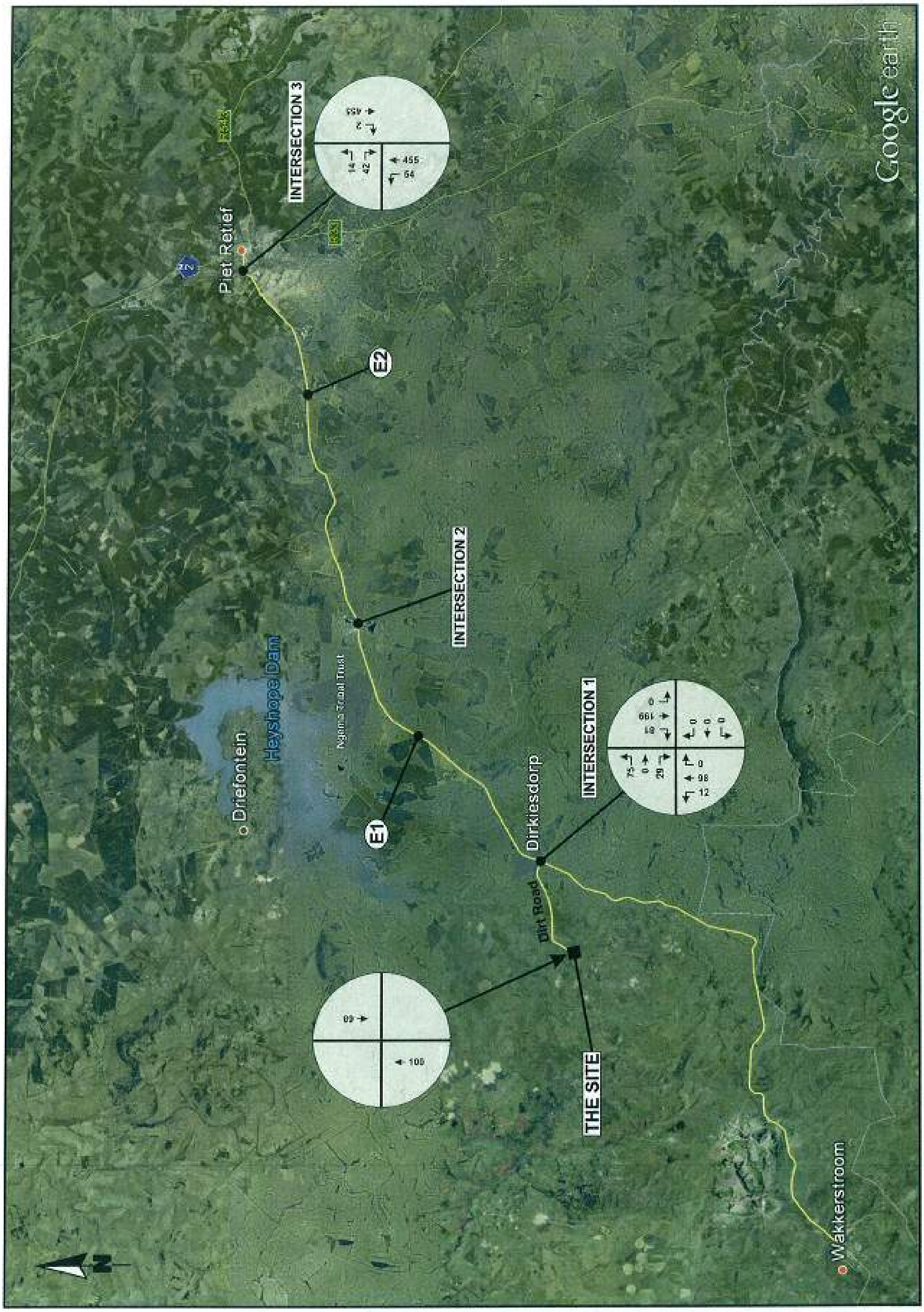


Figure 11: Base Year (2016) PM Peak Hour Traffic with Yzermyn Mine

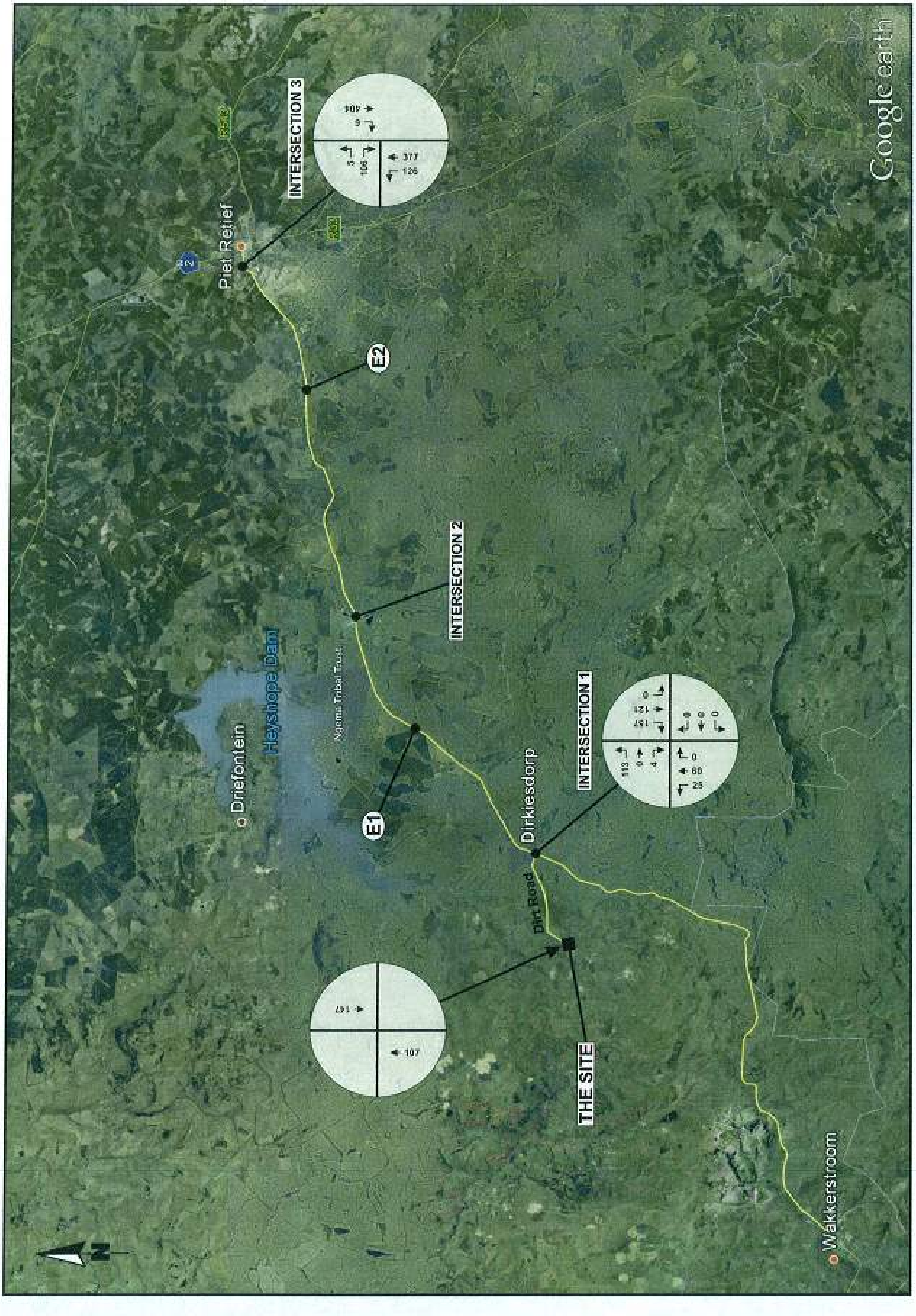


Figure 12: Full Operation (2018) AM Peak Hour Traffic

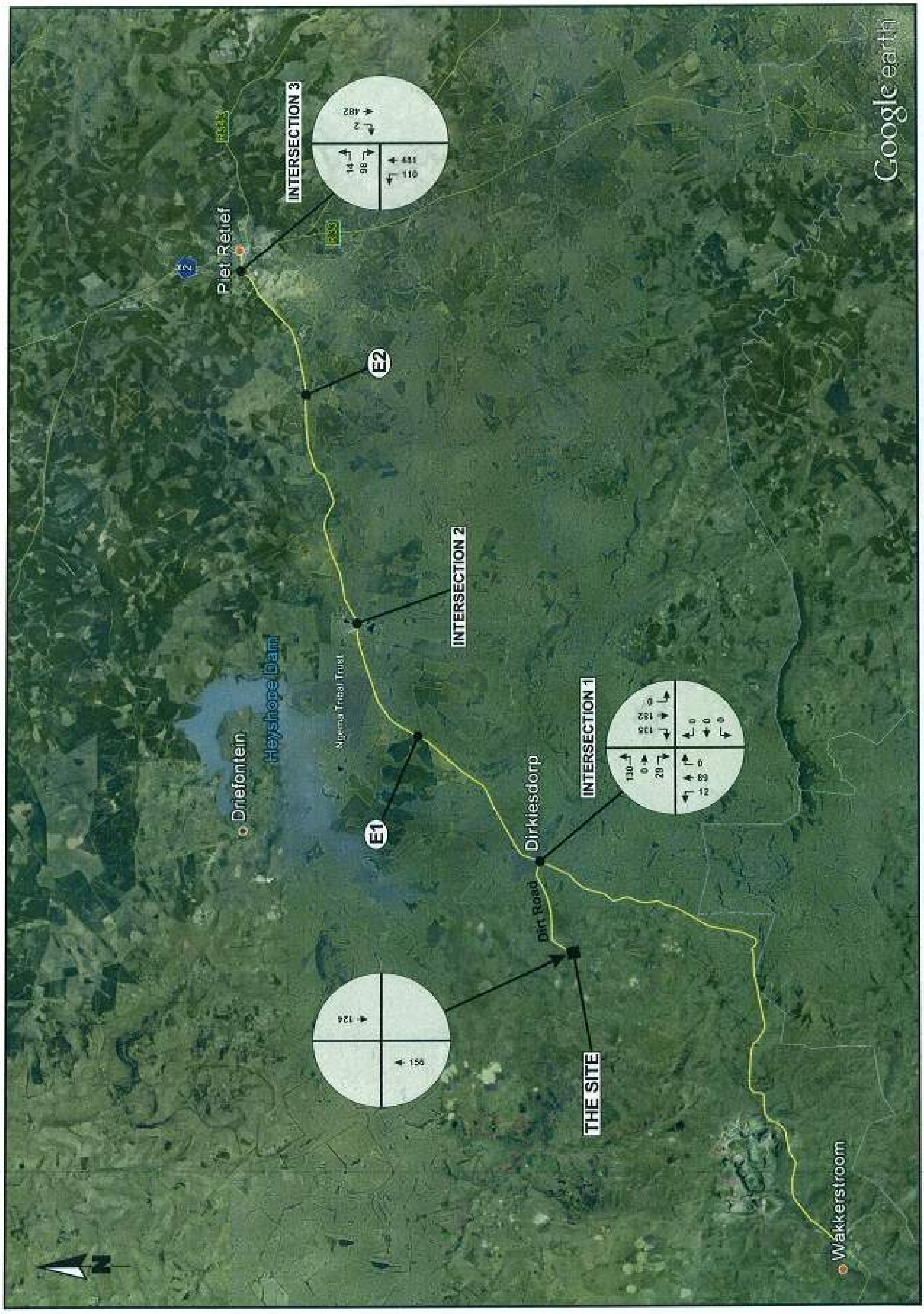


Figure 13: Full Operation (2018) PM Peak Hour Traffic

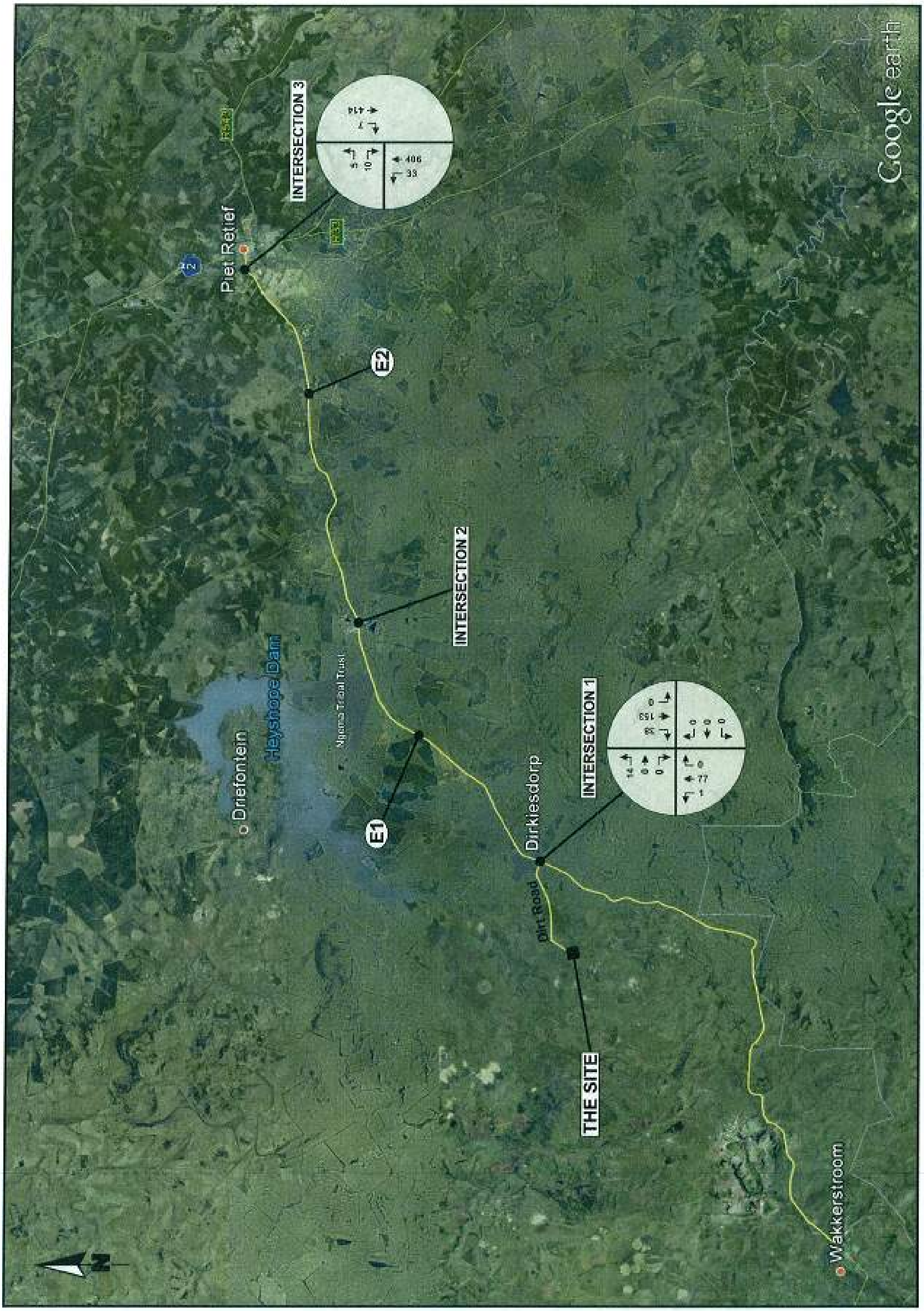


Figure 14: Horizon Year (2021) AM Peak Hour Traffic

Figure 15: Horizon Year (2021) PM Peak Hour Traffic

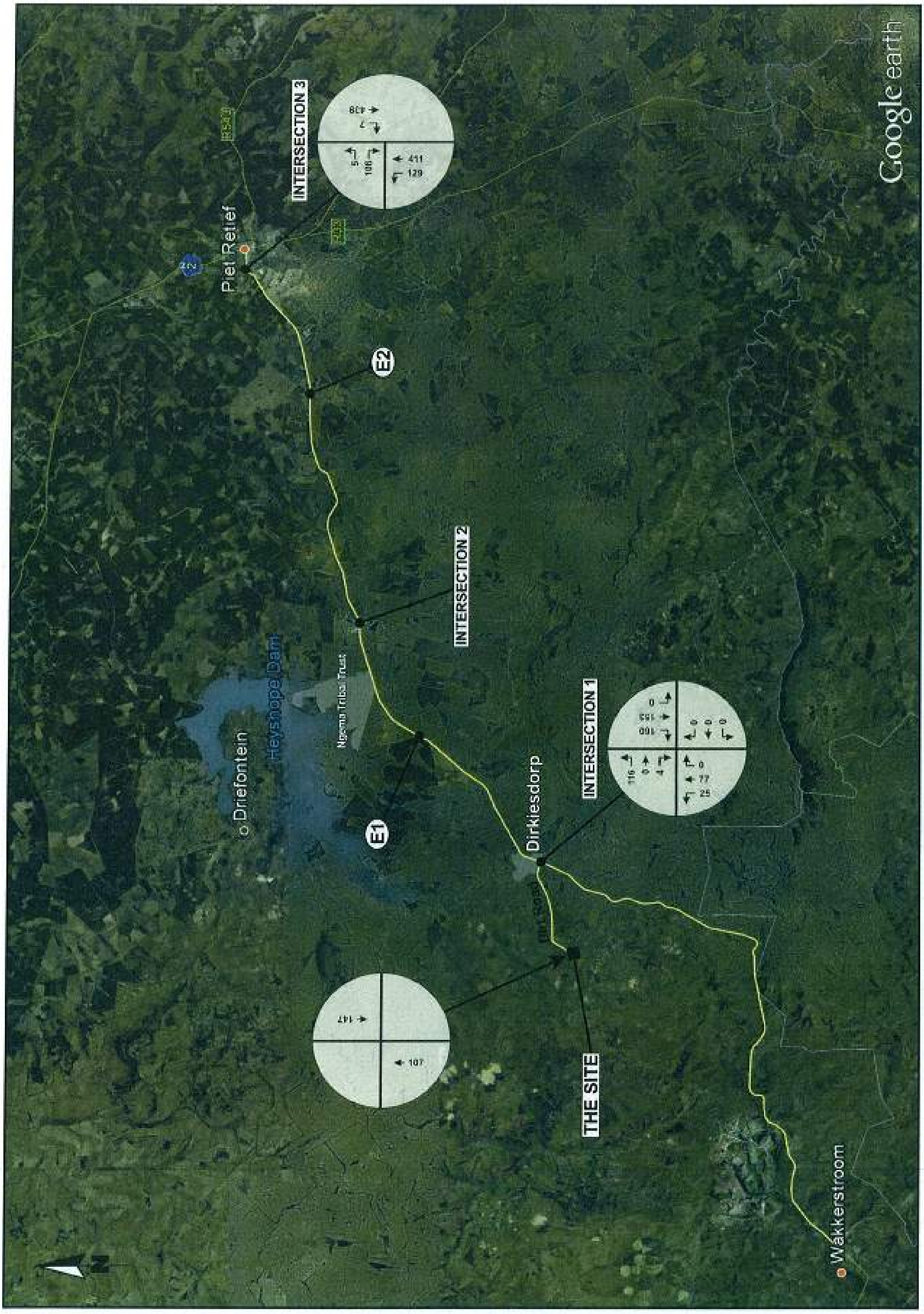


Figure 16: Horizon Year (2021) AM Peak Hour Traffic with Yzermyn Mine

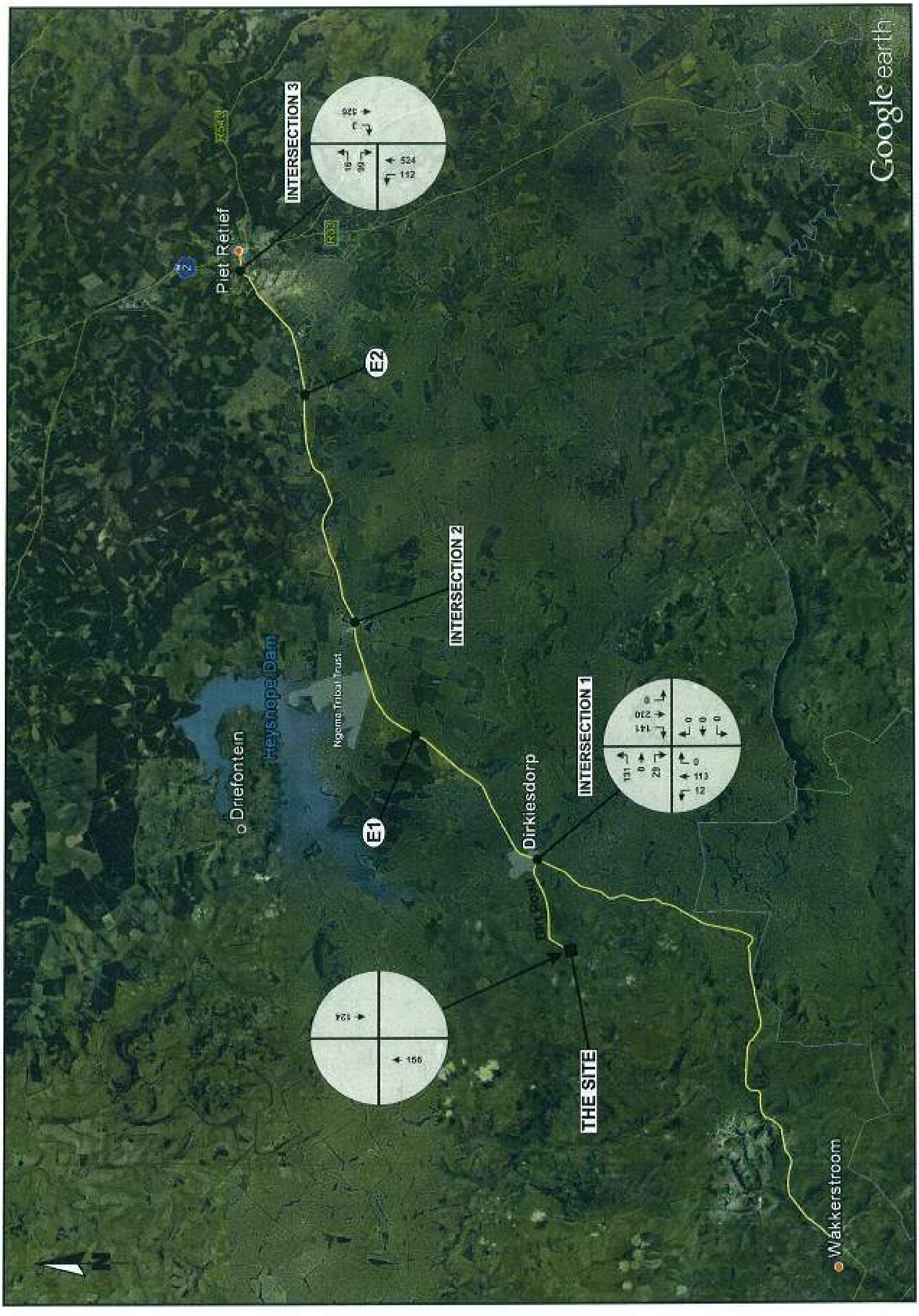


Figure 17: Horizon Year (2021) PM Peak Hour Traffic with Yzermyn Mine

5 Operational Assessment

5.1 Levels of Service

Operating conditions for peak hours are normally assessed in terms of Levels of Service (LOS), volume to capacity ratios (v/c), and average delay.

At this point it is worth considering what is meant in terms of levels of service. In this regard the following is an extract from the US Highway Capacity Manual:

"The concept of level of service uses qualitative measures that characterize operational conditions within a traffic stream and their perception by motorists and passengers. The descriptions of individual levels of service characterize these conditions in terms of such factors as speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with level of service (LOS) A representing the best operating conditions and LOS F the worst. Each level of service represents a range of operating conditions.

The volume of traffic that can be served under the stop-and-go conditions of LOS F is generally accepted as being lower than possible at LOS E, consequently, service flow rate E is the value that corresponds to the maximum flow rate, or capacity, on the facility. For most design or planning purposes, however, service flow rates D or C are usually used because they ensure a more acceptable quality of service to facility users."

5.2 Operational Assessment

According to the South African Manual for Traffic Impact Studies (1), a development of this size requires an analysis for the base year, which has been assumed to be 2016 and a horizon year of 5 years; i.e. 2021.

In this regard the AM and PM peak hours of the following scenarios have been considered for analysis:

- Scenario 1: Existing traffic (2013);
- Scenario 2: Base year (2016) without Yzermyn Mine;
- Scenario 3: Base year (2016) with Yzermyn Mine;
- Scenario 4: Full operation of Yzermyn (2018);
- Scenario 5: Horizon year (2021) without Yzermyn Mine; and
- Scenario 6: Horizon year (2021) with Yzermyn Mine.

Analysis of the operational conditions with respect to the above has been undertaken using the SIDRA 5.1 software (2).

5.3 SIDRA Analysis Results

The results of the analysis of the Intersections1 and 3 can be summarized as follows.

5.3.1 Intersection 1: R543/Vaalbank Road

The following comments are relevant to the analysis of the intersection of the R543 and Vaalbank Road.

Figure 18 below shows the schematic layout of the existing two-way stop controlled intersection. The SIDRA results are summarized in Table 5.1 and 5.2 below. The detailed analysis results are included herewith in Appendix C.

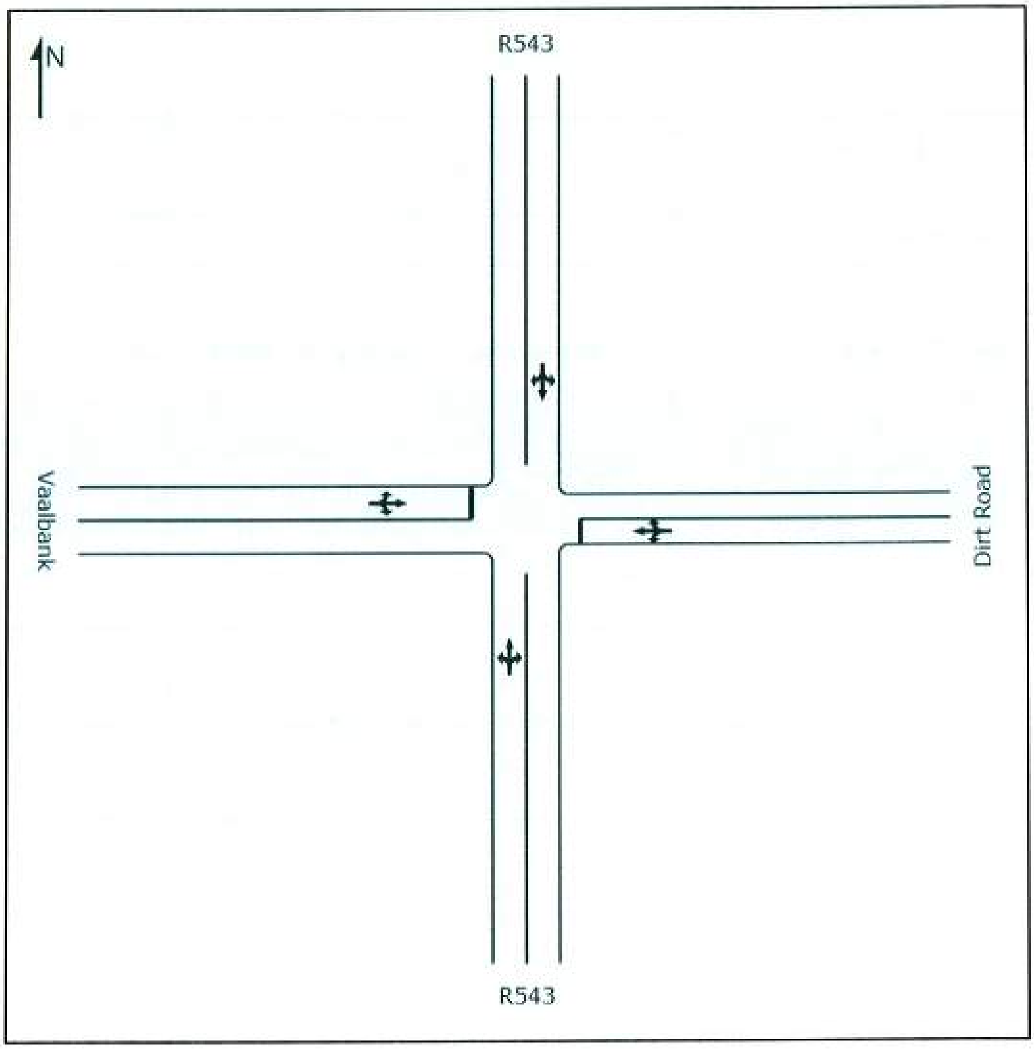


Figure 18: Existing Layout of the Intersection 1 (R543/Vaalbank Road)

Table 5.1: SIDRA Results for Intersection 1 during the AM Peak Hour

Approach	Movement	Existing (2012)		Base Year (2016)				Full Operation (2018)		Horizon Year (2021)			
				Without Mine		With Mine				Without Mine		With Mine	
		v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS
R543 (South)	L T R	0.041	A	0.045	A	0.061	A	0.057	A	0.052	A	0.068	A
Dirt Road (East)	L T R	0.004	B	0.004	B	0.005	B	0.006	B	0.005	B	0.006	C B
R543 (North)	L T R	0.101	A	0.111	A	0.172	A	0.218	A	0.129	A	0.244	A
Vaalbank (West)	L T R	0.013	B	0.014	B	0.063	B	0.114	B	0.016	B	0.120	B
Average Delay (sec)		2.2		2.2		4.9		6.1		2.3		5.8	

Table 5.2: SIDRA Results for Intersection 1 during the PM Peak Hour

Approach	Movement	Existing (2012)		Base Year (2016)				Full Operation (2018)		Horizon Year (2021)			
				Without Mine		With Mine				Without Mine		With Mine	
		v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS
R543 (South)	L T R	0.064	A	0.071	A	0.079	A	0.073	A	0.081	A	0.089	A
Dirt Road (East)	L T R	0.005	B	0.005	B	0.006	C B	0.007	C	0.006	B	0.008	C
R543 (North)	L T R	0.138	A	0.151	A	0.204	A	0.245	A	0.175	A	0.285	A
Vaalbank (West)	L T R	0.010	B	0.012	B	0.190	B	0.264	B	0.012	B	0.290	B
Average Delay (sec)		1.7		1.8		5.1		6.3		1.9		6.1	

5.3.1.1 Scenario 1: Existing Traffic (2013)

- **AM Peak Hour**

  All movements are well above the acceptable level of service D, operating at LOS A and B, and all $^{V}/_{C}$ ratios are well below 0.95 during the existing (2013) AM peak hour. The overall average delay per vehicle is 2.2 seconds.

- **PM Peak Hour**

  Similar to the AM peak hour, all movements during the PM peak hour are well above the acceptable level of service D (LOS A and B) and all $^{V}/_{C}$ ratios are well below 0.95. The overall average delay per vehicle is slightly lower than during the AM peak hour, i.e. 1.7 seconds.

5.3.1.2 Scenario 2: Base year (2016) without Yzermyn Mine

- **AM and PM Peak Hours**

  Traffic growth alone has hardly any effect on the traffic operating conditions during both the AM and PM peak hours.

5.3.1.3 Scenario 3: Base year (2016) with Yzermyn Mine

- **AM and PM Peak Hours**

  The estimated trips generated by Yzermyn Mine have a noticeable impact on the average delay per vehicle and the $^{V}/_{C}$ ratio from the western approach. However, the operating conditions are expected to continue at very good levels of service during both the AM and PM peak hours.

5.3.1.4 Scenario 4: Full Operation (2018)

Yzermyn Mine is expected to reach maximum production in 2018, at which point the maximum number of haul trucks to/from the mine will be generated.

- **AM Peak Hour**

  The levels of service remain unchanged during the AM peak hour. Slight increases in the $^{V}/_{C}$ ratios and average delays are expected. Operating conditions remain at acceptable LOS.

- **PM Peak Hour**

  During the PM peak hour the LOS from the eastern approach changes from B to C, which is still acceptable. As with the AM peak hour slight increases in the $^{V}/_{C}$ ratios and average delays are expected, but operating conditions remain at acceptable.

5.3.1.5 Scenario 5: Horizon year (2021) without Yzermyn Mine

- **AM and PM Peak Hours**

  Traffic growth between the base and horizon years has hardly any effect on the traffic operating conditions during both the AM and PM peak hours.

5.3.1.6 Scenario 6: Horizon year (2021) with Yzermyn Mine

- **AM Peak Hour**

  The estimated mine trips will change the LOS of the left-turn from the eastern approach from LOS B to C. The other LOS remains unchanged and the intersection continues to operate at acceptable conditions during the AM peak hour.

- **PM Peak Hour**

  The trips generated by the mine will change the LOS on the eastern approach from B to C. The other LOS remains unchanged and the intersection continues to operate at acceptable conditions during the PM peak hour.

5.3.2 Intersection 3

The following comments are relevant to the analysis of the T-junction of the R543 and the access road to the Railway Siding.

Figure 19 below shows the schematic layout of the T-junction with the stop-controlled access road and free-flow along the R543. The SIDRA results are summarized in Table 5.3 and 5.4 below. The detailed analysis results are included herewith in Appendix D.

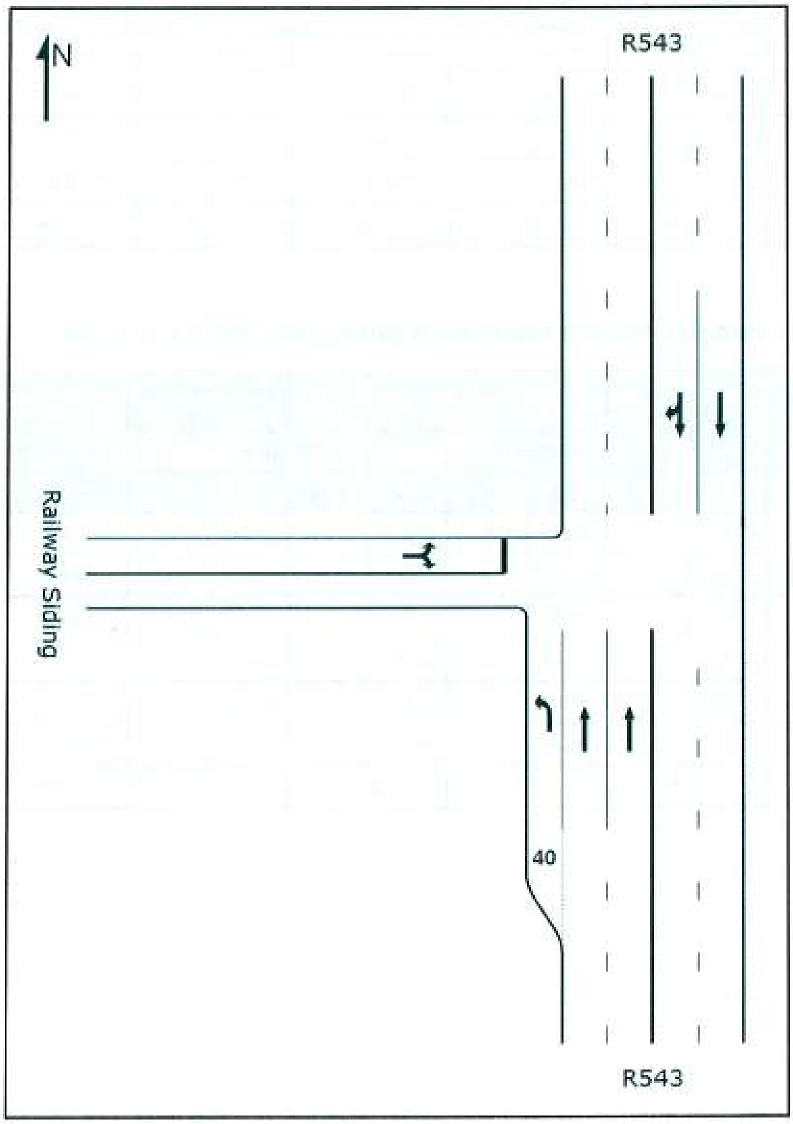


Figure 19: Existing Layout of Intersection 3 (R543/Siding Access)

Table 5.3: SIDRA Results for Intersection 3 during the AM Peak Hour

Approach	Movement	Existing (2013)		Base Year (2016)				Full Operation (2018)		Horizon Year (2021)			
				Without Mine		With Mine				Without Mine		With Mine	
		v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS
R543 (South)	L	0.016	A	0.017	A	0.042	A	0.078	A	0.020	A	0.080	A
	T	0.088	A	0.095	A	0.097	A	0.103	A	0.111	A	0.112	A
R543 (North)	T	0.112	A	0.124	A	0.132	A	0.141	A	0.145	A	0.155	A
	R	0.112	B	0.124	B	0.132	B	0.141	C	0.145	B	0.155	C
Railway Siding (West)	L	0.026	B	0.032	B	0.143	C	0.319	C	0.039	C	0.352	C
	R	0.026	B	0.032	B	0.143	C	0.319	C	0.039	C	0.352	C
Average Delay (sec)		1.8		2.0		3.4		5.1		2.4		5.3	

Table 5.4: SIDRA Results for Intersection 3 during the PM Peak Hour

Approach	Movement	Existing (2013)		Base Year (2016)				Full Operation (2018)		Horizon Year (2021)			
				Without Mine		With Mine				Without Mine		With Mine	
		v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS
R543 (South)	L	0.009	A	0.010	A	0.039	A	0.080	A	0.012	A	0.082	A
	T	0.125	A	0.137	A	0.146	A	0.154	A	0.159	A	0.168	A
R543 (North)	T	0.132	A	0.144	A	0.148	A	0.157	A	0.169	A	0.174	A
	R	0.132	C	0.144	C	0.148	C	0.157	C	0.169	C	0.174	D
Railway Siding (West)	L	0.040	B	0.049	B	0.271	C	0.631	D	0.068	B	0.743	D
	R	0.040	B	0.049	B	0.271	C	0.631	D	0.068	C	0.743	D
Average Delay (sec)		2.4		2.7		4.6		7.6		3.4		8.9	

5.3.2.1 Scenario 1: Existing Traffic (2013)

- **AM Peak Hour**

  Currently all movements are well above the acceptable level of service D, operating at LOS A and B, and all $^V/_C$ ratios are well below 0.95 during the AM peak hour. The overall average delay per vehicle is 1.8 seconds.

- **PM Peak Hour**

  Similar to the AM peak, all movements are well above the acceptable level of service D, operating at LOS A to C, and all $^V/_C$ ratios are well below 0.95. The average delay per vehicle is slightly higher during the PM peak hour, i.e. 2.4 seconds.

5.3.2.2 Scenario 2: Base year (2016) without Yzermyn Mine

- **AM and PM Peak Hours**

  The effect of traffic growth alone is insignificant in terms of the operating conditions during both the AM and PM peak hours.

5.3.2.3 Scenario 3: Base year (2016) with Yzermyn Mine

- **AM and PM Peak Hours**

  The estimated trips generated by the mine will change the LOS from the siding from B to C during both peak hours. The other LOS remains the same as before. The average vehicle delay is slightly increased by the additional traffic volumes.

5.3.2.4 Scenario 4: Full Operation (2018)

- **AM Peak Hour**

  The LOS of the right-turn from the northern approach will change from B to C during the AM peak hour. The other LOS remains the same.

- **PM Peak Hour**

  During the PM peak hour the LOS on from the railway siding is changed from LOS C to D, which is still acceptable. The other levels of service are not affected.

5.3.2.5 Scenario 5: Horizon year (2021) without Yzermyn Mine

- **AM Peak Hour**

  Traffic growth between the base and horizon years results in the LOS from the siding access to change from B to C during the AM peak hour.

- **PM Peak Hour**

  During the PM peak hour only the right-turn from the siding access road is affected and changed from LOS B to C.

5.3.2.6 Scenario 6: Horizon year (2021) with Yzermyn Mine

- **AM Peak Hour**

  The estimated mine traffic is expected to change the LOS of the right-turn from the north (R543) from LOS B to C. The intersection will still be operating at acceptable LOS during the AM peak hour.

- **PM Peak Hour**

  During the PM peak hour the mine traffic will change the LOS of the right-turn from the north from C to D and both movements from the railway siding is expected to operate at LOS D. These operating conditions are still considered to be acceptable.

5.3.3 Mitigation Measures

The Manual for Traffic Impact Studies(1) states that the traffic impact of any proposed development should be mitigated under the following circumstances:

- If the level of service (LOS) of any element of the facility drops below D; or
- If the volume to capacity (v/c) ratio of any element of the facility increases above 0.950; and
- If the contribution of the development is at least 2% of the sum of the critical lane volumes of the element.

The above relates to peak hour conditions and based on these warrants, and taking the above analysis results into account no mitigation measures to the intersections are required as a result of the proposed Yzermyn Mine.

6 Public and Road Safety Issues

The following issues are considered to be relevant to the public and road safety in the vicinity of the proposed mine, as well as along the haul route (R543).

6.1 Public Safety

There are two schools in the study area, one along the dirt road between Dirkiesdorp and the proposed mine site (shown in Photo 1, Appendix A) and the other in Dirkiesdorp. The learners walk, play and stand around in the roadway as shown in Photo 6 in Appendix A. This is obviously a public safety concern, which will be exacerbated once the traffic volumes on the R543 increase due to Yzermyn mine.

The public, especially children, needs to be educated about road safety. Consideration should be given to pedestrian crossing(s) for children who need to cross the R543. These should be clearly marked with the appropriate road signs as per the South African Road Traffic Signs Manual.

Note that the use of pedestrian crossings could increase accident potential as pedestrians would expect vehicles to stop at the crossings but in reality the case is not always so. An alternative is to place warning signs along the route near the schools to warn motorists of pedestrians.

6.2 Road Safety

The following issues are considered to be relevant to road safety:

- Shoulder sight distance;
- Heavy vehicle turning movements;
- Dust; and
- Road surface conditions.

6.2.1 Shoulder Sight Distance

Shoulder sight distance is the distance that the driver of a vehicle that is stationary at the stop line of a minor road can see along the major road, to be able to enter or cross the major road before an approaching vehicle reaches the intersection.

It is therefore a function of the speed of vehicles travelling on the major road, the width of the major road and the type of vehicles that are trying to cross.

In the case of the intersection of the R543 and Vaalbank Road the speed to consider on the R543 is 60km/h, the width of the R543 is assumed to be 7m to 7.5m and the design vehicle is assumed to be a single unit plus trailer (SU+T), according to TRH 17, Geometric Design of Rural Roads (3), the shoulder site distance at the intersection should be of the order of 225m. There is an existing shoulder site distance greater than 225m in both the south and north directions of the intersection.

The speed in the vicinity of the Piet Retief Railway Siding intersection is 60km/h, the width of the R543 is assumed to be 14m to 14.5m and the design vehicle is assumed to be a single unit plus trailer (SU+T). According to TRH 17 the shoulder site distance at the intersection should be of the order of 250m. There is an existing shoulder site distance greater than 250m in the southern direction of the intersection. In the northern direction the existing shoulder site distance is approximately 150m due to the obstruction of the railway bridge and is considered insufficient. Figure 20 shows the sight distance to the north at the Siding.

As there are already heavy vehicles using the existing Siding access with the sub-standard northern shoulder site distance, the addition of heavy vehicles from the proposed mine site to this access will increase the accident potential of the intersection. It is recommended that the intersection control be altered, i.e. signalisation, or the access be moved towards the south, which will require expropriation of land. Further investigation should be undertaken to determine the most appropriate solution. Note that the stopping sight distance, according to TRH 17, of vehicles approaching from the north at 60km/h is required to be 85m. The existing site distance from the railway bridge to the siding access is 150m which is well above the required distance. The existing stopping sight distance will accommodate vehicles travelling above 80km/h and is considered sufficient for the siding access to operate under safe conditions given the absence of shoulder sight distance to the north.

Figure 20: Sight Distance at Piet Retief Siding to the North

6.2.2 Heavy Vehicle Turning Movements

The W107 and W108 intersection warning signs should be erected either side of the Yzermyn access in accordance with the requirements of the South African Road Traffic Signs Manual (SARTSM) and it is recommended that IN 11.569 supplementary warning plates be added to these warning signs indicating the presence of heavy vehicles at the intersection. This signage should also be provided at the siding intersection if signs are not provided already.

W107

W108

IN11.569

6.2.3 Dust

Dust should not be an issue on the tarred R543 transport route because it is situated far from the mine site. Fine coal dust could impair driver visibility at the new mine access and mitigating measures should be implemented, i.e. cleaning of area and wetting etc.

6.2.4 Road Surface Conditions

A visual inspection of the existing road surfaces in the vicinity of the proposed mine and along the R543 was undertaken during a site visit on 29 March 2012.

The R543 is tarred all the way between Dirkiesdorp and Piet Retief and is mostly in an acceptable condition for current traffic use. There is however a few sections of the R543 which show signs of failure (cracked surface, filled in potholes and crocodile cracks in wheel paths), as shown in Photos 7, 8, 9 and 10 in Appendix A. The irregular road surface is a road safety concern, especially in dark or wet conditions when potholes aren't clearly visible.

The road leading from Dirkiesdorp to the proposed mine is a dirt road and would require major upgrades in order to be used as a haul route from the proposed mine. A few sections of the dirt road are shown in Photos 11, 12, 13, 14 and 15 in Appendix A.

6.2.4 Noise

It was indicated that haul trucks will operate for 20 hours per day (2 x 10-hour shifts), which means that the transportation of coal to the Piet Retief siding will continue during the night. Transportation during the night will have a noise impact on the residential areas, such as Dirkiesdorp, along the transport route. This potential social impact should be further investigated and addressed.

7 Road Pavement Management

7.1 R543 Pavement

The problem areas in terms of existing road pavement that were identified along the R543 which forms part of the proposed haul route are shown in Photos 7 to 10. Localised pavement failure is apparent in the presence of potholes and previously repaired potholes. The road surface is cracked and crocodile cracking is visible in the wheel paths. The surface appears to be asphalt with rolled in chips.

7.2 Route between Yzermyn and Dirkiesdorp

As shown in Photos 11 to 15 in Appendix A, this road is currently not surfaced. A detailed pavement and geometric design will be required for this road.

7.3 Current Traffic Loading

Traffic loading is measured in E80's which is defined by the Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development (Amended 1995) as follows:

"The cumulative damaging effect of all individual axle loads is expressed as the number of equivalent 80kN single-axle loads (E80's). This is the number of 80kN single-axle loads that would cause the same damage to the pavement as the actual spectrum of axle loads."

The impact of the relatively low volume of light vehicles along the proposed haul route (R543) is considered to be insignificant. The 24-hour 7-day average traffic volumes from Table 3.1 were used to determine the existing heavy vehicle loading. It was assumed that the average heavy vehicle is equal to 3 E80's and the calculated current traffic loading is given in Table 7.1 below.

Table 7.1: Current Annual Traffic Loading

Station	Direction of Travel	Daily HV Traffic Volume	E80 per year	MESA* per year
E1	Northbound	104	113 880	0.11
	Southbound	104	113 880	0.11
E2	Northbound	130	142 350	0.14
	Southbound	95	104 025	0.10

* Million equivalent standard axles.

7.4 Additional Loading

The cumulative effect of the existing and additional traffic loading from Yzermyn along the R543 to Piet Retief is analysed over the estimated life of the mine.

The number of loaded trucks was calculated from the estimated annual production volumes and is summarised in Table 7.2 below. It was assumed that one empty truck will return to Yzermyn mine for every loaded truck that departs from the mine

Table 7.2: Loaded trucks from Yzermyn

Description:	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Trucks/annum	27 243	46 194	63 259	65 298	64 654	64 520	65 457	62 943	64 734	65 211	64 281	61 061	44 859	9 771
Trucks/month	2270	3849	5272	5441	5388	5377	5455	5245	5394	5434	5357	5088	3738	814
Trucks/day	103	175	240	247	245	244	248	238	245	247	243	231	170	37
Trucks/hour	5	9	12	12	12	12	12	12	12	12	12	12	8	2

It was assumed that a loaded truck from Yzermyn is equal to 3.6 E80's and each of the empty, returning trucks, is equal to 0.2 E80's. The additional traffic loading from Yzermyn mine to the Railway Siding is summarised in Table 7.3 below.

Table 7.3: Additional Traffic Loading between Yzermyn and Piet Retief Siding

Direction of Travel	Total Trucks (2016 – 2029)	Total E80	MESA*
Yzermyn to Siding (loaded)	769 483	2 770 140	2.77
Yzermyn to Siding (empty)	769 483	153 897	0.15

* *Million equivalent standard axles.*

7.5 Required Measures

The additional loading calculated above is likely to accelerate the deterioration of the existing surfacing, causing more potholes and breaking up of the surfacing. The existing surfacing therefore needs to be replaced in the identified problem areas. As a minimum requirement, to ensure no significant deterioration, a surface treatment is required.

7.6 Further Investigation

Further investigation, which is beyond the scope of this report, would be required to establish the remaining capacity of the road, as well as the materials classification to be able to make a more informed recommendation with regards to the requirements that should be undertaken.

A generic Road Maintenance Management Proposal to facilitate on-going management and maintenance of the haul route is included in Appendix E.

8 Conclusions and Recommendations

8.1 Conclusions

In view of the findings of this assessment, the following conclusions and recommendations may be drawn:

(i) It was found that the impact of the proposed mine on the peak hour traffic operating conditions of the surrounding road network will not necessitate any mitigation measures such as intersection upgrades.

(ii) There are two schools along the haul route which raise public safety issues which need to be addressed for current and future road use.

(iii) The heavy vehicle loading impact of the proposed mine on the existing road network will require the replacement of surfacing at the problem areas identified. At the very least a surface treatment is required.

(iv) The northern shoulder site distance at the intersection of the R543 and the Piet Retief Railway Siding is insufficient but the stopping site distance for traffic approaching from the north is adequate.

(v) The potential noise as a result of haul trucks operating during the night will have to be investigated and addressed.

8.2 Recommendations

(i) Taking the above conclusions into account, with respect to roads and traffic, the impacts associated with the proposed mine can be managed and accommodated within normal, acceptable limits.

(ii) Further investigation should be undertaken to determine the remaining pavement capacity of the haul route and to establish the upgrading and maintenance requirements.

(iii) Further investigation should be undertaken to determine if the intersection of the R543 and the Piet Retief Railway Siding's control should be altered, i.e. signalised, or if the siding access should be moved southwards to improve the northern shoulder site distance, taking into account the excess available stopping site distance.

9 References

- Wepener, D. A., Engelbrecht, R. J., & Kruger, P., 1995. MANUAL FOR TRAFFIC IMPACT STUDIES, Report No. RR93/35, Department of Transport, Pretoria.

- Committee of State Road Authorities, 1988. GEOMETRIC DESIGN OF RURAL ROADS (TRH17), 1st Ed., Department of Transport, South Africa.

- Committee of State Road Authorities, 1991. TRAFFIC LOADING FOR PAVEMENT AND REHABILITATION DESIGN, Draft TRH16, Department of Transport, Pretoria.

10 Appendices

Appendix A	Photographs
Appendix B	Traffic Counts
Appendix C	R543 / Vaalbank Sidra Results
Appendix D	R543 / Railway Siding Sidra Results
Appendix E	Road Maintenance Management Proposal

Appendix A Photographs

PHOTO 1: School near Dirkiesdorp

PHOTO 2: Trucks used for transport of coal

PHOTO 3: Access Intersection to Yzermyn Mine (view from Dirt Road to Intersection)

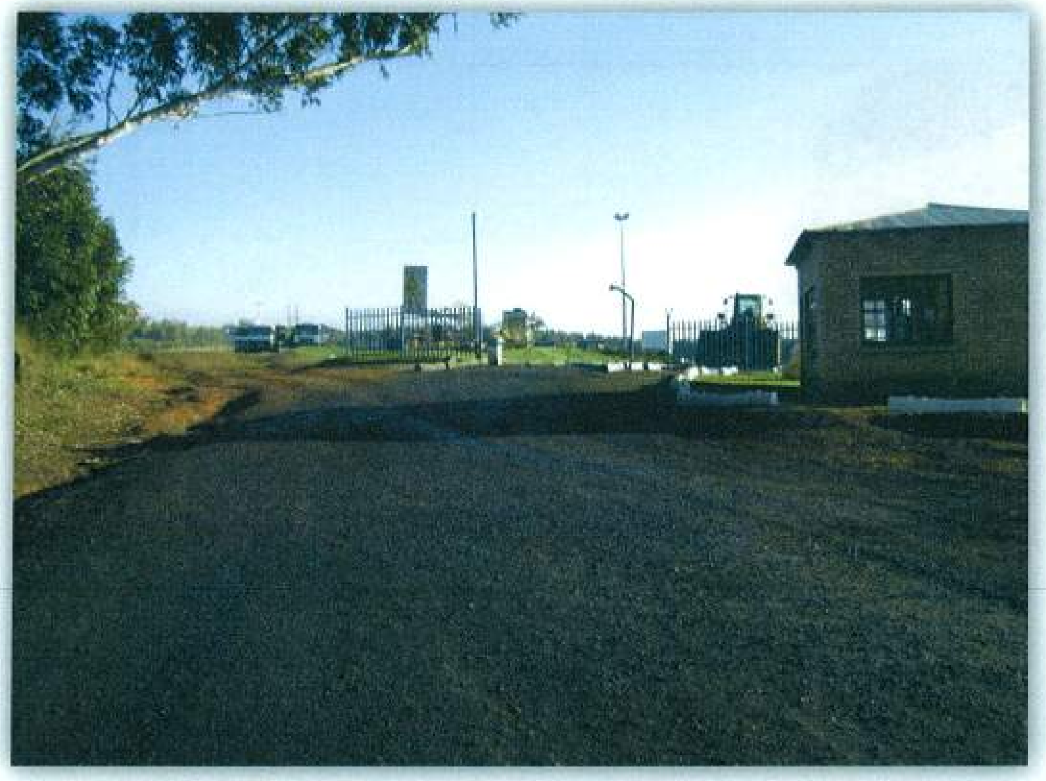


PHOTO 4: Entrance Road to Railway Siding (Photo 1)

PHOTO 5: Entrance Road to Railway Siding (Photo 2)

PHOTO 6: Primary School Learners in the Road (Dirkiesdorp)

PHOTO 7: R543 Road Condition (Photo 1)

PHOTO 8: R543 Road Condition (Photo 2)

PHOTO 9: R543 Road Condition (Photo 4)

PHOTO 10: R543 Road Condition (Photo 5)

PHOTO 11: Dirt Road from Dirkiesdorp to Proposed Mine (Photo 1)

PHOTO 12: Dirt Road from Dirkiesdorp to Proposed Mine (Photo 2)

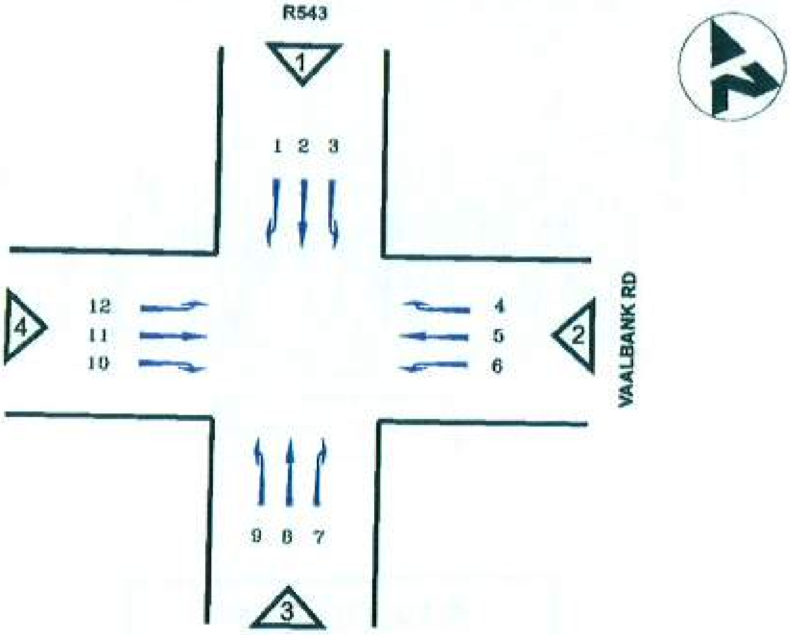
PHOTO 13: Dirt Road from Dirkiesdorp to Proposed Mine (Photo 3)

PHOTO 14: Dirt Road from Dirkiesdorp to Proposed Mine (Photo 4)

PHOTO 15: Dirt Road from Dirkiesdorp to Proposed Mine (Photo 5)

Appendix B Traffic Counts

6



CO-ORDINATES

LATITUDE : 27° 10' 38.6" S
LONGITUDE: 30° 24' 10.8" E

5

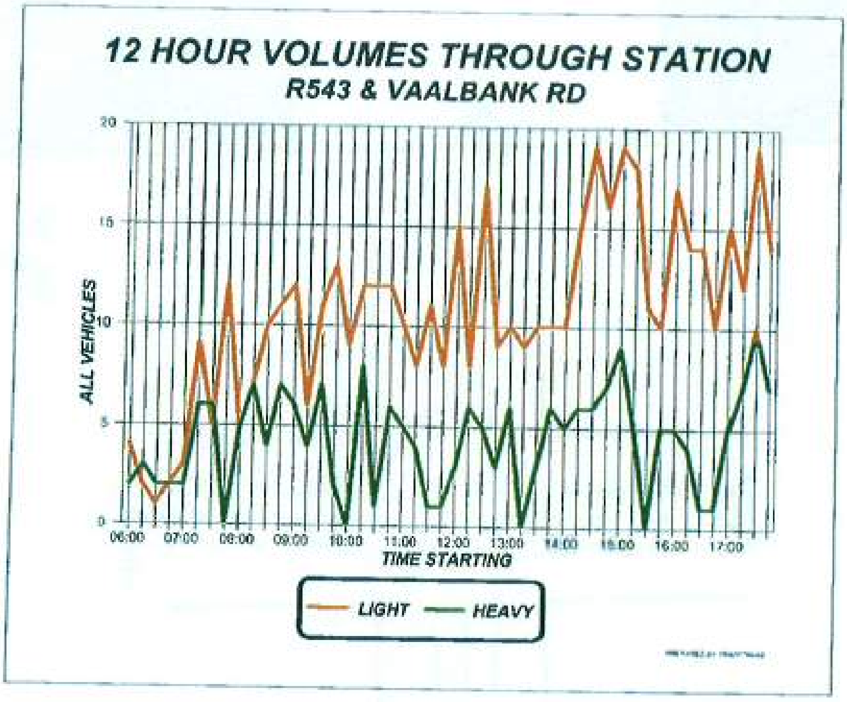
LOCATION: INTERSECTION: R543 & VAALBANK RD
AREA: PIET RETIEF, MPUMALANGA
STATION NUMBER: M1
DATE: 16/05/2012
DAY: WEDNESDAY
TIME: 06:00 to 18:00
TYPE OF COUNT: CLASSIFIED COUNTS PER TURNING MOVEMENT
DESCRIPTION: CLASSIFICATION: LIGHT AND HEAVY VEHICLES

STATION LAYOUT

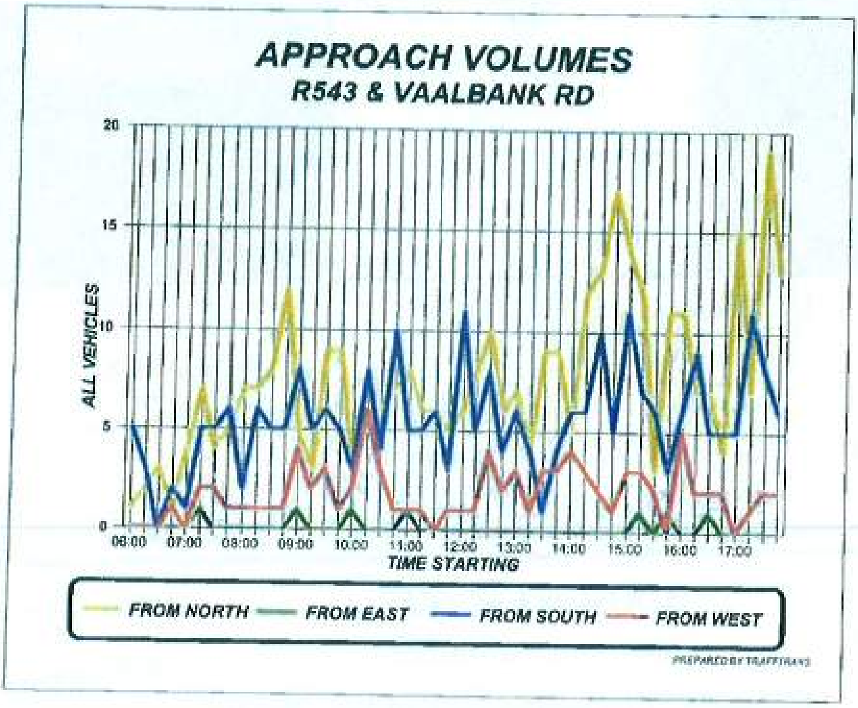
YZERMYN, PIET RETIEF

PROJ. T2012/029
DATE May 2012

TRAFFTRANS (EDMS) BPK


12 HOUR VOLUMES THROUGH STATION
R543 & VAALBANK RD

STATION M1


APPROACH VOLUMES
R543 & VAALBANK RD

SUMMARY OF TRAFFIC COUNTS

STATION: M1

LOCATION: R543 & VAALBANK RD

LAT: 27° 10' 38.6" S

LONG: 30° 24' 10.8" E

DATE: 16/05/2012

Wednesday

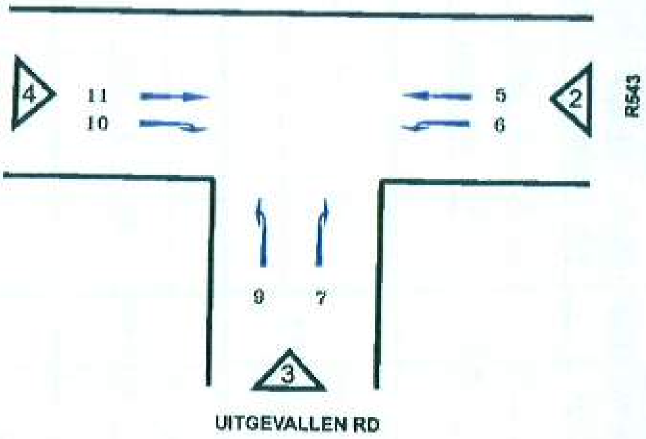
MOVEMENT		AM PEAK HOUR				MIDDAY PEAK HOUR				PM PEAK HOUR				12 HOUR COUNT		
FROM	NO	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL
NORTH	1	5	3 38%	8	0.84	7	5 42%	12	0.62	8	2 20%	10	0.82	71	15 17%	86
	2	13	13 50%	26		27	8 23%	35		25	19 43%	44		189	82 30%	271
	3													3	3 50%	6
EAST	4				n.a.				n.a.				n.a.		1 100%	1
	5														1 100%	1
	6													5		5
SOUTH	7				0.79				0.63				0.73	4		4
	8	11	6 35%	17		18	8 31%	26		22	8 27%	30		167	83 33%	250
	9	1		1		1		1						9	2 18%	11
WEST	10				1.00				0.63	1		1	0.75	7	2 22%	9
	11													1	1 50%	2
	12	3	1 25%	4		7	3 30%	10		4		4		60	16 21%	76
TOTAL		33	23 41%	56	0.78	60	24 29%	84	0.79	60	29 33%	89	0.87	516	206 29%	722
		PERCENTAGE OF:	12H	7.8%		PERCENTAGE OF:	12H	11.6%		PERCENTAGE OF:	12H	12.3%				

STARTING TIME OF PEAK HOUR	AM	MID	PM
	08:00	14:00	17:00

PREPARED BY TRAFFTRANS (PTY) LTD

6

1



CO-ORDINATES

LATITUDE : 27° 04' 16.2" S
LONGITUDE: 30° 33' 41.3" E

5

LOCATION: INTERSECTION: R543 & UITGEVALLEN RD

AREA: PIET RETIEF, MPUMALANGA

STATION NUMBER: M2

DATE: 16/05/2012

DAY: WEDNESDAY

TIME: 06:00 to 18:00

TYPE OF COUNT: CLASSIFIED COUNTS PER TURNING MOVEMENT

DESCRIPTION: CLASSIFICATION: LIGHT AND HEAVY VEHICLES

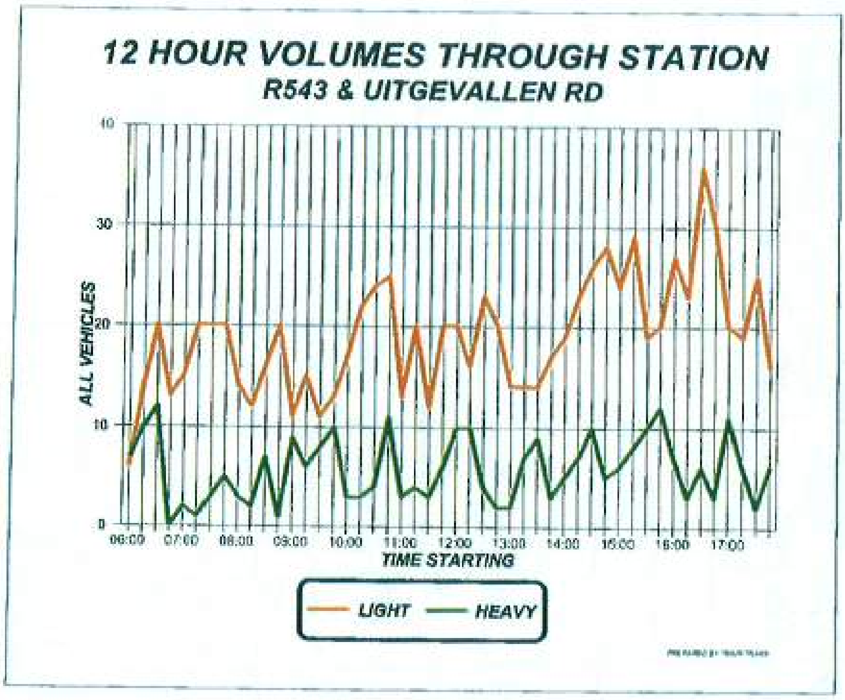
STATION LAYOUT

YZERMYN, PIET RETIEF

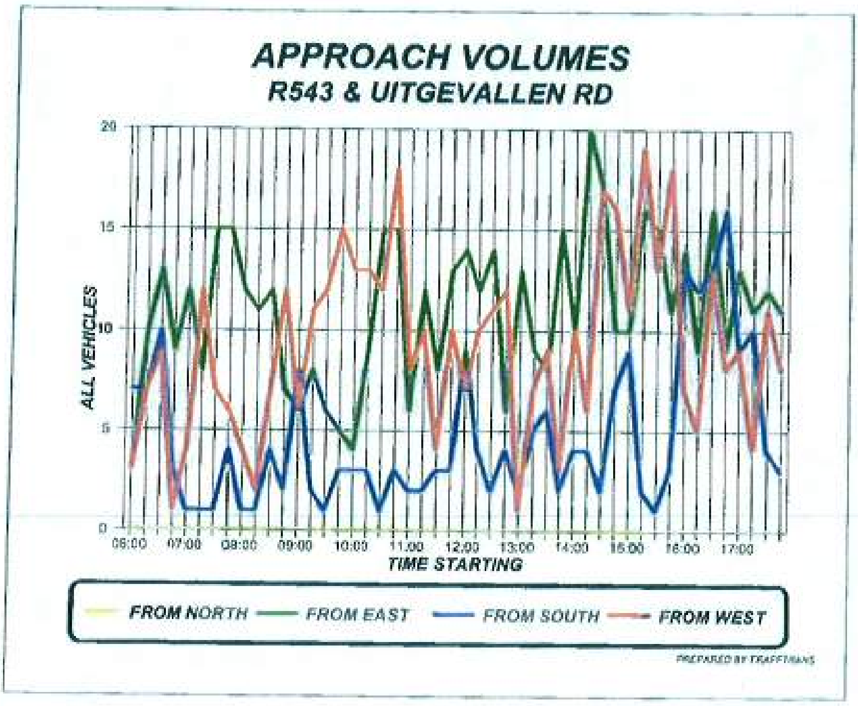
PROJ. T2012/029

DATE May 2012

TRAFFTRANS (EDMS) BPK


12 HOUR VOLUMES THROUGH STATION
R543 & UITGEVALLEN RD
ALL VEHICLES
0
10
20
30
40
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
TIME STARTING
LIGHT
HEAVY
PREPARED BY TRAFFTRANS

STATION M2


APPROACH VOLUMES
R543 & UITGEVALLEN RD
ALL VEHICLES
0
5
10
15
20
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
TIME STARTING
FROM NORTH
FROM EAST
FROM SOUTH
FROM WEST
PREPARED BY TRAFFTRANS

SUMMARY OF TRAFFIC COUNTS

STATION: M2

LOCATION: R543 & UITGEVALLEN RD

LAT: 27° 10' 38.6" S
LONG: 30° 24' 10.8" E

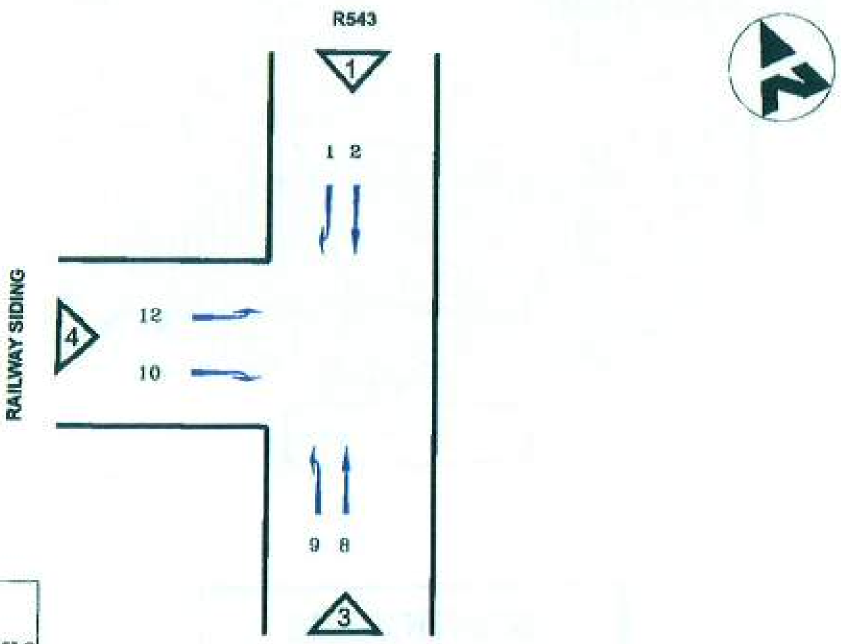
DATE: 16/05/2012
Wednesday

MOVEMENT		AM PEAK HOUR				MIDDAY PEAK HOUR				PM PEAK HOUR				12 HOUR COUNT		
FROM	NO	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL	TOTAL VOL
NORTH	1				n.a.				n.a.				n.a.			
	2															
	3															
EAST	4				0.67				0.76				0.71			
	5	20	6 23%	26		42	8 16%	50		35	8 19%	43		301	93 24%	394
	6	16	2 11%	18		7		7		4	1 20%	5		107	28 21%	135
SOUTH	7	6	7 54%	13	0.68	7	1 13%	8	0.54	38	3 7%	41	0.61	122	32 21%	154
	8															
	9	7	1 13%	8		8	1 11%	9		10	3 23%	13		50	18 26%	68
WEST	10	8		8	0.56	5	1 17%	6	0.68	1		1	0.74	42	7 14%	49
	11	5	8 62%	13		27	16 37%	43		28	4 13%	32		293	99 25%	392
	12															
TOTAL		62	24 28%	86	0.67	96	27 22%	123	0.78	116	19 14%	135	0.90	915	277 23%	1192
		PERCENTAGE OF:	12H	7.2%		PERCENTAGE OF:	12H	10.3%		PERCENTAGE OF:	12H	11.3%				

STARTING TIME OF PEAK HOUR	AM	MID	PM
	06:15	14:00	16:00

PREPARED BY TRAFFTRANS (PTY) LTD

6



CO-ORDINATES

LATITUDE : 27° 00' 20.5" S
LONGITUDE: 30° 47' 19.5" E

5

2

LOCATION: INTERSECTION: R543 & RD TO RAILWAY SIDING

AREA: PIET RETIEF, MPUMALANGA

STATION NUMBER: M3

DATE: 16/05/2012

DAY: WEDNESDAY

TIME: 06:00 to 18:00

TYPE OF COUNT: CLASSIFIED COUNTS PER TURNING MOVEMENT

DESCRIPTION: CLASSIFICATION: LIGHT AND HEAVY VEHICLES

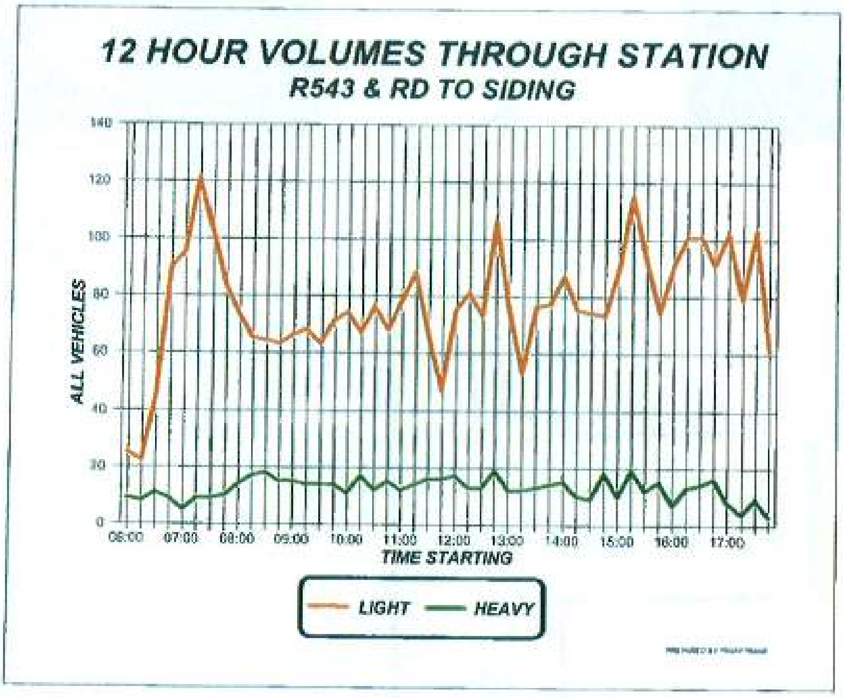
STATION LAYOUT

YZERMYN, PIET RETIEF

PROJ. T2012/029

DATE May 2012

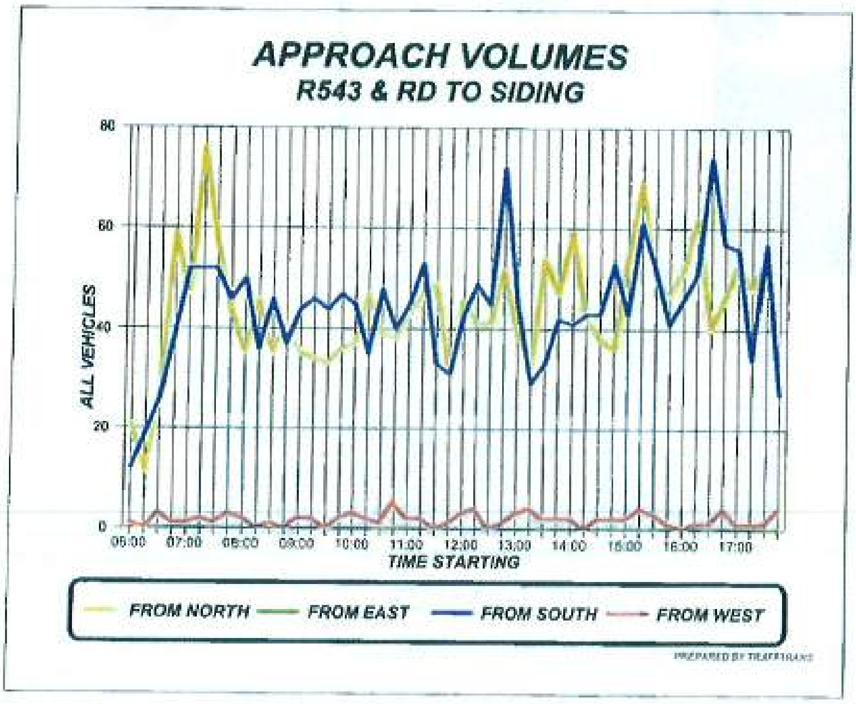
TRAFFTRANS (EDMS) BPK



12 HOUR VOLUMES THROUGH STATION

R543 & RD TO SIDING

STATION M3



APPROACH VOLUMES

R543 & RD TO SIDING

SUMMARY OF TRAFFIC COUNTS

STATION: M3
LOCATION: R543 & RD TO SIDING

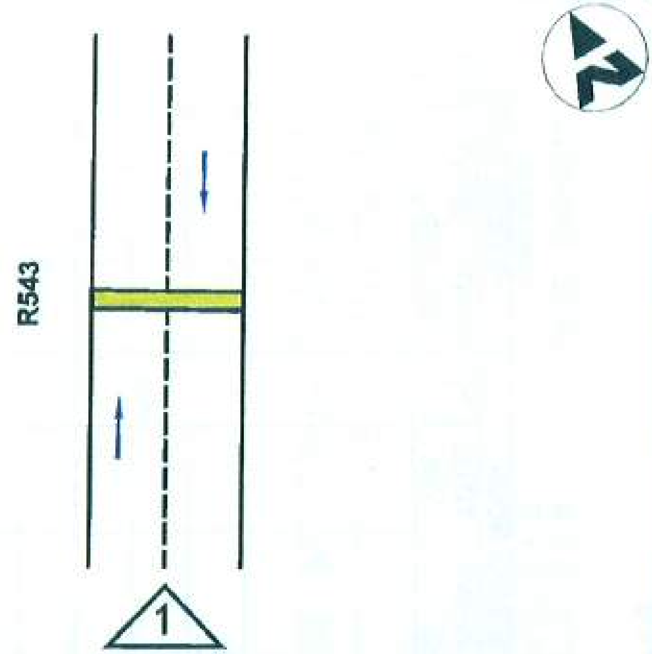
LAT: 27° 10' 38.6" S
LONG: 30° 24' 10.8" E

DATE: 16/05/2012
Wednesday

MOVEMENT		AM PEAK HOUR					MIDDAY PEAK HOUR					PM PEAK HOUR					12 HOUR COUNT			
FROM	NO	LIGHT VOL	HEAVY VOL		TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL		TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL		TOTAL VOL	PHF	LIGHT VOL	HEAVY VOL		TOTAL VOL
NORTH	1	5			5		1	1	50%	2		2			2		41	13	24%	54
	2	224	11	5%	235	0.79	153	25	14%	178	0.89	172	27	14%	199	0.81	1784	266	13%	2050
	3																			
EAST	4																			
	5					n.a.					n.a.					n.a.				
	6																			
SOUTH	7																			
	8	174	17	9%	191	0.94	171	33	16%	204	0.73	211	22	9%	233	0.80	1795	275	13%	2070
	9	1	3	75%	4		5			5		4	1	20%	5		23	22	49%	45
WEST	10		1	100%	1		2	1	33%	3		2			2		19	11	37%	30
	11					0.63					0.50					0.44				
	12	4			4		3	2	40%	5		4	1	20%	5		43	12	22%	55
TOTAL		**408**	**32**	**7%**	**440**	**0.85**	**335**	**62**	**16%**	**397**	**0.73**	**395**	**51**	**11%**	**446**	**0.97**	**3705**	**599**	**14%**	**4304**
		PERCENTAGE OF:	12H		10.2%		PERCENTAGE OF:	12H		9.2%		PERCENTAGE OF:	12H		10.4%					

	AM	MID	PM
STARTING TIME OF PEAK HOUR	06:45	12:00	16:15

PREPARED BY TRAFFTRANS (PTY) LTD



CO-ORDINATE

Latitude	27° 06' 23.5" S
Longitude	30° 29' 08.4" E

LOCATION: ROAD LINK: R543 - At Wakkerstroom 50km road sign

AREA: PIET RETIEF MPUMALANGA

STATION NUMBER: E-1

DATE: FROM THURSDAY: 17/05/2012 TO WEDNESDAY: 23/05/2012

TYPE OF COUNT: CLASSIFIED COUNTS PER DIRECTION

DESCRIPTION: CLASSIFICATION: LIGHT AND HEAVY VEHICLES

STATION LAYOUT

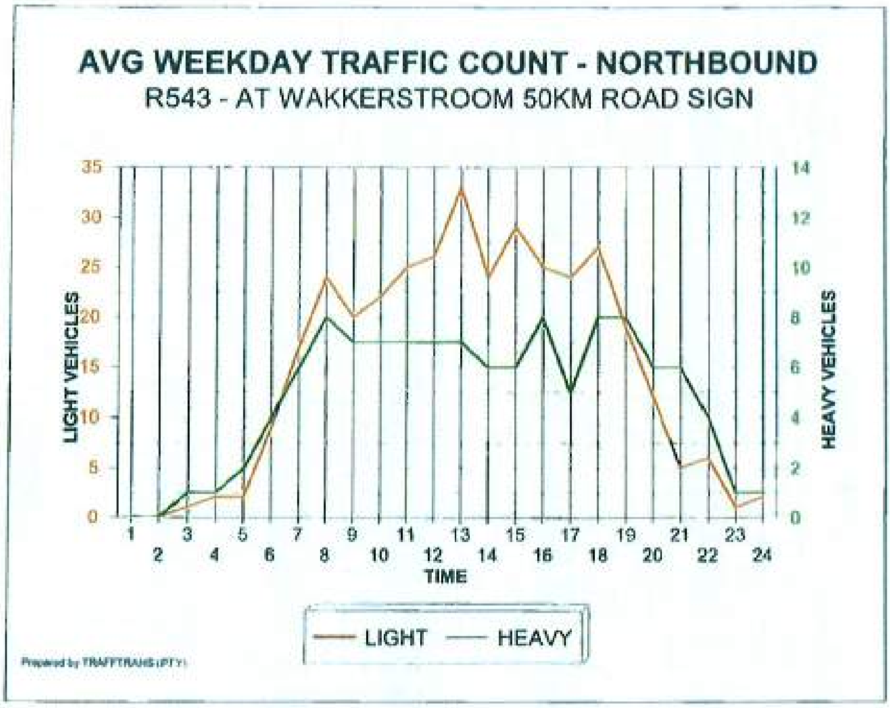
YZERMYN, PIET RETIEF

PROJ. T2012/029

DATE May 2012

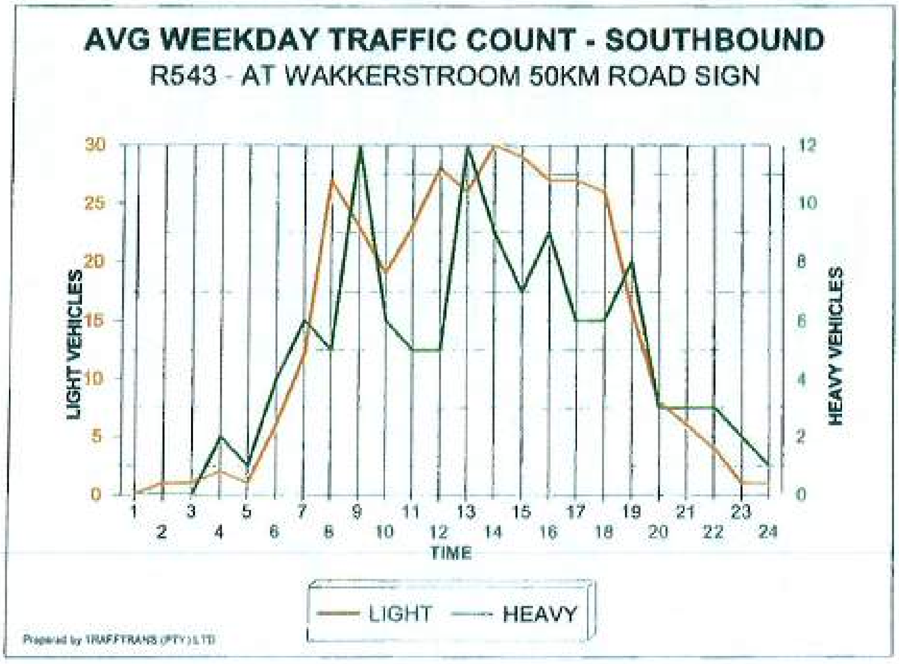
TRAFFTRANS (EDMS) BPK

DIRECTIONAL FLOW


AVG WEEKDAY TRAFFIC COUNT - NORTHBOUND

R543 - AT WAKKERSTROOM 50KM ROAD SIGN

STATION: E1


AVG WEEKDAY TRAFFIC COUNT - SOUTHBOUND

R543 - AT WAKKERSTROOM 50KM ROAD SIGN

SUMMARY OF 7-DAY ELECTRONIC TRAFFIC COUNTS

ALL VEHICLES

LOCATION: E1: R543 - AT WAKKERSTROOM 50KM ROAD SIGN

TYPE OF VEHICLE: *ALL VEHICLES*

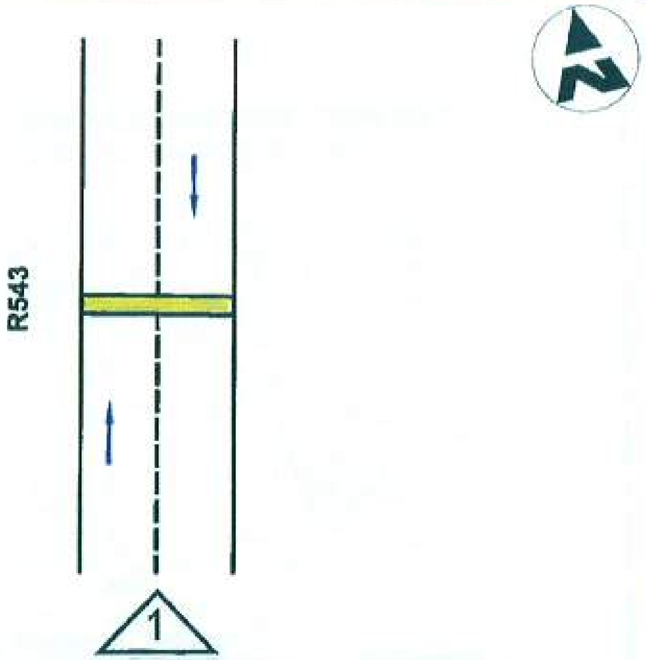
STARTING DATE: *17-May-12* Thursday

LAT: 27° 06' 23.5" S

LONG: 30° 29' 08.4" E

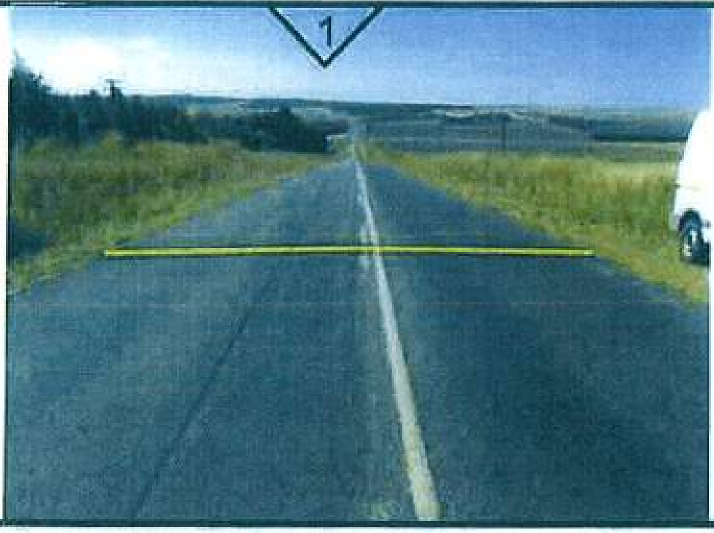
TYPE	NORTHBOUND							SOUTHBOUND							NORTHBOUND AND SOUTHBOUND						
	Mon	Tue	Wed	Thu	Fri	Sat	Son	Mon	Tue	Wed	Thu	Fri	Sat	Son	Mon	Tue	Wed	Thu	Fri	Sat	Son
24 HOUR TOTAL	422	496	510	409	535	439	292	395	476	509	429	481	449	312	817	972	1019	838	1016	888	604
PEAK HOUR: AM																					
START TIME	10:30	07:00	09:30	10:45	06:30	10:00	06:15	10:30	06:30	08:00	08:30	07:15	11:00	08:45	10:30	06:45	07:15	10:45	11:00	11:00	08:30
FLOW	39	43	49	36	39	38	24	45	43	56	41	37	39	30	84	78	87	69	69	74	52
% OF 24 HOUR FLOW	9.2%	8.7%	9.6%	8.8%	7.3%	8.7%	8.2%	11.4%	9.0%	11.0%	9.6%	7.7%	8.7%	9.6%	10.3%	8.0%	8.5%	8.2%	6.8%	8.3%	8.6%
PEAK HOUR: PM																					
START TIME	14:00	12:00	16:30	14:15	12:00	13:45	14:30	12:00	12:45	12:30	14:15	12:15	13:30	12:30	13:15	12:45	16:00	14:15	12:00	13:45	14:30
FLOW	35	44	43	41	59	39	31	39	49	44	44	51	42	34	72	85	82	85	108	81	60
% OF 24 HOUR FLOW	8.3%	8.9%	8.4%	10.0%	11.0%	8.9%	10.6%	9.9%	10.3%	8.6%	10.3%	10.6%	9.4%	10.9%	8.8%	8.7%	8.0%	10.1%	10.6%	9.1%	9.9%
PEAK QUARTER HOUR: AM																					
START TIME	11:15	07:30	10:15	10:45	07:15	10:30	09:00	10:45	07:15	08:30	08:45	07:15	11:45	08:45	11:15	07:00	07:15	10:45	11:30	11:45	08:45
FLOW	13	15	14	12	14	14	8	14	12	18	13	12	12	12	25	22	38	21	22	23	16
PEAK QUARTER HOUR: PM																					
START TIME	14:15	12:00	17:15	14:30	12:30	14:15	15:00	12:00	13:30	13:15	14:30	12:15	14:00	13:15	13:15	12:45	16:15	14:30	12:15	14:15	14:30
FLOW	10	14	16	13	21	13	10	14	15	13	15	18	14	9	21	26	28	28	35	25	19
OTHER FACTORS																					
PEAK HOUR FACTOR - AM	0.75	0.72	0.88	0.75	0.70	0.68	0.75	0.80	0.90	0.78	0.79	0.77	0.81	0.63	0.84	0.89	0.57	0.82	0.78	0.80	0.81
PEAK HOUR FACTOR - PM	0.88	0.79	0.67	0.79	0.70	0.75	0.78	0.70	0.82	0.85	0.73	0.71	0.75	0.94	0.86	0.82	0.73	0.76	0.77	0.81	0.79
7-DAY FACTOR	0.948	1.115	1.146	0.919	1.202	0.987	0.656	0.904	1.089	1.165	0.982	1.101	1.027	0.714	0.929	1.106	1.159	0.953	1.156	1.01	0.687
5-DAY FACTOR	0.888	1.044	1.074	0.861	1.126			0.862	1.039	1.111	0.937	1.05			0.878	1.044	1.095	0.9	1.091		
HEAVY VEHICLES (% of 24 hour)	23.2%	27.0%	24.9%	22.2%	25.2%	20.5%	16.1%	21.5%	26.5%	26.1%	25.6%	24.1%	20.9%	20.8%	22.4%	26.7%	25.5%	24.0%	24.7%	20.7%	18.5%
24 HOUR TRAFFIC (% of week)	13.6%	16.0%	16.4%	13.2%	17.2%	14.1%	9.4%	12.9%	15.6%	16.7%	14.1%	15.8%	14.7%	10.2%	13.3%	15.8%	16.6%	13.6%	16.5%	14.4%	9.8%
NIGHT TRAFFIC (% of 24 hour)	19.2%	19.2%	18.2%	18.6%	23.0%	17.5%	19.9%	14.2%	19.3%	16.1%	16.3%	15.0%	18.0%	16.0%	16.8%	19.2%	17.2%	17.4%	19.2%	17.8%	17.9%
12 HOUR TRAFFIC (06:00 to 18:00)	341	401	417	333	412	362	234	339	384	427	359	409	368	262	680	785	844	692	821	730	496

Prepare by TRAFFTRANS (PTY)LTD



CO-ORDINATE

Latitude	27° 02' 30.3" S
Longitude	30° 42' 59.3" E



LOCATION: ROAD LINK: R543 - At Piet Retief 10km road sign

AREA: PIET RETIEF, MPUMALANGA

STATION NUMBER: E-2

DATE: FROM THURSDAY: 17/05/2012 TO TUESDAY: 22/05/2012

TYPE OF COUNT: CLASSIFIED COUNTS PER DIRECTION

DESCRIPTION: CLASSIFICATION: LIGHT AND HEAVY VEHICLES

STATION LAYOUT

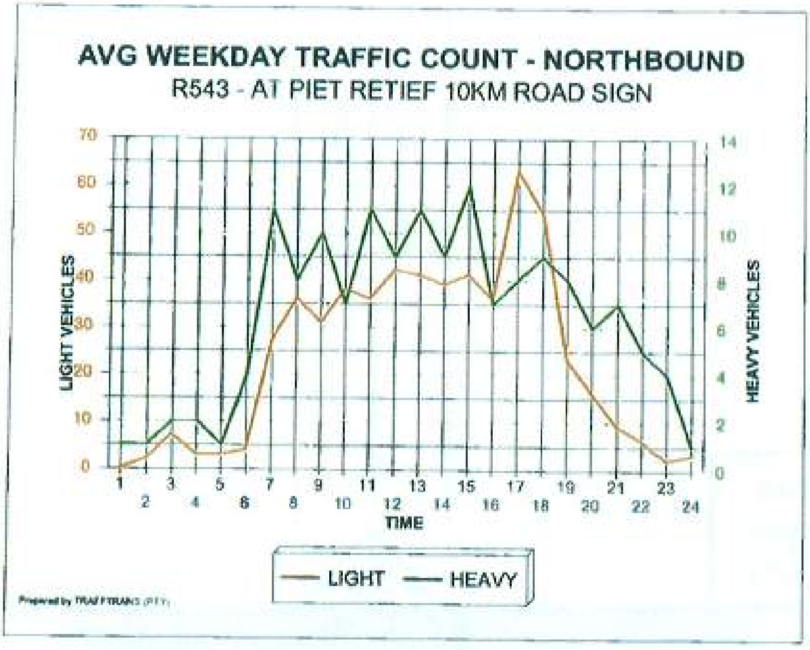
YZERMYN, PIET RETIEF

PROJ. T2012/029

DATE May 2012

TRAFFTRANS (EDMS) BPK

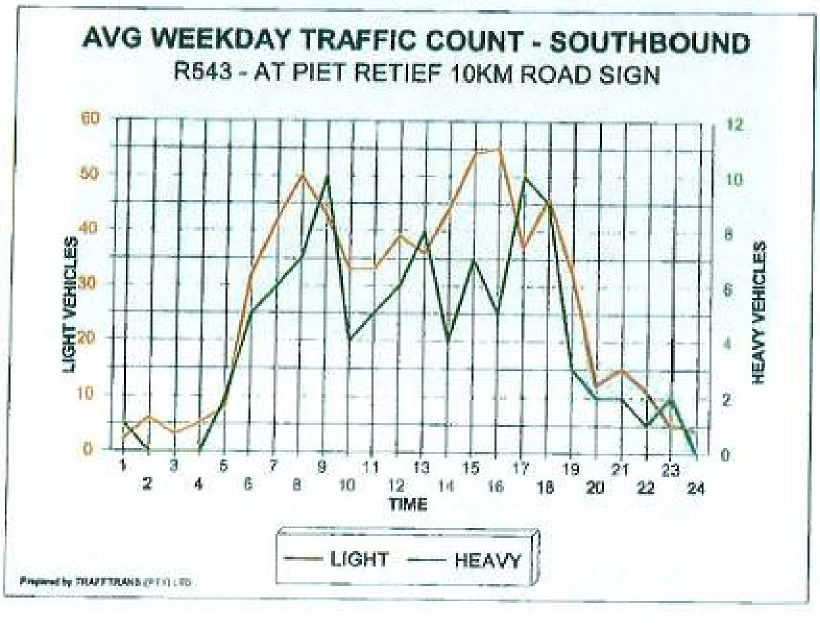
DIRECTIONAL FLOW



AVG WEEKDAY TRAFFIC COUNT - NORTHBOUND

R543 - AT PIET RETIEF 10KM ROAD SIGN

STATION: E2



AVG WEEKDAY TRAFFIC COUNT - SOUTHBOUND

R543 - AT PIET RETIEF 10KM ROAD SIGN

SUMMARY OF 7-DAY ELECTRONIC TRAFFIC COUNTS

ALL VEHICLES

LOCATION: E2: R543 - AT PIET RETIEF 10KM ROAD SIGN

TYPE OF VEHICLE: *ALL VEHICLES*

STARTING DATE: *17-May-12* Thursday

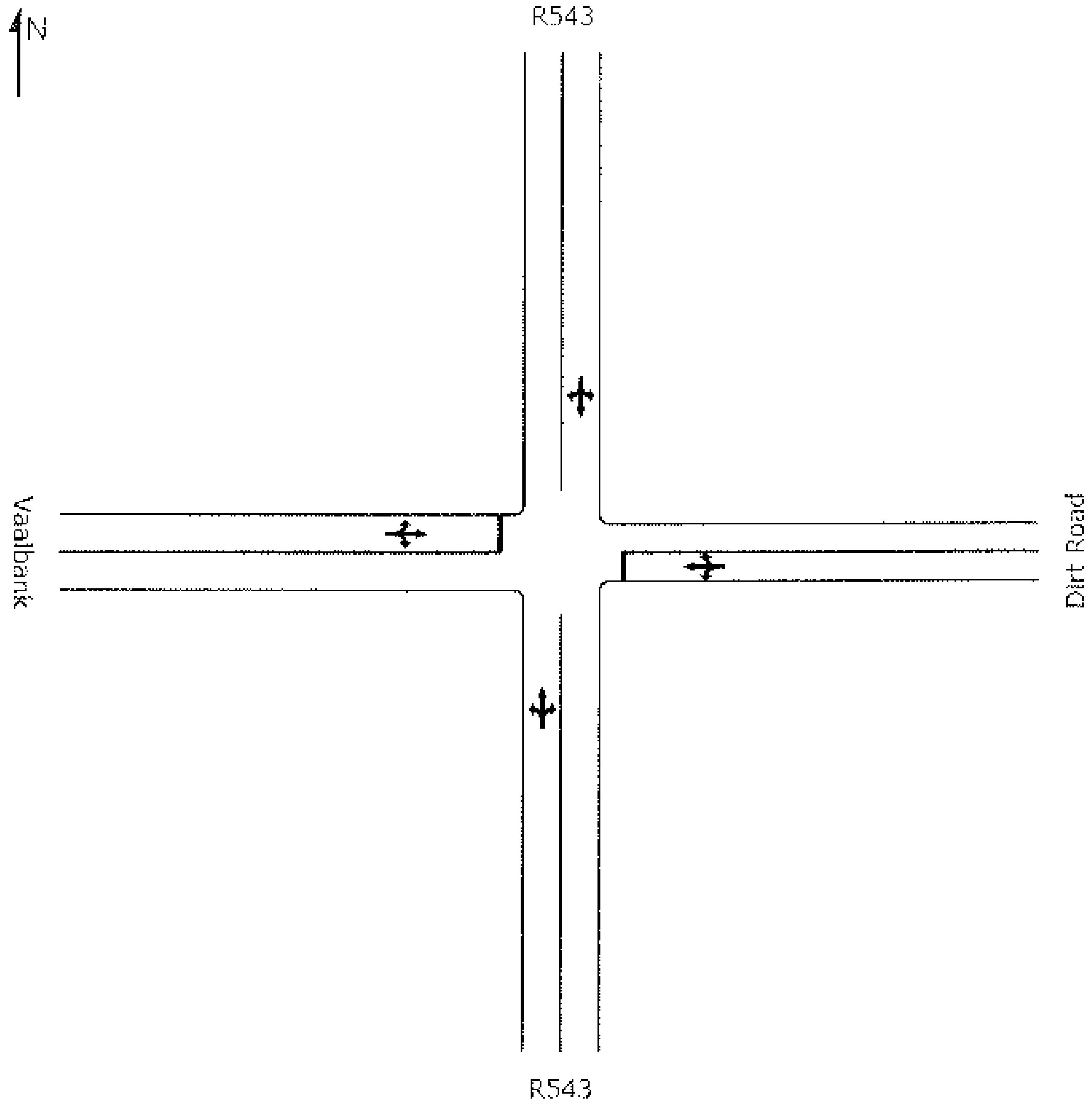
LAT: 27° 02' 30.3" S

LONG: 30° 42' 59.3" E

TYPE	NORTHBOUND							SOUTHBOUND							NORTHBOUND AND SOUTHBOUND						
	Mon	Tue	Wed	Thu	Fri	Sat	Son	Mon	Tue	Wed	Thu	Fri	Sat	Son	Mon	Tue	Wed	Thu	Fri	Sat	Son
24 HOUR TOTAL	674	746	734	654	762	590	427	701	762	812	674	781	667	477	1375	1508	1546	1328	1543	1257	904
PEAK HOUR: AM																					
START TIME	10:45	10:30	11:00	06:30	10:45	10:15	08:15	06:45	08:00	07:30	07:45	06:45	06:15	06:15	06:45	08:00	07:30	07:45	06:45	10:00	08:15
FLOW	58	55	60	56	58	58	41	68	67	80	66	63	57	38	110	113	129	105	116	93	72
% OF 24 HOUR FLOW	8.6%	7.4%	8.2%	8.6%	7.6%	9.8%	9.6%	9.7%	8.8%	9.9%	9.8%	8.1%	8.5%	8.0%	8.0%	7.5%	8.3%	7.9%	7.5%	7.4%	8.0%
PEAK HOUR: PM																					
START TIME	16:15	16:15	16:30	16:15	16:30	12:00	17:15	14:30	14:15	14:15	14:15	15:15	14:15	16:30	16:15	16:45	16:30	14:15	15:15	14:15	17:00
FLOW	81	76	92	85	78	52	58	66	69	67	74	85	70	46	138	135	145	128	137	110	103
% OF 24 HOUR FLOW	12.0%	10.2%	12.5%	13.0%	10.2%	8.8%	13.6%	9.4%	9.1%	8.3%	11.0%	10.9%	10.5%	9.6%	10.0%	9.0%	9.4%	9.6%	8.9%	8.8%	11.4%
PEAK QUARTER HOUR: AM																					
START TIME	11:30	10:30	11:45	06:45	10:45	11:00	08:45	07:30	08:45	08:15	08:30	06:45	06:15	06:30	07:30	08:45	07:30	08:00	06:45	10:30	08:30
FLOW	20	18	20	15	19	19	14	31	23	25	21	21	23	13	37	34	40	30	41	25	28
PEAK QUARTER HOUR: PM																					
START TIME	17:00	16:15	16:30	16:30	17:00	12:00	17:15	14:45	15:00	14:45	15:00	15:15	14:15	16:30	17:00	17:30	17:15	15:00	15:15	14:15	17:15
FLOW	24	25	30	25	23	15	20	19	26	22	24	25	28	16	38	37	44	41	46	37	34
OTHER FACTORS																					
PEAK HOUR FACTOR - AM	0.73	0.76	0.75	0.93	0.76	0.76	0.73	0.55	0.73	0.80	0.79	0.75	0.62	0.73	0.74	0.83	0.81	0.88	0.71	0.93	0.64
PEAK HOUR FACTOR - PM	0.84	0.76	0.77	0.85	0.85	0.87	0.73	0.87	0.66	0.76	0.77	0.85	0.63	0.72	0.91	0.91	0.82	0.78	0.74	0.74	0.76
7-DAY FACTOR	1.031	1.141	1.122	1	1.165	0.902	0.653	1.006	1.093	1.165	0.967	1.121	0.957	0.684	1.017	1.115	1.143	0.982	1.141	0.93	0.669
5-DAY FACTOR	0.944	1.045	1.028	0.916	1.067			0.94	1.021	1.088	0.903	1.047			0.942	1.033	1.059	0.91	1.057		
HEAVY VEHICLES (% of 24 hour)	22.6%	22.8%	21.4%	18.3%	22.0%	15.9%	12.6%	14.1%	14.4%	15.5%	13.1%	10.1%	13.2%	13.4%	18.3%	18.6%	18.3%	15.7%	16.0%	14.5%	13.1%
24 HOUR TRAFFIC (% of week)	14.7%	16.3%	16.0%	14.3%	16.6%	12.9%	9.3%	14.4%	15.6%	16.7%	13.8%	16.0%	13.7%	9.8%	14.5%	15.9%	16.3%	14.0%	16.3%	13.3%	9.6%
NIGHT TRAFFIC (% of 24 hour)	13.4%	17.4%	14.6%	16.1%	21.0%	21.2%	20.8%	18.3%	18.6%	23.0%	21.5%	21.0%	18.6%	24.5%	15.9%	18.0%	19.0%	18.8%	21.0%	19.8%	22.8%
12 HOUR TRAFFIC (06:00 to 18:00)	584	616	627	549	602	465	338	573	620	625	529	617	543	360	1157	1236	1252	1078	1219	1008	698

Prepare by TRAFFTRANS (PTY) LTD

Appendix C R543 / Vaalbank SIDRA Results


N
R543
Vaalbank
Dirt Road
R543

MOVEMENT SUMMARY

Site: Existing 2013 AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	1	0.0	0.041	8.7	LOS A	0.2	1.7	0.28	0.76	49.1
8	T	76	0.0	0.041	0.5	LOS A	0.2	1.7	0.28	0.00	54.8
7	R	1	0.0	0.041	9.0	LOS A	0.2	1.7	0.28	0.97	49.0
Approach		78	0.0	0.041	0.8	NA	0.2	1.7	0.28	0.03	54.6
East: Dirt Road											
6	L	1	0.0	0.004	12.4	LOS B	0.0	0.1	0.35	0.78	45.3
5	T	1	0.0	0.004	12.0	LOS B	0.0	0.1	0.35	0.83	45.7
4	R	1	0.0	0.004	12.2	LOS B	0.0	0.1	0.35	0.87	45.5
Approach		3	0.0	0.004	12.2	LOS B	0.0	0.1	0.35	0.83	45.5
North: R543											
3	L	1	0.0	0.101	8.5	LOS A	0.6	4.0	0.20	0.76	48.8
2	T	144	0.0	0.101	0.3	LOS A	0.6	4.0	0.20	0.00	56.0
1	R	36	0.0	0.101	8.6	LOS A	0.6	4.0	0.20	0.89	48.8
Approach		181	0.0	0.101	2.0	NA	0.6	4.0	0.20	0.18	54.4
West: Vaalbank											
12	L	11	0.0	0.013	11.3	LOS B	0.0	0.3	0.18	0.88	46.1
11	T	1	0.0	0.013	10.8	LOS B	0.0	0.3	0.18	0.93	46.5
10	R	1	0.0	0.013	11.2	LOS B	0.0	0.3	0.18	0.96	46.2
Approach		13	0.0	0.013	11.2	LOS B	0.0	0.3	0.18	0.89	46.2
All Vehicles		276	0.0	0.101	2.2	NA	0.6	4.0	0.22	0.18	53.9

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: Existing 2013 PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	1	0.0	0.064	9.1	LOS A	0.4	3.0	0.37	0.68	49.2
8	T	122	0.0	0.064	0.9	LOS A	0.4	3.0	0.37	0.00	53.4
7	R	1	0.0	0.064	9.3	LOS A	0.4	3.0	0.37	0.98	49.2
Approach		125	0.0	0.064	1.1	NA	0.4	3.0	0.37	0.02	53.3
East: Dirt Road											
6	L	1	0.0	0.005	13.4	LOS B	0.0	0.1	0.44	0.77	44.5
5	T	1	0.0	0.005	13.0	LOS B	0.0	0.1	0.44	0.83	44.9
4	R	1	0.0	0.005	13.3	LOS B	0.0	0.1	0.44	0.86	44.7
Approach		3	0.0	0.005	13.2	LOS B	0.0	0.1	0.44	0.82	44.7
North: R543											
3	L	1	0.0	0.138	8.7	LOS A	0.9	6.0	0.27	0.73	49.0
2	T	222	0.0	0.138	0.5	LOS A	0.9	6.0	0.27	0.00	54.8
1	R	30	0.0	0.138	8.9	LOS A	0.9	6.0	0.27	0.91	48.9
Approach		254	0.0	0.138	1.6	NA	0.9	6.0	0.27	0.11	54.0
West: Vaalbank											
12	L	5	0.0	0.010	12.2	LOS B	0.0	0.2	0.28	0.83	45.4
11	T	1	0.0	0.010	11.8	LOS B	0.0	0.2	0.28	0.91	46.7
10	R	1	0.0	0.010	12.1	LOS B	0.0	0.2	0.28	0.93	45.5
Approach		8	0.0	0.010	12.2	LOS B	0.0	0.2	0.28	0.85	45.5
All Vehicles		389	0.0	0.138	1.7	NA	0.9	6.0	0.31	0.10	53.4

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: Base 2016 without Mine AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	1	0.0	0.045	8.8	LOS A	0.3	1.9	0.30	0.75	49.1
8	T	84	0.0	0.045	0.6	LOS A	0.3	1.9	0.30	0.00	54.5
7	R	1	0.0	0.045	9.0	LOS A	0.3	1.9	0.30	0.97	49.1
Approach		86	0.0	0.045	0.9	NA	0.3	1.9	0.30	0.03	54.3
East: Dirt Road											
6	L	1	0.0	0.004	12.6	LOS B	0.0	0.1	0.37	0.78	46.2
5	T	1	0.0	0.004	12.2	LOS B	0.0	0.1	0.37	0.83	45.5
4	R	1	0.0	0.004	12.4	LOS B	0.0	0.1	0.37	0.87	45.4
Approach		3	0.0	0.004	12.4	LOS B	0.0	0.1	0.37	0.83	45.4
North: R543											
3	L	1	0.0	0.111	8.5	LOS A	0.6	4.4	0.21	0.76	48.9
2	T	157	0.0	0.111	0.3	LOS A	0.6	4.4	0.21	0.00	55.8
1	R	39	0.0	0.111	8.7	LOS A	0.6	4.4	0.21	0.88	48.8
Approach		198	0.0	0.111	2.0	NA	0.6	4.4	0.21	0.18	54.2
West: Vaalbank											
12	L	12	0.0	0.014	11.3	LOS B	0.1	0.4	0.19	0.88	46.1
11	T	1	0.0	0.014	10.9	LOS B	0.1	0.4	0.19	0.93	46.5
10	R	1	0.0	0.014	11.2	LOS B	0.1	0.4	0.19	0.95	46.2
Approach		14	0.0	0.014	11.3	LOS B	0.1	0.4	0.19	0.89	46.1
All Vehicles		301	0.0	0.111	2.2	NA	0.6	4.4	0.24	0.18	53.7

Level of Service (LOS) Method: Delay (HCM 2000).

Vehicle movement LOS values are based on average delay per movement

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model used.

Processed: 26 July 2013 03:00:36 PM
SIDRA INTERSECTION 5.1.3.1990
Project: W:\Deltek Projects\13000\13944 R - Yzermyn TIS\11 - Reports\11.1 Other Reports\Revised TIS_2013-07-19\SIDRA_2013-07-26\Intersection1_R543&Vaalbank.sip
6000993, WSP SA CIVIL & STRUCTURAL ENGINEERS (PTY) LTD, LIMITED

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Base 2016 without Mine PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	Distance	Prop. Queued	Effective Stop Rate	Average Speed
South: R543											
9	L	1	0.0	0.071	9.2	LOS A	0.5	3.4	0.39	0.65	49.2
8	T	134	0.0	0.071	1.0	LOS A	0.5	3.4	0.39	0.00	53.0
7	R	1	0.0	0.071	9.5	LOS A	0.5	3.4	0.39	0.96	49.2
Approach		137	0.0	0.071	1.2	NA	0.5	3.4	0.39	0.02	52.9
East: Dirt Road											
6	L	1	0.0	0.005	13.8	LOS B	0.0	0.1	0.46	0.77	44.2
5	T	1	0.0	0.005	13.4	LOS B	0.0	0.1	0.46	0.83	44.6
4	R	1	0.0	0.005	13.6	LOS B	0.0	0.1	0.46	0.85	44.4
Approach		3	0.0	0.005	13.6	LOS B	0.0	0.1	0.46	0.82	44.4
North: R543											
3	L	1	0.0	0.151	8.8	LOS A	1.0	6.7	0.29	0.73	49.0
2	T	243	0.0	0.151	0.6	LOS A	1.0	6.7	0.29	0.00	54.4
1	R	33	0.0	0.151	8.9	LOS A	1.0	6.7	0.29	0.90	48.9
Approach		277	0.0	0.151	1.6	NA	1.0	6.7	0.29	0.11	53.7
West: Vaalbank											
12	L	7	0.0	0.012	12.3	LOS B	0.0	0.3	0.29	0.84	45.4
11	T	1	0.0	0.012	11.8	LOS B	0.0	0.3	0.29	0.91	45.7
10	R	1	0.0	0.012	12.2	LOS B	0.0	0.3	0.29	0.94	45.5
Approach		9	0.0	0.012	12.2	LOS B	0.0	0.3	0.29	0.86	45.4
All Vehicles		426	0.0	0.151	1.8	NA	1.0	6.7	0.32	0.10	53.2

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

Processed: 26 July 2013 03:00:37 PM
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8000993, WSP SA CIVIL & STRUCTURAL ENGINEERS (PTY) LTD, LIMITED

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Base 2016 with Mine AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	32	0.0	0.061	8.8	LOS A	0.4	2.6	0.34	0.60	48.7
8	T	84	0.0	0.061	0.6	LOS A	0.4	2.6	0.34	0.00	53.3
7	R	1	0.0	0.061	9.0	LOS A	0.4	2.6	0.34	0.83	48.6
Approach		116	0.0	0.061	2.9	NA	0.4	2.6	0.34	0.17	51.9
East: Dirt Road											
6	L	1	0.0	0.005	13.6	LOS B	0.0	0.1	0.41	0.76	44.4
5	T	1	0.0	0.005	13.1	LOS B	0.0	0.1	0.41	0.85	44.7
4	R	1	0.0	0.005	13.4	LOS B	0.0	0.1	0.41	0.88	44.5
Approach		3	0.0	0.005	13.4	LOS B	0.0	0.1	0.41	0.83	44.5
North: R543											
3	L	1	0.0	0.172	8.7	LOS A	1.0	6.8	0.26	0.62	48.5
2	T	157	0.0	0.172	0.5	LOS A	1.0	6.8	0.26	0.00	54.5
1	R	118	0.0	0.172	8.9	LOS A	1.0	6.8	0.26	0.79	48.4
Approach		276	0.0	0.172	4.1	NA	1.0	6.8	0.26	0.34	51.7
West: Vaalbank											
12	L	58	0.0	0.063	11.4	LOS B	0.2	1.6	0.21	0.88	46.1
11	T	1	0.0	0.063	11.0	LOS B	0.2	1.6	0.21	0.96	46.4
10	R	4	0.0	0.063	11.3	LOS B	0.2	1.6	0.21	0.99	46.2
Approach		63	0.0	0.063	11.4	LOS B	0.2	1.6	0.21	0.89	46.1
All Vehicles		459	0.0	0.172	4.9	NA	1.0	6.8	0.27	0.38	50.9

Level of Service (LOS) Method: Delay (HCM 2000)
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: Base 2016 with Mine PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	16	0.0	0.079	9.2	LOS A	0.5	3.8	0.41	0.69	49.0
8	T	134	0.0	0.079	1.1	LOS A	0.5	3.8	0.41	0.00	52.5
7	R	1	0.0	0.079	9.6	LOS A	0.5	3.8	0.41	0.91	49.0
Approach		152	0.0	0.079	2.0	NA	0.5	3.8	0.41	0.07	52.0
East: Dirt Road											
6	L	1	0.0	0.006	15.1	LOS C	0.0	0.2	0.50	0.75	43.2
5	T	1	0.0	0.006	14.7	LOS B	0.0	0.2	0.50	0.85	43.5
4	R	1	0.0	0.006	14.9	LOS B	0.0	0.2	0.50	0.89	43.3
Approach		3	0.0	0.006	14.9	LOS B	0.0	0.2	0.50	0.83	43.3
North: R543											
3	L	1	0.0	0.204	8.9	LOS A	1.3	9.0	0.32	0.62	48.6
2	T	243	0.0	0.204	0.7	LOS A	1.3	9.0	0.32	0.00	53.6
1	R	99	0.0	0.204	9.1	LOS A	1.3	9.0	0.32	0.83	48.6
Approach		343	0.0	0.204	3.2	NA	1.3	9.0	0.32	0.24	52.1
West: Vaalbank											
12	L	100	0.0	0.190	13.2	LOS B	0.8	5.3	0.34	0.86	44.6
11	T	1	0.0	0.190	12.7	LOS B	0.8	5.3	0.34	0.99	45.0
10	R	39	0.0	0.190	13.1	LOS B	0.8	5.3	0.34	1.01	44.7
Approach		140	0.0	0.190	13.1	LOS B	0.8	5.3	0.34	0.90	44.7
All Vehicles		638	0.0	0.204	5.1	NA	1.3	9.0	0.36	0.35	50.2

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

Processed: 26 July 2013 03:00:37 PM
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SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Full Operation 2018 AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	32	0.0	0.057	8.7	LOS A	0.3	2.4	0.33	0.61	48.7
8	T	76	0.0	0.057	0.6	LOS A	0.3	2.4	0.33	0.00	53.5
7	R	1	0.0	0.057	9.0	LOS A	0.3	2.4	0.33	0.82	48.6
Approach		109	0.0	0.057	3.0	NA	0.3	2.4	0.33	0.19	51.9
East: Dirt Road											
6	L	1	0.0	0.006	14.3	LOS B	0.0	0.1	0.42	0.75	43.7
5	T	1	0.0	0.006	13.9	LOS B	0.0	0.1	0.42	0.86	44.0
4	R	1	0.0	0.006	14.1	LOS B	0.0	0.1	0.42	0.90	43.9
Approach		3	0.0	0.006	14.1	LOS B	0.0	0.1	0.42	0.84	43.9
North: R543											
3	L	1	0.0	0.218	8.7	LOS A	1.2	8.5	0.26	0.58	48.3
2	T	144	0.0	0.218	0.5	LOS A	1.2	8.5	0.26	0.00	54.3
1	R	187	0.0	0.218	8.8	LOS A	1.2	8.5	0.26	0.74	48.3
Approach		332	0.0	0.218	5.2	NA	1.2	8.5	0.26	0.42	50.7
West: Vaalbank											
12	L	113	0.0	0.114	11.3	LOS B	0.4	3.0	0.21	0.89	46.1
11	T	1	0.0	0.114	10.9	LOS B	0.4	3.0	0.21	0.98	46.5
10	R	4	0.0	0.114	11.2	LOS B	0.4	3.0	0.21	1.01	46.2
Approach		118	0.0	0.114	11.3	LOS B	0.4	3.0	0.21	0.90	46.2
All Vehicles		562	0.0	0.218	6.1	NA	1.2	8.5	0.26	0.48	49.9

Level of Service (LOS) Method: Delay (HCM 2000).

Vehicle movement LOS values are based on average delay per movement

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model used.

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Full Operation 2018 PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	16	0.0	0.073	9.1	LOS A	0.5	3.4	0.39	0.61	49.0
8	T	122	0.0	0.073	0.9	LOS A	0.5	3.4	0.39	0.00	52.8
7	R	1	0.0	0.073	9.3	LOS A	0.5	3.4	0.39	0.90	49.0
Approach		140	0.0	0.073	2.0	NA	0.5	3.4	0.39	0.08	52.3
East: Dirt Road											
6	L	1	0.0	0.007	16.0	LOS C	0.0	0.2	0.51	0.74	42.4
5	T	1	0.0	0.007	15.6	LOS C	0.0	0.2	0.51	0.85	42.7
4	R	1	0.0	0.007	15.8	LOS C	0.0	0.2	0.51	0.92	42.6
Approach		3	0.0	0.007	15.8	LOS C	0.0	0.2	0.51	0.84	42.6
North: R543											
3	L	1	0.0	0.245	8.9	LOS A	1.5	10.6	0.31	0.58	48.4
2	T	222	0.0	0.245	0.7	LOS A	1.5	10.6	0.31	0.00	53.5
1	R	165	0.0	0.245	9.0	LOS A	1.5	10.6	0.31	0.78	48.4
Approach		388	0.0	0.245	4.3	NA	1.5	10.6	0.31	0.33	51.2
West: Vaalbank											
12	L	173	0.0	0.264	12.8	LOS B	1.1	7.8	0.32	0.87	44.9
11	T	1	0.0	0.264	12.4	LOS B	1.1	7.8	0.32	1.00	45.3
10	R	39	0.0	0.264	12.7	LOS B	1.1	7.8	0.32	1.02	45.0
Approach		213	0.0	0.264	12.8	LOS B	1.1	7.8	0.32	0.89	44.9
All Vehicles		744	0.0	0.264	6.3	NA	1.5	10.6	0.33	0.45	49.4

Level of Service (LOS) Method: Delay (HCM 2000).

Vehicle movement LOS values are based on average delay per movement

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model used.

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SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: Horizon 2021 with Mine AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
South: R543											
9	L	32	0.0	0.068	8.9	LOS A	0.4	3.0	0.37	0.59	48.7
8	T	97	0.0	0.068	0.7	LOS A	0.4	3.0	0.37	0.00	52.9
7	R	1	0.0	0.068	9.2	LOS A	0.4	3.0	0.37	0.84	48.7
Approach		130	0.0	0.068	2.8	NA	0.4	3.0	0.37	0.15	51.8
East: Dirt Road											
6	L	1	0.0	0.006	15.1	LOS C	0.0	0.2	0.47	0.74	43.1
5	T	1	0.0	0.006	14.7	LOS B	0.0	0.2	0.47	0.86	43.4
4	R	1	0.0	0.006	14.9	LOS B	0.0	0.2	0.47	0.90	43.3
Approach		3	0.0	0.006	14.9	LOS B	0.0	0.2	0.47	0.83	43.3
North: R543											
3	L	1	0.0	0.244	8.8	LOS A	1.4	10.1	0.29	0.57	48.3
2	T	182	0.0	0.244	0.7	LOS A	1.4	10.1	0.29	0.00	53.7
1	R	190	0.0	0.244	9.0	LOS A	1.4	10.1	0.29	0.76	48.3
Approach		374	0.0	0.244	4.9	NA	1.4	10.1	0.29	0.39	50.8
West: Vaalbank											
12	L	116	0.0	0.120	11.5	LOS B	0.5	3.2	0.24	0.89	46.1
11	T	1	0.0	0.120	11.0	LOS B	0.5	3.2	0.24	0.99	46.4
10	R	4	0.0	0.120	11.4	LOS B	0.5	3.2	0.24	1.01	46.2
Approach		121	0.0	0.120	11.5	LOS B	0.5	3.2	0.24	0.89	46.1
All Vehicles		628	0.0	0.244	5.8	NA	1.4	10.1	0.30	0.44	49.9

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Horizon 2021 with Mine PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	16	0.0	0.089	9.5	LOS A	0.6	4.5	0.45	0.56	49.0
8	T	155	0.0	0.089	1.3	LOS A	0.6	4.5	0.45	0.00	51.9
7	R	1	0.0	0.089	9.7	LOS A	0.6	4.5	0.45	0.92	49.1
Approach		173	0.0	0.089	2.1	NA	0.6	4.5	0.45	0.06	51.6
East: Dirt Road											
6	L	1	0.0	0.008	17.6	LOS C	0.0	0.2	0.57	0.75	41.2
5	T	1	0.0	0.008	17.2	LOS C	0.0	0.2	0.57	0.87	41.5
4	R	1	0.0	0.008	17.4	LOS C	0.0	0.2	0.57	0.93	41.4
Approach		3	0.0	0.008	17.4	LOS C	0.0	0.2	0.57	0.85	41.4
North: R543											
3	L	1	0.0	0.285	9.1	LOS A	1.9	13.4	0.37	0.54	48.4
2	T	280	0.0	0.285	1.0	LOS A	1.9	13.4	0.37	0.00	52.5
1	R	172	0.0	0.285	9.3	LOS A	1.9	13.4	0.37	0.80	48.4
Approach		454	0.0	0.285	4.1	NA	1.9	13.4	0.37	0.31	50.9
West: Vaalbank											
12	L	175	0.0	0.290	13.5	LOS B	1.2	8.5	0.38	0.87	44.4
11	T	1	0.0	0.290	13.0	LOS B	1.2	8.5	0.38	1.00	44.8
10	R	39	0.0	0.290	13.4	LOS B	1.2	8.5	0.38	1.01	44.5
Approach		215	0.0	0.290	13.5	LOS B	1.2	8.5	0.38	0.89	44.4
All Vehicles		844	0.0	0.290	6.1	NA	1.9	13.4	0.39	0.41	49.2

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Horizon 2021 without Mine AM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: R543											
9	L	1	0.0	0.052	8.9	LOS A	0.3	2.3	0.33	0.72	49.2
8	T	97	0.0	0.052	0.7	LOS A	0.3	2.3	0.33	0.00	54.0
7	R	1	0.0	0.052	9.1	LOS A	0.3	2.3	0.33	0.96	49.1
Approach		100	0.0	0.052	0.9	NA	0.3	2.3	0.33	0.02	53.9
East: Dirt Road											
6	L	1	0.0	0.005	13.0	LOS B	0.0	0.1	0.40	0.77	44.9
5	T	1	0.0	0.005	12.6	LOS B	0.0	0.1	0.40	0.83	45.2
4	R	1	0.0	0.005	12.8	LOS B	0.0	0.1	0.40	0.86	45.1
Approach		3	0.0	0.005	12.8	LOS B	0.0	0.1	0.40	0.82	45.1
North: R543											
3	L	1	0.0	0.129	8.6	LOS A	0.8	5.3	0.23	0.73	48.8
2	T	182	0.0	0.129	0.4	LOS A	0.8	5.3	0.23	0.00	56.3
1	R	45	0.0	0.129	8.7	LOS A	0.8	5.3	0.23	0.88	48.8
Approach		229	0.0	0.129	2.1	NA	0.8	5.3	0.23	0.18	53.9
West: Vaalbank											
12	L	14	0.0	0.016	11.4	LOS B	0.1	0.4	0.21	0.87	46.0
11	T	1	0.0	0.016	11.0	LOS B	0.1	0.4	0.21	0.93	46.4
10	R	1	0.0	0.016	11.3	LOS B	0.1	0.4	0.21	0.96	46.1
Approach		16	0.0	0.016	11.4	LOS B	0.1	0.4	0.21	0.88	46.1
All Vehicles		348	0.0	0.129	2.3	NA	0.8	5.3	0.26	0.17	53.4

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Horizon 2021 without Mine PM

R543 and Vaalbank Road
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		Vehicles veh	Distance m		per veh	km/h
South: R543											
9	L	1	0.0	0.081	9.4	LOS A	0.6	4.1	0.43	0.62	49.2
8	T	166	0.0	0.081	1.3	LOS A	0.6	4.1	0.43	0.00	52.4
7	R	1	0.0	0.081	9.7	LOS A	0.6	4.1	0.43	0.96	49.3
Approach		168	0.0	0.081	1.4	NA	0.6	4.1	0.43	0.01	52.4
East: Dirt Road											
6	L	1	0.0	0.006	14.5	LOS B	0.0	0.1	0.49	0.77	43.7
5	T	1	0.0	0.006	14.1	LOS B	0.0	0.1	0.49	0.84	44.0
4	R	1	0.0	0.006	14.3	LOS B	0.0	0.1	0.49	0.87	43.9
Approach		3	0.0	0.006	14.3	LOS B	0.0	0.1	0.49	0.83	43.8
North: R543											
3	L	1	0.0	0.175	8.9	LOS A	1.2	8.1	0.32	0.68	49.0
2	T	280	0.0	0.175	0.7	LOS A	1.2	8.1	0.32	0.00	53.9
1	R	38	0.0	0.175	9.1	LOS A	1.2	8.1	0.32	0.90	48.9
Approach		320	0.0	0.175	1.7	NA	1.2	8.1	0.32	0.11	53.2
West: Vaalbank											
12	L	7	0.0	0.012	12.6	LOS B	0.0	0.3	0.32	0.83	45.1
11	T	1	0.0	0.012	12.2	LOS B	0.0	0.3	0.32	0.92	45.5
10	R	1	0.0	0.012	12.5	LOS B	0.0	0.3	0.32	0.94	45.2
Approach		9	0.0	0.012	12.5	LOS B	0.0	0.3	0.32	0.86	45.2
All Vehicles		490	0.0	0.175	1.9	NA	1.2	8.1	0.36	0.10	52.7

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
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Appendix E Road Maintenance Management Proposal

YZERMYN COAL MINE

ROAD MAINTENANCE MANAGEMENT PROPOSAL

1. INTRODUCTION

Routine road maintenance needs to be carried out by a team that can:

- appreciate the various aspects of road management, priorities, safety, environmental issues, materials and equipment;
- identify various problems that need attention;
- understand the reasons for the problems;
- select suitable actions or repair methods;
- prioritize actions required; and
- have a systematic approach to maintenance work.

Pavement structures, materials, traffic and climate are all important variables that affect the actions required in response. In addition a balance is required between a safe, efficient road network and responsible environmental practice.

2. ROAD MANAGEMENT

2.1 Management Duties and Inspections

The maintenance team should inspect the site frequently so that problems are identified, the causes investigated and assessed and the actions required identified and carried out timeously. These inspections should also be carried out at night to view potentially hazardous locations, signs and markings, and in adverse weather conditions to assess drainage and the performance of the road elements, like signs and road markings, under these conditions.

Obvious problems should be noted as soon as they become evident and serious situations should be reacted to and reported immediately. A list containing the various aspects to be checked, the frequency of the inspections, previous inspection date and due date of next inspection should be drawn up. The following requirements should be taken into account in drawing up the check list:

Road Elements	Frequency of Inspections
1. Signs	Annually
2. Road markings	Annually
3. Guardrails	Weekly
4. Structures	Annually
5. Road condition	Annually
6. Drainage	Monthly

7. Instabilities	Dependent of degree of problem
8. Fencing	Monthly
9. Illegal signage	Weekly

2.2 Pavement Information (Structure and Condition)

A basic knowledge of the pavement structure along the route is essential. Where "as-built" plans are available the team should have a copy. The type of surfacing, base and sub-base together with the age of the pavement should all be known. This information should be supplemented by in-situ testing of the surfacing and underlying pavement layers by standard methods such as dynamic cone penetrometer tests (DCP's).

The team should know the overall condition of the various sections of the route and rates of deterioration. This information assists in the decision on what actions need to be taken particularly with regard to the extent and prioritization of repairs.

Inability to correctly identify problems and understand the cause can, and has resulted in unnecessary or wrong repair methods being used. Having correctly identified the problem it is equally important to select an appropriate treatment. Because situations are not always the same more than one treatment may need to be considered.

2.3 Maintenance Rates and Quantities

Familiarity with rates and quantities is needed not only to control the expenditure on the project but also to test the cost implications of various repair methods. Frequently more than one repair method is possible and cost should be a key factor to be weighed against other issues such as materials availability, weather, traffic and constructability, in making the correct choice.

The team should have a good idea of which materials are available, their cost and their source locations. Before considering the use of material from a borrow pit or quarry, the status of the material source should be clarified in terms of approval by the Department of Minerals and Energy (DME). Advance laboratory testing also needs to done as part of quality control.

3. PRIORITIES

It is likely that road maintenance in particular will always be faced with budgetary constraints. As a result it is vitally important that maintenance is cost effective and that work is prioritized in situations of limited funding.

The three main objectives of routine road maintenance are to:

- Provide a safe and acceptable level of service for the travelling public;

- Maintain the condition of the road such that maximum life is obtained from the road; and
- Ensure that the road environment is attractive.

Top priority is to keep the road safe at all times. Situations which may result in accidents or cause damage to vehicles should be handled first. Generally this will mean that a failed road surface will receive top priority. Secondary issues such as smooth surfaces and rutting also pose a safety threat

To prioritize other maintenance actions the question should be asked "will this action protect the pavement and prevent further deterioration?" Any situation where significant amounts of water can get into the pavement is critical and, if left unattended, will result in rapid deterioration of the pavement structure.

4. GENERAL ROAD PAVEMENT REPAIRS

4.1 Materials

While there are numerous repair materials the following are the most significant in this particular case:

- **Base Material:** Experience indicates that the use of unsuitable material is the primary cause of early failure of base repairs; and
- **Modified Cape Seal:** This consists of a tack coat of emulsion with a chip size dependant on the layer thickness required and slurry.

4.2 Repair of Road Failures

Failure is a term widely used but one that is not clearly defined. Failure can be described as a situation where an element (or elements) in the road system no longer performs satisfactorily and can lead to a rapid deterioration in the function of other elements in the system, or affect road safety.

Failure can be indicated by the breaking up of the road surface and in some cases the underlying pavement layers. While some of the conditions preceding failure, such as surface cracking, may be due to other causes failure of the road surface is usually associated with the action of vehicle wheels and in particular heavy vehicles. Water increases the rate of deterioration of the road pavement and many more failures can be expected during or just after wet weather.

Two broad categories can be used to group failures as follows:

- **Non- structural**, such as surfacing failures and potholes; and
- **Structural**, such as pavement failures.

The actions required are described under the following headings:

- **Failures:** surfacing failures, potholes, and pavement failures;

- **Active cracks:** Stabilization cracks, volcano cracks, expansive soil cracks, and longitudinal cracks;
- **Passive cracks:** surfacing cracks, crocodile cracks, long cracks, pumping, deformation, rutting, settlement, and undulations;
- **Texture:** bleeding and raveling; and
- **Shoulders:** edge break, gravel loss/steep shoulders, and flat/high/obstructed.

5. ROAD RESERVE MANAGEMENT

Management of the road reserve is also important to enable the road structure to be protected and to provide a safe operating environment for the road user. Issues to be considered include:

- **Guardrails:** An assessment of the overall guardrail system condition should be made on an annual basis to identify deterioration and allow early forecasting of any replacement costs;
- **Fencing:** This can be damaged or lost as a result of ageing, accidents, theft or cutting to provide access for grazing animals or people to the road reserve. Where fences are damaged due to accidents where they act as barriers to livestock they should be repaired immediately, unrestricted movement of livestock can be extremely dangerous.
- **Grass cutting:** This should be carried out for reasons of visibility, drainage, plant invader control, and security and fire hazard. Grass can however form an essential part of the road reserve environment, preventing dust and erosion; and
- **Pruning of trees and shrubs:** This only really needs to be done where they overhang the road, obscure signs, or affect lines of sight.

6. TRAFFIC DATA

Understanding the nature of the traffic that uses the various sections of a road is also an important issue connected to effective road maintenance and management. Ideally classified traffic counts should be carried out for at least a continuous period of 7-days on a regular basis depending of the level of development in the area. In this case a frequency of 3-5 years should be sufficient. At the same time it would also be beneficial to undertake vehicle weigh-in-motion measurements to maintain records of the cumulative loading on the road structure. This is relevant when deciding on the type of repairs that are most cost-effective.

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